Contribution of Livestock to Mountain Livelihoods

Research and Development Issues

Editors
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about the organisations

International Centre for Integrated Mountain Development (ICIMOD)

The International Centre for Integrated Mountain Development (ICIMOD)is an international organisation devoted to development of the Hindu Kush-Himalayan region covering all or parts of eight sovereign states, Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan. The Centre is located in Kathmandu, Nepal. The primary objective of the Centre is to promote the development of an economically and environmentally sound mountain ecosystem and to improve the living standards of mountain populations. The Mountain Farming Systems' Division at ICIMOD was established to promote improvement of farm productivity on small mountain farms without degrading the resource base.

Systemwide Livestock Programme (SLP)

The Systemwide Livestock Programme (SLP) is sponsored by CGIAR and convened by ILRI. It focuses on building and strengthening linkages with plant-oriented centres in order to develop integrated and coherent strategic and applied research programmes on the development of livestock feed, natural resource management, and associated policies. SLP mobilises the CGIAR resources invested in the programmes of different centres, ecoregional initiatives, and other systemwide programmes to effectively support development and natural resource management research. The SLP links the livestock-related research of CGIAR's partners worldwide and is thus a unique vehicle for enhancing the contribution of animal agriculture to CGIAR's objectives of increasing food production, eradicating poverty, and protecting the environment.

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The Food and Agriculture Organization of the United Nations (FAO) was founded in 1945 with the mandate to raise levels of nutrition and standards of living, to improve agricultural productivity, and to better the condition of rural populations. FAO has its headquarters in Rome, Italy, and is the largest autonomous agency within the United Nations system with 180 member nations plus the EC (member organisation). The Animal Production and Health Division (AGA) of FAO is entrusted with clarifying and facilitating the role of global livestock production in food security and food safety, as well as in poverty alleviation, while protecting the environment. The Division has six major project areas – Global Livestock Information and Policy; Decision Support for Efficient Livestock Resource Use; Livestock and Poverty Alleviation; Animal Genetic Resources; Veterinary Public Health Management, which hosts the Programme Against African Trypanosomosis (PAAT); and Transboundary Animal Diseases (EMPRES).

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The Centro Internacional de la Papa (CIP), or International Potato Center, is a non-profit, scientific institution that works to bring about a sustainable increase in the production and utilisation of potato, sweet potato, and other roots and tubers in developing countries. CIP is located in Lima, Peru, and is a member of the Consultative Group on International Agricultural Research (CGIAR), an association of governments and public and private sector institutions supporting a network of 16 research centres worldwide. CIP is the convenor of the Global Mountain Program (GMP), founded by CGIAR in response to the recommendations of UNCED. The GMP links CIP, the Consortium for the Sustainable Development of the Andean Ecoregion (CONDESAN), the International Centre for Research in Agroforestry (ICRAF), ILRI, and ICIMOD. It supports cooperation and information sharing between researchers working in the Andes, the highlands of East and Central Africa, and the Himalayas in crosscutting research themes including natural resource management, biodiversity conservation, socioeconomic and policy issues, and agricultural production systems with the expectation that solutions to problems in one region may be useful in another.

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Cover Plates

Background – Steep, eroding land and land use for survival in a mountain region (M.S. Mohamed Saleem) (also b/w divider for Section 1).

Inset (clockwise) – Alpacas contribute to the sustainable use of hign mountain areas (Julio Sumar K.) (also b/w divider for Section 4).

Threshing the crops by using livestock is a common practice in the mountains (M.S. Mohamed Saleem).

Collecting fodder for stall-fed animals is a problem in many areas (Pradeep Tulachan)(also b/w divider for Section 3).

Women are important players and beneficiaries in market-oriented, smallholder dairy systems (ILRI)(also b/w divider for Section 2).

Foreword

The value of mountain areas is only now being recognised, although they have always been important sources of food, water, energy, and timber. Mountain resources directly contribute to the livelihoods of several hundred million people living in mountain areas and indirectly support the livelihoods of several billion people living downstream. It was only after the RIO (UNCED) endorsement of Agenda 21, Chapter 13 in 1992 that international organisations started expressing concern about mountain ecosystems and mountain inhabitants. The state and use of mountain resources constitute an issue that affects us all, and the International Centre for Integrated Mountain Development (ICIMOD) is at the forefront of efforts to help promote the development of an economically and environmentally sound mountain ecosystem and to improve the living standards of mountain populations.

Livestock are an integral, but under appreciated, component of farming in the mountains and highlands. They provide food, wool, and hides for people and draught power and fertiliser for the cultivation of crops. Livestock are the key to ensuring that farmers in remote areas, without access to outside inputs, can practise a self-sustaining and self-sufficient form of agriculture in reasonable harmony with the natural resources of the mountains. Without livestock, these farmers would be unable to survive and many nutrients would not be recycled. Despite their tremendous importance, however, livestock have been marginalised in development agendas and have received little attention in international meetings.

By 1999, a number of activities had been initiated by different organisations with the aim of filling this gap. The Food and Agriculture Organisation (FAO), as Task Manager of Agenda 21, Chapter 13, had facilitated a number of inter-agency and inter-governmental meetings on mountain issues, but still felt the need to develop a clear vision of how livestock could be used best to develop sustainable agricultural

systems. The Animal Production and Health Division of FAO was holding independent regional consultations in Asia with ICIMOD, in Africa with the International Livestock Research Institute (ILRI), and in Latin America with the Centro para la Investigación en Sistemas Sostenibles de Producción Agropecuaria (CIPAV). The Consultative Group on International Agricultural Research (CGIAR) had initiated a Systemwide Livestock Programme (SLP), which is convened by ILRI, and in collaboration with ICIMOD and the Centro Internacional de la Papa (International Potato Center, CIP) set aside funds for a project development consultation with key stakeholders. ICIMOD was investigating the status of livestock in mixed farming systems and in pastoral areas in the Hindu Kush-Himalayan region. Recognising the complementary nature of these activities, four agencies – ICIMOD, ILRI (SLP), FAO, and CIP (Global Mountain Program, GMP) – decided to organise a joint symposium to discuss the issues worldwide and to develop an action plan to highlight the role and importance of livestock for highland communities.

ICIMOD was delighted to be able to host the International Symposium 'Livestock in Mountain/Highland Production Systems: Research & Development Challenges into the Next Millennium' in Pokhara, a place of immense natural beauty in western Nepal, from 7-10 December 1999. For the first time, the meeting brought together representatives of governments; local and international NGOs; research, development, donor, and funding institutions; and community leaders and farmers from the major mountain regions of the world. Sixty-eight participants from fifteen countries in six continents attended.

I am pleased to join with our partners to present this book. It is based on the papers presented and discussions from the symposium summarising the present state of knowledge about and the future possibilities for livestock in mixed farming systems in the mountains. I am sure this will prove an invaluable resource for all those working towards the sustainable development of mountain agriculture and the maintenance of fragile mountain ecosystems. I thank specially all those who contributed to making the symposium a success, the organisers, the organising committee, the participants – including those who, unable to attend in person, contributed to the e-conference – and the editors of this publication who have prepared the results in a form that all can use. Last but not least we thank the Systemwide Livestock Programme convened by ILRI for its support to the Symposium and for bearing the costs of this publication.

J. Gabriel Campbell
Director General, ICIMOD

Executive Summary

This book is a summary of the proceedings of the International Symposium on 'Livestock in Mountain/Highland Production Systems: Research and Development Challenges into the Next Millennium', which took place from 7-10 December 1999, in Pokhara, Nepal. The symposium was jointly sponsored by the International Centre for Integrated Development (ICIMOD), the Systemwide Livestock Programme of the Consultative Group on International Agricultural Research (CGIAR) convened by the International Livestock Research Institute (ILRI), the Food and Agriculture Organisation (FAO), and the Centro Internacional de la Papa (International Potato Center, CIP). The aim was to address the critical issues facing research and development of livestock in mixed farming systems in mountain and highland regions in Africa, the Andes, and the Hindu Kush-Himalayas and to provide a direction for future activities. The meeting highlighted the main current and future trends and constraints to livestock production systems in mountain and highland environments. It discussed participatory research and development approaches to optimising livestock production and product supply systems with the aim of achieving sustainable increases in food security, income generation, and poverty reduction whilst maintaining the natural resource base. The meeting successfully established an inter-regional framework for testing and sharing of appropriate options and experiences and prepared a joint manifesto, the 'Pokhara Call for Action', as an expression of the commitment of the participants to work towards common objectives.

Eighteen papers on livestock and livestock-related issues were presented in plenary sessions. Separate working groups discussed, and developed action plans for, four thematic areas – livestock production systems (farm level); post production processes; livestock biodiversity and conservation; and livestock policy issues. The

symposium was preceded by an electronic conference, which provided people who could not attend the Pokhara Symposium with a forum in which they could contribute to developing a comprehensive livestock research and development agenda. This electronic conference was hosted on the FAO mail-server and ran for eight weeks. Nearly 600 subscribers from Africa, Asia, Latin America, Europe, and the United States participated.

The book is divided into four sections.

Part I is an introduction and summary, with a brief account of the symposium, the main points raised in the plenary sessions and working group discussions, the issues and challenges raised during the symposium and in more detail in the papers, and the text of the 'Pokhara Call for Action'.

Part II contains papers related to the role of livestock production systems in the context of changing socioeconomic circumstances, trends in livestock production and consumption, issues related to livestock biodiversity, the effect of technological and institutional changes on smallholders, problems of and the research needed to support sustainable livestock development, and niche-based livestock products. It closes with a report of the findings of the electronic conference.

Part III describes the results of three separate regional studies sponsored by FAO, in the Hindu Kush-Himalayas, East African Highlands, and the Andean region, on livestock production systems in high pressure mountain/highland areas.

Part IV is concerned with livelihoods and sustainability issues in mountain livestock farming systems. It includes chapters on concerns about sustainability, the need to make research more relevant to individual mountain smallholders using a holistic approach on the watershed scale, issues related to draught animal power and livestock as a source of household energy, the success and failure of milk co-operatives, gender roles in livestock management, and the potential and environmentally friendly nature of llamas and alpacas.

The Symposium Agenda, list of participants, and some information on the authors of the chapters in the book are presented in three Annexes.

One significant outcome of the symposium was the declaration of the 'Pokhara Call for Action'. In this the participants agreed

- to prepare a global research and development agenda to improve livelihoods in livestock-dependent mountain and highland communities which emphasise

understanding of the dynamics of evolving livestock production systems, the strengthening of appropriate technologies and strategies, and the contribution of policies and capacity building that link R&D, and focuses on utilisation and conservation of production resources, sustainable market-oriented livestock production systems, post-production processes, and trade and regional integration;

- to prepare a livestock agenda for incorporation into the framework for the International Year of the Mountains in 2002;
- to encourage collaboration across the different mountain/highland eco-regions;
- to encourage governments, and donor and funding agencies, to give higher priority in national and international development agendas to the gender-balanced participation, empowerment, and property rights of livestock-dependent mountain and highland populations; and
- to encourage research and development organisations to undertake activities to improve livelihoods in livestock-dependent communities in mountain and highland eco-regions.

Acknowledgements

We are grateful to Mr Chakra Prasad Bastola, Minister of Agriculture of His Majesty's Government of Nepal, for graciously inaugurating the symposium and consenting to be the chief guest at the opening ceremony. We would like to express our gratitude to Mr. Egbert Pelinck, the former Director General of ICIMOD, and Dr. Mahesh Banskota, the former Deputy Director General of ICIMOD, for their inspiration, support, and guidance. We thank Dr. Hugo Li-Pun, Director of the Sustainable Production System Programme of ILRI, for delivering the keynote address; Dr. Jimmy Smith, Coordinator of the Systemwide Livestock Programme, ILRI, and Dr. Roberto Quiroz, Head of the Department of Production Systems and Natural Resources Management, CIP, for their intellectual support; and Mr. Jeroen Dijkman, FAO and ILRI, for facilitating the electronic conference that brought in inputs from a wider audience. Special thanks are due to Ms Beryl Rajbhandari for her assistance in organising the symposium and in the preparation of this book. We would also like to thank Dr. Laxman Sherchan for his review of the final draft and the entire support staff of ICIMOD for their assistance. We also thank all the people who presented the papers that enabled the meeting to highlight livestock issues and options for mountain and highland communities across the globe, the symposium participants, and the contributors to the electronic conference. Finally, we wish to thank the four institutions, ICIMOD, ILRI (SLP), FAO, and CIP, for their generous financial and logistic support, without which the symposium would not have been possible.

Acronyms and Abbreviations

ADB	Asian Development Bank
AEZ	agro-ecological zones
AHI	African Highlands Initiative (convened by ICRAF)
AI	artificial insemination
ALDI	Agricultural Development Led Industrialisation
APROSC	Agricultural Projects' Services' Centre (Nepal)
AU	animal units
BBM	broad bed maker
CAC	Central Asian countries
CATIE	Tropical Agronomic Research and Training Center
CEU	cattle equivalent units
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical (Colombia)
CIID	Centro Internacional de Investigaciones para el Desarrollo
CIP	Centro Internacional de la Papa (International Potato Center) (Lima, Peru)
CIPAV	Centro para la Investigación en Sistemas Sostenibles de Producción Agropecuaria (Colombia)
CIRNMA	Centro de Investigación de Recursos Naturales y Medio Ambiente (Bolivia)
CONDENSAN	Consortium for the Sustainable Development of the Andean Ecoregion
CPR	common property resources
CTA	Technical Centre for Agricultural and Rural Cooperation (Netherlands)

DAH	Decentralised Animal Health Project (ITDG)
DAP	draught animal power
DDE	dairy development enterprise (Ethiopia)
DFC	dairy farmers' cooperative
DP	dual purpose dairy
DSE	Deutsche Stiftung fuer internationale Entwicklung (German Foundation for International Development)
EAH	East African Highlands
EAP	economically active population
EARO	Ethiopian Agricultural Research Organization
ESCAP	Economic and Social Commission for Asia and the Pacific
FYM	farmyard manure
FAO	Food and Agriculture Organization
FY	financial year
GDP	gross domestic product
GI	galvanised iron
GIS	geographic information system
GMP	Global Mountain Program (CIP)
GNP	gross national product
GPS	global positioning system
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (German Technical Cooperation)
HDI	human development index
HKH	Hindu Kush-Himalayas
HMGN	His Majesty's Government of Nepal
HP	Himachal Pradesh
HYVs	high yield varieties
IAC	International Agricultural Centre (Netherlands) check with CTA
IAR	Institute of Agricultural Research (Ethiopia)
IC	internal combustion
ICA	Colombian Agriculture Institute
ICIMOD	International Centre for Integrated Mountain Development (Nepal)
ICRAF	International Centre for Research in Agroforestry (Kenya)
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics

IDRC	International Development Research Center (Canada)
IFPRI	International Food Policy Research Institute (Washington)
IICA	Instituto Interamericano de Cooperación Agrícola (Costa Rica/ Ecuador)
IIED	International Institute for Environment and Development (London)
ILCA	International Livestock Centre for Africa
ILRI	International Livestock Research Institute
INGO	international non-government organisation
INIA	Instituto Nacional de Investigaciones Agropecuarias (Puno, Peru)
IR	Indian Rupee
ISNAR	International Service for National Agricultural Research
ITDG	Intermediate Technology Development Group
IYM	International Year of the Mountains
JVP	Joint Vertisol Project (Ethiopia)
KCC	Kenya Cooperative Producers
KVIC	Khadi and Village Industries Commission
MOA	Ministry of Agriculture
MPA	Milk Producers' Association
NGO	non-government organisation
NPV	net present value
NRM	natural resource management
PISA	Proyecto de Investigacion de Sistemas Agropecuarios Andinos (INIA)
PPR	private property resources
PRA	participatory rural assessment
PRODASA	Proyecto de Desarrollo Agropecuario Sostenido en el Altiplano (convenor CIP-INIA/CONDESAN)
R&D	research and development
REPAAN	Red de Pastizales Andinos (FUNDAGRO project, Ecuador)
RET	renewable energy technologies
SAC	south Andean camelid
SD	specialised dairy

SLP	Systemwide Livestock Programme (convenor ILRI)
SSA	Sub-Saharan Africa
TLU	tropical livestock units
UNCED	United Nations Convention on Environment and Development
UNFPA	United Nations Population Fund
VDCs	village dairy cooperatives (India), Village Development Committee (Nepal)

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Introduction

Part One

Chapter 1

Livestock in the Mountains and Highlands of Asia, Africa and South America: An Overview of Research and Development Issues and Challenges

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The Context

Most mountain and highland areas in the tropics and sub-tropics are particularly suitable for rearing livestock as a result of their ecology, climate, and the relative absence of disease. Production trends, however, have not been able to keep pace with the increase in human population. Although changes in world production and consumption patterns have opened up favourable new opportunities for smallholder livestock producers, the absence of appropriate infrastructure, technologies, support services, and enabling domestic policies has impeded the expected production increases in many developing nations. With both rural and urban populations expected to maintain their growth, constraints related to the intensification and commercialisation of animal agriculture, such as conservation of the natural resource base and changes in the requirements for infrastructure and livestock-related services, are likely to increase. Nevertheless, there is evidence that increased integration of livestock production into highland crop farming systems could have significant beneficial effects on the sustainability of these systems as well as on the conservation of natural resources. Livestock research and development initiatives in these regions must address the identification, testing, and implementation of options and strategies that optimise livestock production and crop/livestock integration with the aim of achieving a sustainable increase in household food security, income generation, and poverty reduction while maintaining the natural resource base.

Although mountain areas have always been important sources of food, water, energy, and timber, this fact has only been recognised recently. It was only after endorsement

of the United Nations Convention on Environment and Development (UNCED) of Agenda 21, Chapter 13 in 1992 that international organisations started expressing concern about mountain ecosystems and mountain inhabitants. As the Task Manager of Chapter 13, the Food and Agriculture Organisation (FAO) has facilitated a number of inter-agency and inter-governmental meetings. Although these meetings recognised the importance of livestock in highland farming systems, they did not develop a clear vision of how livestock could be best utilised to develop sustainable agricultural systems. It was in this context that the international symposium on 'Livestock in Mountain/Highland Production Systems' was organised in Pokhara, Nepal, in December 1999.

The symposium focused on issues related to livestock in mixed farming systems, that is farming systems in which crop production is combined with keeping of livestock, in highland and mountainous regions. The symposium provided a forum at which the participants could discuss and share experiences related to the use of livestock as a valuable natural resource to improve people's livelihoods, particularly in the mountain and highland regions of the Hindu Kush-Himalayas, Africa, and South America. These regions are characterised by a predominance of subsistence rather than commercial farming, unlike similar regions in North America, Australia, and Europe. In the following pages, the term 'mixed farming systems' is used to denote the major agricultural systems addressed in the regions as given. The terms mountain/highland or 'mountains and highlands' are used interchangeably to avoid the problems that arise from the lack of a common definition of the two terms in different regions (see the discussion at Forum Mondial de la Montagne (2000), International Mountain Research Workshop on *Mountain Regions: A Research Subject?* 4-7th June 2000, Autrans/Grenoble, France). Some of the chapters refer to 'mountains' or 'highlands' only according to the author's preference; the reader should understand these as essentially referring to the same thing.

Studies presented during this symposium from the Hindu Kush-Himalayas (HKH), Andes, and African highlands show that, despite their geographical separation, these areas have many similarities in terms of the role of livestock in production systems, environmental and sustainability concerns, gender issues, and the constraints and challenges stemming from the technological, institutional, and economic situations.

In this first chapter we attempt to provide an overview of the main points raised in the papers presented at the workshop and during the discussions that followed; the details can be found in the chapters that follow. The issues raised are summarised from all three regions under different thematic headings.

The Major Issues Raised

Livestock in mountain and highland economies

Livestock play an important role in mountain economies. In the HKH, livestock contribute 20-40% or more to the income of mixed farming households (Tulachan, Chapter 10). Overall livestock contribute 36 to 47% of the total agricultural income in the mountains and hills of Nepal. In Tibet, they account for more than 50% of the total gross production value of agriculture (Tashi, Chapter 13). Livestock play an equally important role in the agricultural economy of the African highlands. In Ethiopia, animals and their products account for 30% of agricultural GDP and 12% of total GDP, excluding the value of draught and manure (Sileshi and Tegegne, Chapter 7).

The income-generating functions of livestock vary from livestock being the main cash crop, as in smallholder dairy systems, to the occasional chicken or goat sold to cover sporadic or emergency expenses. The range and the amount of products sold depend on the different systems but they can vary from meat to manure, eggs to fibre, milk to work (Dijkman, Chapter 11). Livestock are one of the common ways in which the poor build their assets and are able to finance their children's education and other important requirements (Li Pun and Mares, Chapter 2).

Livestock are critical in maintaining soil fertility. They allow land-use intensification through the concentration of nutrients and the acceleration of nutrient cycling. In the majority of mountain areas, chemical fertilisers are still unavailable or beyond farmers' means. In such cases manure serves as the fertiliser. Unfortunately, significant amounts of nutrients are often lost as the result of poor collection and storage methods for manure and the exposure of livestock excreta (Dijkman, Chapter 11; Tulachan, Chapter 10).

Various attributes of draught animals – energy for agricultural operations, physical products, income and employment gains, and sociocultural and ecological services – are vital for the sustainable development of mountain highland agriculture in the HKH (Singh and Partap, Chapter 16; Tulachan, Chapter 10). In Ethiopia, animal power is used for 15 different types of farm operation; more than 90% of the crops are cultivated using about 6 million draught animals, mainly oxen (Zinash Sileshi and Azage Tegegne, Chapter 7).

Complementary links between livestock and other factors such as environment, socioeconomic conditions, land-use changes, and technological innovations are recognised by Jodha (Chapter 3) and in the Andean context by Estrada and Quiroz (Chapter 6). In the livestock-crop mixed farming situation, understanding of

complementary links between the activities in livestock production systems helps understanding of the multiple complementary links that are crucial to environmental stability and the security of people's livelihoods in mountain areas.

Trends and management strategies in livestock production systems

Over the past years, considerable changes have taken place in populations of livestock and the composition of livestock holdings, as well as in management strategies, as a result of population growth and land-use intensification. In mixed farming systems in the HKH there has been a decline in the populations of cattle and sheep and an increase in the populations of buffalo and goats, indicating a growing importance of buffaloes and goats in the livestock economy (Tulachan, Chapter 10).

In the HKH, accessibililty and development of road networks has played a crucial role in the development of smallholder dairies as an integral part of mountain farming systems. There has been a considerable shift in the management strategies of smallholder dairy farmers; from extensive grazing to intensive stall feeding, from use of public land to use of private land for growing fodder and forage crops, and from feeding crop-residues to increasing use of purchased feeds (Tulachan, Chapter 10). According to Singh et al. (Chapter 18) there is a growing trend in Himachal Pradesh towards keeping buffaloes and cross-bred cows for milk production – reflecting a shift from low-producing indigenous animals to dairy animals with higher milk yields.

Analysis of the livestock production trends in high-pressure areas across the East African region indicate that there is an increasing trend towards smallholder crop-livestock production. Smallholder dairies have flourished better in Kenya than in Ethiopia, partly because of the better market infrastructure in Kenya and partly as a result of differences in the types of animals raised in the two countries. In Kenya, dairy development has been based on the use of cross-bred animals, whereas in Ethiopia the numbers of these animals are negligible (Dijkman, Chapter 11).

An interesting trend is emerging in livestock production systems in Tibet, especially in the lower altitude areas, with a transition from animal husbandry based on rangelands to a mixed crop-livestock system, i.e., from the extensive traditional system to an intensified system. Commercialised livestock production is increasing as a result of both state and private investment. In the future it is likely that mixed crop-livestock production systems will be promoted, whereas pastoral livestock production systems will focus on rehabilitation and conservation (Tashi, Chapter 13).

Smallholder dairies and factors affecting their success

In the HKH, smallholder dairy farming has been gaining in importance (Tulachan, Chapter 10). There is an emerging trend towards the introduction of new dairy

livestock species for better milk yields. Certain preconditions must be fulfilled to ensure the success of introducing such species, and the approach used must be appropriate for local conditions. Tulachan cites two examples; one each from Nepal and India. In the hills of Nepal, veterinary health support services are limited and supplies of quality feed inadequate, thus outright adoption of improved cattle is not possible. Under these circumstances it is more appropriate to introduce improved buffaloes, which adapt better to the locally available feed resources while giving better milk yields than local cows – and this is what is happening. In Himachal Pradesh in India the necessary conditions for rearing improved dairy cattle exist, and introduction of improved cattle should be encouraged – as in fact it is.

Singh et al. (Chapter 18) examine the operation of dairy cooperatives in Himachal Pradesh and outline the factors determining their success and failure. These co-operatives were introduced as a management strategy for milk producers under the 'Operation Flood' programme and were intended to act as reliable market outlets for milk producers and as regular suppliers of milk at reasonable prices to consumers. A total of 250 dairy cooperatives was set up of which a quarter are now defunct. At present only 7.7% of the milk produced in the state is being collected through these cooperatives, so there is considerable scope for expansion provided they are conducted professionally. The failures resulted from inefficient management and the problem of vested interests, with people using the cooperatives as a way of gaining power and prestige.

The keys to the success of dairy cooperatives are sound business practices, competent managerial personnel, and systematic training of members and office bearers. Other factors such as favourable government policies and presence of a competitive environment are also critical. The most important variable observed related to success or failure is accountability. To whom is the dairy cooperative accountable? Are its decisions made mostly in the interests of its members or are they shaped in response to government objectives and policies? Do cooperative officials mostly look 'downward' to members or 'upward' to higher officials? Do members see the dairy cooperative as belonging to themselves or to the government? (Singh et al., Chapter 18)

Kenya in East Africa is one of the few success stories for smallholder dairy development on the African continent. The success mainly resulted from the introduction of exotic and crossbred cattle by Europeans. A profit analysis of the adoption of dairy cattle in the Kenyan highlands indicated that household characteristics, local area characteristics, availability of veterinarians, the agro-climate, and formal markets are the important factors affecting the successful adoption of crossbred cattle. An increase of one per cent in the proportion of local sales to formal

markets is associated with a more than three per cent increase in the probability of adoption. This can be attributed to the greater reliability and lower risks in milk marketing which reduce the risks associated with adoption. The availability of a veterinarian also reduces risks and has a large positive effect. The distance by road to an urban centre also has a significant impact (Staal and Jabbar, Chapter 4).

Zapata Cadavid (Chapter 12) examines the systems of dairy production practised in two areas of the Andean region of Colombia; the North High Plateau of Antioquia and Quindio Department, both located in the central range of the mountains. Specialised dairy is the common system in Antioquia, whereas both specialised and dual purpose dairy is practised in Quindio. The most popular breed of cattle is Holstein and the most popular grass is *Pennisetum clandestinum*. Feeding is based on pasture. Lactating cows are supplemented with concentrate. In the North High Plateau of Antioquia the system called 'pigs-pasture-milk' is popular: pigs are penned in a high part of the farm, their manure is used as fertiliser to increase grass production, and the grass is fed to the cattle.

Natural resource management (NRM), environment and sustainability concerns

Livestock production is intrinsically associated with environmental quality. When there is good grass cover, soil erosion is less than in areas with crops alone. Crop and pasture productivity on hillsides is directly associated with soil erosion, which also affects the supply and quality of water downstream (Leon-Velarde et al., Chapter 14). Equally, population increases and the expansion of tourism mean that some of the main grazing areas formerly used for ruminant livestock are no longer available for grazing (e-conference, Chapter 9).

Use of environmentally friendly technology in farming practices is critical for minimising environmental degradation. This approach is based on maintaining soil fertility by recycling livestock waste as organic fertiliser, rather than by application of chemical fertilisers (Zapata Cadavid, Chapter 12). Many people have a narrow view of mountain rangelands. They regard mountain grassland simply as feed for livestock and ignore the important role it plays in carbon sequestration, nutrient cycling, water capture, soil conservation, and conservation of biodiversity (Li Pun and Mares, Chapter 2).

In the Andes, rangelands constitute the main feed resource for ruminant species. Grazing of native pasture is complemented with crop residues like stovers and introduced improved feed resources. The extent to which livestock on aggregate degrade or upgrade soil is a matter of debate. In the high pressure areas of the HKH, pressure on the environment and common property resources is declining as a result

of the trends towards smaller herd sizes, use of private land to plant fodder resources, stall-feeding, and use of external inputs such as purchased feed (Tulachan, Chapter 10). Use of manure to produce biogas, as practised in the mid-hills of Nepal, is a further benefit from livestock that has a positive effect on the environment, especially on forests (Rijal, Chapter 17). Likewise, intensification of some highland production systems in Latin America is based on the use of concentrates, which means less pressure on local natural resources (e-conference, Chapter 9).

Kaufmann and Saleem (Chapter 15), in a paper based mainly on collaborative research in one of the watersheds in Ethiopia involving the Ethiopian Agricultural Research Organisation (EARO), the International Crops Research Institute for Semi-Arid Tropics (ICRISAT), and the International Livestock Research Institute (ILRI), draw attention to concerns about the sustainability of natural resource bases in the African Highlands. Improving the welfare of smallholders involves developing land-use systems that meet both the socioeconomic needs and the requirements for sustainable use of the production resources; the reconciliation of public and private goods is important for achieving these goals. Kaufmann and Saleem argue that the conventional approach to development focuses primarily on policy interventions and technology components and their interactions at the household/farm level. To have a sustainable impact on human welfare in terms of poverty alleviation, food security, better nutrition, and human and environmental health it is necessary to go beyond household profitability, resource productivity, and resource requirements. Technologies and policies and their interactions have to be integrated at both the community and the household levels. Unless common and private interests are reconciled, the conflict between them will be detrimental to both. The authors suggest mechanisms for mobilising community action to reconcile these using an example of water management in the landscape.

In East Africa the problems of concentration of people, a fragile environment, and deterioration of natural resources form a vicious cycle. At present agricultural production is decreasing by three per cent per annum, whereas the population is increasing at close to the same rate. In Ethiopia, loss of soil is aggravated by removal of manure which people use as fuel for cooking as a result of lack of other sources of fuel (Li Pun and Mares, Chapter 2).

Although many local systems of resource management have a proven record in protecting communal areas, these systems have not functioned well in protecting and ensuring the judicious use of forest and pasture areas because of the high population pressure. Tree lopping and grazing of forests in some pocket areas of Nepal have become so intense that trees are degraded and there is no forest regeneration. Even where collective forest management is being tried, there are significant problems with

what has been called the 'free-rider' effect, in which the benefits that people obtain are not commensurate with their contribution. Nevertheless, the community forestry programme has been successful where local people were genuinely given the ownership of forests to manage by themselves. Leasehold forestry is another successful example. In the leasehold project, blocks of degraded forest are leased to the poorest farmers and assistance provided to help them regenerate the land for the households' exclusive use. In these areas the number of less productive animals has decreased, and income from livestock products and livestock related products such as fodder has increased. There has been a massive regeneration of forest species at most of the sites, with a positive influence on adjacent forest areas and reputed aversion of forest encroachment and shifting cultivation (e-conference, Chapter 9).

Livestock biodiversity and other production resources

The introduction of exotic species has often been associated with problems like resource and climate mismatches. When improved animals from lowland areas are introduced into highland areas they can encounter specific health problems, not to mention problems related to services and feed resources. One such example was observed in the Andes. When exotic broilers and dairy grade cattle were introduced in the Colombian highlands, difficulties were experienced as a result of the sudden and large diurnal variation in ambient temperatures. Exotic species should be introduced with caution to avoid high mortality (e-conference, Chapter 9). Careful consideration of technologically narrow and short-term approaches, and conducting genetic impact analyses prior to the introduction of exotics, might help mitigate such risks (Valle Zarate, Chapter 5).

A study conducted in the Andean Valley of Bolivia in which breeding groups held under different ecological and socioeconomic conditions were compared, showed the clear superiority of pure-bred, local animals in harsh environments, crossbreeds in improved environments, and pure-bred exotics under conditions of intensive feeding and husbandry. Crossbred and pure-bred animals are not available to most farmers in mountainous areas, however. The results show that local genetic resources play an important role in producing optimised breeding stock (Valle Zarate, Chapter 5).

Camino and Sumar (Chapter 20) examine the scope for introducing South American lamoids – llamas and alpacas – in other mountain/highland regions. Native to the fragile Andean ecosystem, these animals can survive cold, heat, and intense solar radiation (ultraviolet) and can also survive on a dry coarse diet with very little water. Their ability to survive in harsh conditions and their productive superiority give them a clear advantage over other animals like sheep, goats, and cattle, thus they can be termed 'super species'. Recent introductions of alpacas and llamas into the

United States, Israel, Canada, and New Zealand, have shown that they can be reared successfully outside the Andes for commercial purposes.

Biologically, lamoids are among the most environmentally gentle ruminants. With their soft-padded feet, they do not scour steep hillsides. With their sharp front teeth, they clip off grass rather than tear it off like sheep and cattle. Moreover, with their efficient digestive system alpacas and llamas can survive on coarse native grasses. Thus in contrast to sheep and cattle they require no pasture improvement or other modification of the unique, high-altitude environment. Lamoids can easily be integrated into the farming systems and economies of mountain/highland areas because rearing them involves only a very small investment in terms of labour and technology. Lamoids have several economically beneficial characteristics. The animals have multiple uses: the medium to fine quality llama wool can be used in making tapestries and garments; they can be used as beasts of burden to transport goods over rugged mountains; and they can also be a source of meat. When animals are introduced into new surroundings, however, special care must be taken to prevent transmission of infectious diseases from local livestock and consumption of toxic plants.

Gender concerns in livestock management

Gender is a vital issue for the sustainable management of livestock in mixed crop-livestock farming systems because of the substantial role women play in livestock management. Men and women have different domains of activity and different knowledge and skills. In some areas the knowledge and skills of women are considerably greater than those of men, but in general this does not receive due recognition. Women also face barriers related to access to and control of essential items (Njiro, Chapter 19) and still have very limited access to all types of services from credit to veterinary services (e-conference, Chapter 9).

Two communities of Turkana were studied in Kenya. In these communities, male elders have a strong authority and make the major decisions on family issues and herding groups. Women do have a voice within the society, however, they are free to talk in the presence of men and to be represented at the community 'tree'. The Turkana women play a key role in maintaining household food security. A married woman is responsible for feeding the members of her household (children, husband, and dependants); she prepares, stores, cooks, and serves all food, whether it consists of animal products or purchased or aid-food (Njiro, Chapter 19).

Amongst the Sambura People at Baragoi in Kenya, women are believed to be incapable of the strenuous tasks involved in treating animals, like carrying cattle to the treatment centre. But in fact in the absence of male household members they do

perform such tasks. Overall women were found to be more concerned about the health of their livestock than were men. They purchased drugs more often and noticed sickness first. Some women were acknowledged as experts in certain specific areas like birthing or retained placenta, and with small stock or cattle (Njiro, Chapter 19).

Women in general have been marginalised in research and development programmes in the African Highlands (Dijkman, Chapter 11). A similar marginalisation and disregard for women's knowledge, skills, and contribution in raising livestock is common in the HKH (Tulachan, Chapter 10). However, changes have been taking place in the HKH with regard to women's access to cash and decision-making in livestock management. Women are increasingly taking control of the cash earned by raising livestock and spending it on the household, and they play a more active role than men in goat, poultry, and pig farming (Tulachan, Chapter 10).

In the Andes, too, women play an important role in livestock production systems. It is estimated that women produce, process, or sell up to 80% of the food in the Andean countries (Li Pun and Mares, Chapter 2).

Technological and institutional issues

Despite an array of scientific innovations, science and technology have had little impact on livestock development or improvement in developing countries. Sound policy backing is crucial for the dissemination of technology. Having policies to promote credit is a key element in the adoption of improved technologies. Credit must be made available to farmers, so that they can make use of new technologies (Li Pun and Mares, Chapter 2).

Estrada and Quiroz (Chapter 6) discuss the technological and institutional changes affecting mixed crop-livestock production systems in the Andean countries of Colombia, Ecuador, Peru, and Bolivia. At the beginning of the 1990s, changes in government policies substantially modified the mixed crop-livestock production systems of small producers in the mountain regions. Many of the basic crops like corn, wheat, and barley went out of production as a result of increasing imports. In addition to the land-use changes, state power became greatly reduced, limiting to a great extent the ability of the state to support research, extension, and credit activities.

Zapata Cadavid (Chapter 12) discusses two productive technologies aimed at increasing farm production: a conventional and a new approach. The conventional technical approach tries to increase milk yields using imported concentrates, improved breeds such as Holsteins, and vast amounts of chemical fertilisers. This approach has drawbacks such as the need for large amounts of capital, dependency

on imported inputs, and deterioration of the environment. The new approach is an integrated and environmentally-friendly technology. It uses crossbred cattle and pigs, biodigesters to produce energy, and earthworms for composting solid wastes which, combined with the effluent from the biodigesters, provide organic fertiliser. Some of the numerous advantages of this technology are a feed supply for cattle and pigs, food for humans, pest-free and healthy pastures, natural regeneration of fragile areas, maintenance of soil fertility, a supply of biogas for cooking, and the availability of high quality fertiliser. The extent to which this new technology can be transferred to other areas still needs to be investigated. The heterogeneity of mountain regions in terms of factors like altitude, climate, soils, quality and quantity of feed resources, and ethnic background poses a great challenge to the transfer of technologies like this from one region to another (Leon Velarde et al., Chapter 14).

In Africa some technologies, like the introduction of cross breeds, have brought households additional income. In Kenya, a recent study showed that farmers with crossbred cows had an additional income of 50 dollars per cow per month without the need for additional labour. There was no significant increase in household milk consumption, however. When evaluating the net benefit of new technologies like this, improved nutrition of the household (direct, or indirect through use of the cash income) should be considered (Li Pun and Mares, Chapter 2).

ILRI and its collaborators studied dairy-draught technology (using cows for the dual purposes of milk production and draught power) in the Ethiopian highlands with the aim of determining whether the crossbred cows could provide draught power and replace oxen. The replacement of ox power with dairy draught power proved feasible, as long as the farmers had good access to milk markets, and animal health care and breeding services. Road quality and distance from urban markets were some of the major factors determining the sales' price and thus the feasibility of adoption of the technology (Kaufmann and Saleem, Chapter 15). Dairy-draught technology is attractive because it enables the reduction of animal numbers, and in fragile areas this supports efforts to improve vegetative cover and protect soil. The advantages are best recognised, and the technology most accepted, in those situations in which farmers collectively recognise the limits to the stock-carrying capacity of their watersheds. The feed released by the displaced oxen can be used more profitably by the dual-purpose cows, and as the cows are stall-fed the manure and urine can be more readily collected for use as organic fertiliser. An unexpected benefit observed in Ethiopia was that more children were able to attend school because the need for herding was eliminated (Kaufmann and Saleem, Chapter 15).

In Nepal, manure is used for generating 'biogas', with the slurry used as fertiliser. This reduces the use of wood as a fuel for cooking and heating and has had a

significant impact on forest regeneration and tree cover (Kaufmann and Saleem, Chapter 15). Data from Nepal show that 25% of the country's total energy requirement could be met by biogas technology, without losing the fertiliser value of dung. In many cases it has been reported that the slurry coming out of the biogas digester is of better quality than raw farmyard manure. Decomposition of dung and agricultural residues can also be enhanced by mixing slurry with them. Use of biogas technology minimises the risk of competing use of animal dung for fuel (Rijal, Chapter 17).

Before introducing new technologies, it is important to predict the impact on the economy and the environment. Bioeconomic models can be used to assess the combined impact of a number of technologies in space and time. Such models show, for example, that implementation of some of the present technologies without any constraints can increase farmers' incomes by 50%, but will at the same time increase soil erosion by 34%. Simulation studies recommend stratification to manage watersheds, increase income, and reduce soil erosion. Such stratification would involve agroforestry in the upper hills, zero grazing livestock production in the mid-hills, and intensive cereal production in the flat areas (Li-Pun and Mares, Chapter 2).

Policy issues for livestock development

In the HKH, past livestock policies were supply-driven with little consideration of the socioeconomic and resource-base conditions of the mountains. This resulted in many failures (Tulachan, Chapter 10). Li Pun and Mares (Chapter 2), Zinash Sileshi and Azage Tegegne (Chapter 7), Leon-Velarde et al. (Chapter 14), and Kaufmann and Mohamed Saleem (Chapter 15) all draw attention to the marginalisation of mountain livestock development policies. In all regions, governments have extrapolated the research and development strategies used in the lowlands to the mountains without due consideration of the mountain specificities. These policies were generally sectorally based and inadequate, and in many instances aggravated the production problems faced by smallholders. Thus all authors call for policies that will unleash participatory, inter-sectoral, and holistic approaches in the context of mountain/highland environments.

For the HKH, Jodha (Chapter 3) suggests a number of policy and programme interventions to avoid a backlash from unequal highland-lowland economic links. He suggests a number of policy options that will trigger creation of the necessary physical infrastructure and capacity building of the local communities, as well as institutional arrangements and federating arrangements for input disposal and output supplies (including price support). These changes would also help in reducing the marginality and vulnerability of mountain communities while enabling their participation in competitive markets.

The new policies in the East African Highlands (EAH) lean towards increased market orientation, privatisation or dismantling of state-owned interests in production and distribution, liberalisation of markets and trade, and an increased emphasis on issues of poverty alleviation and social needs. Nevertheless, they have still not been able to overcome major hurdles like problems related to access to credit services. In addition, in many of the EAH countries, such policies have only been partially implemented, and this has caused market distortions and created disincentives (Dijkman, Chapter 11).

Global trends in livestock demand and production point clearly to a strong potential for growth, especially in the developing countries. The questions are whether smallholder mixed farmers will be able to compete with growing industrial systems and participate in the domestic and global market, and what the particular constraints are facing those in the highlands. Policy-makers need to address small-scale production and marketing, poor access to livestock services and credit, policies that favour capital-intensive livestock production, and the growing commercialisation of livestock production (Staal and Jabbar, Chapter 4).

A sound policy backing is of utmost importance for any technology to be effective. For example, the benefits of dairy-draught technology cannot be realised unless the technology is supported by enabling policies that encourage farmers to invest in innovations. One example of such a policy is the promotion of biogas by subsidy schemes, which is justified by balancing the environmental benefits of biogas against the cost of environmental rehabilitation (Kaufmann and Saleem, Chapter 15).

The draught animal power (DAP) system has an essential role to play in the sustainable development of agriculture in mountain regions. In the HKH region, the policies related to DAP are inadequate. A sound ecozone specific DAP policy is necessary to support, promote, augment, and develop the DAP system (Singh and Partap, Chapter 16).

As mentioned above, the move towards economic liberalisation at the onset of the 1990s transformed many government policies in the Andean countries. As a result, many basic crops went out of production, land-use patterns were changed, and needed government activities were reduced (Estrada and Quiroz, Chapter 6).

One of the keys to effective policy-making is understanding the rationality of farming practices. Policy-makers trained in developed countries often overlook the value of farmers' practices. Policies are required that will empower mountain communities through participation, education, and information (Li Pun and Mares, Chapter 2).

Constraints to livestock production systems

The inaccessibility and ruggedness of mountain areas are well recognised as physical constraints, but there are other less well-understood constraints. Human disregard for mountain specificities results in a blanket approach to providing solutions which does not meet the need to improve farmers' welfare. One of the characteristics of the mountain region that enriches its diversity but is a constraint to livestock production systems is its heterogeneity. The heterogeneity of mountain regions impedes the transfer of technology from one region to another (Leon Velarde et al., Chapter 14).

Shortage of animal feed and the lack of adoption of technologies to improve feed production in monocultures or in association with other crops is seen by some as one of the key constraints in the livestock sector (Dijkman, Chapter 11;Tulachan, Chapter 10). Although local agricultural research institutes and universities have a history of research into feed resources, most investigations have been conducted at localised sites and the impact of this research on feed resources in general has been limited.

E-conference contributors draw attention to the presence of anti-nutritional factors in highland vegetation as a fodder problem. Specific reference is made to the tannins present in many trees that have a negative influence on protein digestion. Tree fodder is an integral part of feed in many highland/mountain areas.

The low returns that farmers receive from investments on livestock are another constraint to the development of livestock production systems. The low price of milk has been seen as a disincentive for smallholder dairy farmers in the HKH (Tulachan, Chapter 10).

Broad regional studies and case studies in East Africa show that livestock production is particularly constrained by market and spatial factors. These constraints are likely to become even greater as a result of the high costs of infrastructure and risks of disruption. Selected case studies show that the primary constraints to livestock production in highland and mountain areas are remnants of restrictive policies and regulations, high transaction costs as a result of poor infrastructure and information systems, and poorly developed markets for inputs and outputs. These case studies also show that recent reforms have eased some of these constraints with good results for both producers and consumers. Further reform and investment in supporting infrastructure, including farmer group development, can help provide good growing opportunities for smallholder livestock producers in highland systems (Staal and Jabbar, Chapter 4).

Inadequate veterinary services and health care are a general and serious problem for the development of the livestock sector (Dijkman Chapter 11; Tulachan Chapter

10). In the highlands of South Africa, the withdrawal of subsidised extension and veterinary services has not only affected animal health but also the adoption of technologies (e-conference, Chapter 9).

Efficient use of DAP needs to be supported by developing suitable implements. Lack of new, efficient, and site-specific equipment can be a constraint to realising the full benefits of DAP (Singh and Partap, Chapter 16).

Other constraints include lack of methodologies for integrating research results into technological alternatives, inappropriate incorporation of socioeconomic aspects into the technology development and transfer process (Leon Velarde et al., Chapter 14), and irrelevance of technological innovations to farmers' needs (Kaufman and Saleem, Chapter 15).

Livestock research and development issues

Mountain areas are characterised by some specific features that distinguish them from the plains; we call them 'mountain specificities'. They include limited accessibility, a high degree of biophysical (and social) fragility, marginality, and diversity, and specific niche opportunities—including human adaptation mechanisms. These mountain specificities and their implications for livestock production systems need to be taken into consideration when addressing livestock issues in mountain areas, in particular the potential for development (Jodha, Chapter 3; Tulachan, Chapter 10). The main challenges to livestock research and development (R&D), however, result not from these specificities but from shortcomings in government policies related to institutional and environmental undertakings to market economic technological changes.

Successful development of the livestock sector, particularly market-oriented livestock production systems, requires that everyone involved is aware of mountain specificities, gender issues, and the marginality of farms and livestock farming (Jodha, Chapter 3; Tulachan, Chapter 10). Whereas the socioeconomic circumstances in mountain areas (demographic and institutional) are changing rapidly, the key biophysical condition of these areas has remained broadly unchanged. New developments must be sensitive to these unchanged conditions or they may not prove environmentally and economically sustainable in mountain areas. The complexity and heterogeneity of the different agro-ecological zones need to be recognised and taken into consideration when formulating policies. This heterogeneity is the prime obstacle to the transfer of technologies from one region to another. It is also important to recognise that diversified and inter-linked resource-based activities are a key attribute of sustainable production systems in mountain areas and that R&D has an important role to play in ensuring the continued success

of such systems (Jodha, Chapter 3). If all these constraints are taken into account during the initial design of an R&D programme, there is considerable potential for increasing the sustainability of crop-livestock productivity and household income (Leon Velarde et al., Chapter 14).

Agricultural research previously focused on improving animal and crop productivity independently; in the seventies and eighties it was recognised that crops and livestock interact and must be considered jointly to optimise overall farm performance (Kaufman and Saleem, Chapter 15). More recently it has been recognised that research has to go well beyond farm boundaries to ensure positive impacts on poverty alleviation, natural resource management, and protecting the environment. Developing new holistic initiatives is a challenge for the people working in R&D, however. It not only requires changes in the training of such people around the world, it also requires a clear understanding of the external forces prompting the change (e-conference, Chapter 9).

Scientific communities also need to make research more relevant to the problems of smallholders (Kaufmann and Saleem, Chapter 15). One way of addressing these problems would be through farmer organisations that create better bargaining power and allow the vertical integration of activities (Staal and Jabbar, Chapter 4).

Notwithstanding improved accessibility and market links, the dependence of livestock on local resources will continue to be an important factor. Hence, conservation and efficient use of these resources, including such things as recycling and reprocessing, needs to be an integral part of the management of livestock production systems. R&D efforts should be focused on these aspects and on improving upon traditional methods. With support from institutions, R&D can play an important role in ensuring the efficient use of scarce resources, the quality of animals, and the most effective composition of animal holdings (Jodha, Chapter 3; Staal and Jabbar, Chapter 4).

There is a need to formulate simple and integrated programmes that have multiple functions (from extension to the effective marketing of products) and emphasise the use of local resources to decrease reliance on imports. For example, full utilisation of the genetic variation of local animals needs to be considered in multipurpose production systems before resorting to introductions (e-conference, Chapter 9). Also, research and development programmes should be directed to encouraging and empowering local people to retain their unique genetic livestock resources in these ecologically fragile but globally important mountainous environments (Valle Zarate, Chapter 5).

Zinash Sileshi and Azage Tegegne (Chapter 7) describe three broad themes important for future research in the African highlands: sustainability of the crop-livestock production system, which includes improvement of feed resources, animal traction, nutrient cycling and management, health management at the farm level, and options for diversification of animal power; improvement of market-oriented smallholder production, which includes development of a feeding package, appropriate breeding schemes and recording systems, efficient processing and handling methods, health management and delivery services, health standards for export of meat and animals, policy and institutional adjustment, and marketing; and conservation and utilisation of animal and forage genetic resources, which includes characterisation and evaluation of genetic resources and selection of animals for resistance to diseases and parasites.

Leon Velarde et al. (Chapter 14) point to the need to develop methodologies for integrating research results into technological alternatives to solve the different problems encountered in the Andean region. Characterisation of agro-ecosystems across the region is needed, rather than a localised analysis, to support the sustainable use of the natural resources. There is a need to shift to a holistic approach in research and development activities with participation by a group or consortium of institutions. In one such existing consortium, the Consortium for Sustainable Development of the Andean Region (CONDENSAN), institutions from both the government and private sectors work together to promote sustainable food production without a concomitant deterioration in natural resources and sufficient to cope with population growth (Leon-Velarde et al., Chapter 14; Li Pun and Mares, Chapter 2).

The prerequisite to the successful introduction of new approaches is to ensure participation of local communities from the very beginning. This means participatory planning, community participation with all stakeholders involved from the start. It is particularly important that women are fully included in these planning exercises, and that their unique skills and knowledge are recognised. For effective community development, it may be necessary to show the obvious benefits of what is proposed before people are convinced. This requires specific strategies that need to be worked out well in advance. Future generations should also be involved; one way of realising this could be through educational and curricular changes (e-conference, Chapter 9).

Dijkman (Chapter 11) stresses the need to generate information that can be turned into simple messages for easy communication between extension services and farmers and in a form that allows farmers to take a more active part in the evaluation of alternative strategies. Dairy production messages can be a useful entry point because of the many advantages that dairy has, including a means of constant income for farmers (Li Pun and Mares, Chapter 2).

In the HKH region, the best approach to improving milk production in smallholder dairies is thought to be through reducing the actual numbers of animals whilst improving the quality of the remaining animals and of the feed supply. The major challenge is to increase production whilst avoiding environmental and natural resource degradation (Singh et al., Chapter 18). Leasehold forestry in areas between 500 and 2000 masl, possibly integrated with community forestry programmes, has been suggested as a potential means of improving feed supplies. In both Ethiopia and Bolivia some farmers have developed an integrated food/feed system to improve feed supplies in which weed species are allowed to grow with cereal crops to increase biomass production (e-conference, Chapter 9). Research is needed to facilitate transferral of this system to other regions. Tashi (Chapter 13) calls for improved forage production technologies associated with marginal cropland to increase the feed production in Tibet, and the introduction and expansion of forage crops such as oats, peas, and alfalfa.

There is a need to promote private sector involvement to improve animal health services (Tulachan, Chapter 10) as already practised in countries like Kenya and Tanzania (Dijkman, Chapter 11). There is also a need to preserve and promote ethno-veterinary practices so that farmers are less dependent on conventional veterinary services (e-conference, Chapter 9). Tapping of tannin and other toxins contained in fodder is another challenge for researchers (e-conference, Chapter 9).

Attention should be paid to creating the necessary physical infrastructure, including processing and marketing facilities. Institutional arrangements like local ownership of local commons, group action, arrangements for input disposal and output supplies (including price support), and capacity building of local communities will help in reducing the marginality and vulnerability of mountain communities while facilitating their participation in competitive markets (Jodha, Chapter 3).

Economic liberalisation in the Andes has not produced the desired effects. Estrada and Quiroz (Chapter 6) outline some options for identifying production niches where mixed crop-livestock production systems are the best means of generating employment. Mere assessment of biological, economic, and environmental efficiency may be insufficient. Formation of strategic alliances with the private sector is a possible mechanism to help government and producers finance system changes. Consumers should be encouraged to pay for environmental damage.

At the onset of the new millennium, R&D should focus on the use of information systems to facilitate extrapolation of knowledge from one region to another. Tools such as geographic information systems (GIS), modelling, and information and communication technologies, as well as methods such as participatory research and development, should be used to make assessments and recommend solutions for many problems. Building

partnerships among the different institutions working in the field of livestock is critical to addressing regional and global issues (Li Pun and Mares, Chapter 2).

Prospective studies need to be conducted to support sustainable mountain development. The studies should develop scenarios, and also indicate the consequences, for both mountain and lowland people, of a failure to implement. Researchers and development agents should aim for a win-win solution (increased household income and improved human welfare in mountain/highland areas whilst ensuring the sustainability of common property resources) through raising public awareness about costs and benefits in social, economic, and environmental terms. This is the major challenge for research and development in the livestock sector.

Working Group Sessions and Recommendations

Four parallel working group sessions were held on the third day of the symposium covering four thematic areas related to livestock R&D (see Annex for details of the participants). Participants were asked to put their ideas in writing as well as making contributions to the discussion and both verbal and written contributions were collated by the facilitators. Each group identified the primary issues in its thematic area and made recommendations for future action. The results were presented and discussed at a plenary presentation session. The main points from each group are summarised below.

Topic 1: Livestock production systems and participatory approaches to natural resource management – R&D challenges

The major issues related to this theme were identified as conservation of the natural resource base, poverty alleviation, food and economic security, and gender and equity. Livestock can make a considerable contribution to improving food security and generating income. To safeguard this potential, livestock R&D should focus on understanding the vulnerability of livestock production systems and the external forces that impinge on these systems. Making R&D services more effective and efficient is crucial to livestock development. The group developed suggested action plans and identified desirable activities related to three priority issues.

Priority Issue 1: Rationale and social, economic, and environmental vulnerability of livestock production systems

Objectives

1 To identify key social, economic, and environmental indicators related to livestock production systems and the external forces affecting them
2 To identify any interaction between these indicators in order to assess the social implications of environmental change and the 'trade-offs' involved

Activities

1.1 Selection (random) of a mountain/highland area to be surveyed

1.2 Conduct survey in the area using questionnaire and PRA techniques to identify indicators of social, economic, and environmental change.

1.3&2 Process and analyse the data from the survey of social, economic, or environmental importance.

Priority Issue 2: Generation of socially equitable and environmentally sustainable technologies and strategies

Objectives

1. To generate appropriate technology packages to increase the livestock productivity in specific regions
2. To increase the food and economic security of mountain people

Activities

1.1 Identify the key problems that affect livestock production systems

1.2 Review research findings that address these problems

1.3 Call for necessary research to be performed within a clear time frame into the diversification of livestock resources, feed resources and feeding strategies, animal diseases and strategies to control them, diversification of the use and management of animals (including creation of appropriate harnessing implements), the environment and the effects of global warming

1.4 Test technology packages at the farmers' field level and make recommendations

1.5 Perform simulations of the package for different locations to cover all ecozones

2.1 Create awareness of the new technological packages among rural people

2.2 Support empowerment of farming communities through in situ and ex situ training and visits with emphasis on involving women

2.3 Timely delivery of technical input and services

Priority Issue 3: Improvement of linkages between farm research and livestock services

Objective

1. To make research and development services more output oriented

Activities

1.1 Joint planning, execution, and evaluation of research and development programmes by all stakeholders
1.2 Identification of the appropriate roles of different stakeholders (private and public sectors) to avoid duplication of activities
1.3 Capacity building for sustainable mountain development through empowerment of all stakeholders including farmers
1.4 Identification of most effective and efficient livestock services and their delivery systems

Topic 2: Post production processes (processing, marketing, and consumption) – R&D challenges.

The group identified two essentially different approaches to the improvement of post-production processes: improvement based on realistic practices built on existing knowledge and technology; and improvement based on understanding the role of structural and institutional factors and policies. Product diversification, market development, appropriate policies and planning, and human resource development are the key areas that livestock R&D needs to address to enhance post-production processes. The suggested action plans are summarised below.

Issue 1: Processing and product diversification (technology and economics)

- Appropriate processing technologies and local products at local and community level
- Diversification and value addition on various scales and through packaging

Objectives

1. To promote production diversification
2. To identify, improve, and promote local processing technologies appropriate to indigenous products
3. To establish the scope of diversification and value-added production

Activities

1.1 Identification and refining of processing technologies

2.1 Develop inventory of available, local processing technologies and products
2.2 Assess appropriateness, economic viability, and need for improvement
2.3 Select most promising and adapt or improve technologies

2.4 Promote and popularise through training, workshops, seminars, and similar
2.5 Conduct activities related to monitoring, evaluation, and feedback

3.1 Develop inventory of value-added livestock products in markets and assess supply and demand
3.2 Assess economic viability of selected products
3.3 Disseminate information to entrepreneurs and manufacturers

Issue 2: Market development

- Cooperatives and support services
- Market promotion
- School milk production schemes
- Market information services
- Infrastructure: processing, transport, storage, and others

Objectives

1 To identify and understand the existing marketing system(s)
2 To develop a market infrastructure: processing, transport, storage, and information services
3 To encourage cooperatives and farmers' associations
4 To promote consumption of livestock products

Activities

1.1 Studies/surveys on existing dairy marketing
1.2 Identification of gaps
1.3 Development of strategies to address the information gaps
1.4 Based on findings and results, identify needs and opportunities
1.5 Conduct socioeconomic survey to understand feeding habits, affordability, health consciousness, and other factors in the communities

2.1 Develop inventory of existing marketing infrastructures; identify needs and opportunities
2.2 Establish sustainable interventions in livestock market infrastructures with donors, governments, and the private sector
2.3 Establish livestock marketing information systems and a monitoring database and disseminate

3.1 Identify cooperatives and farmers' groups and associations involved in livestock marketing; identify needs and opportunities

3.2 Assist and promote institutional development of cooperatives and farmers' groups and associations (training needs)
3.3 Provide logistical support to cooperatives and farmers' groups and associations
3.4 Study consumption patterns and preferences

4.1 Promote livestock products through generic campaigns
4.2 Assess the market for product diversification possibilities, e.g., mid-day milk with flavour for school children

Issue 3: Policy and Planning

- Regulation of quality and standards of products
- Animal waste management
- Policy support for local processors/markets
- Prices
- Incentives and subsidies

Objectives

1. To review and provide recommendations on policies for regulation of quality and standards, and to extend policy support to
- local processors and markets
- price incentives and subsidies
- animal waste: utilisation and disposal

Activities

1.1 Policy on regulation of quality and standards
- Review policies on regulation of quality and standards
- Provide recommendations with an action plan to enforce implementation

1.2 Policy on markets
- Study the effects of existing and alternative policy options (price incentives, licensing, import duties, subsidies, animal waste, and others)
- Recommend policy options that support local processors and markets

Issue 4: Training and human resources

Improving capacity for assimilating and disseminating technology
- Quality management
- Marketing and promotion

Objective

To provide need-based training programmes on

- processing and technology development
- ensuring quality management
- marketing and promotion
- developing sound research and development plans

Activities

1.1 Assess human resource development systems and facilities; identify needs and opportunities

1.2 Develop sound human resource development plans (training and facilities)

1.3 Strengthen institutions and facilities

1.4 Provide need-based training at multiple levels

1.5 Create awareness about quality management and its importance

Topic 3: Livestock biodiversity and conservation

Protecting genetic diversity was agreed to be an important task for the sustainability of ecosystems. Conservation of the indigenous knowledge base is equally important for the preservation of livestock diversity. Thus the foremost task for researchers is to assemble knowledge, including indigenous knowledge, on the livestock diversity in different agro-ecological regions. The suggested action plan on livestock biodiversity and conservation is summarised below.

Research Theme: Livestock biodiversity and conservation

Objectives

1. To identify livestock diversity in mountain/highland regions in relation to plants, ecosystems, and people
2. To conserve and use livestock diversity by matching it with agro-ecosystems using an interdisciplinary, hierarchical, and holistic approach

Activities

1.1 Synthesise the state of available knowledge about livestock diversity in different ecosystems and establish an inventory of livestock diversity in the regions

1.2 Carry out a survey of the characterisation and population status of each livestock genotype through participatory action research based

on four hierarchical components (genetic, ecological, socio-cultural-economic, and policy)

2.1 Formulate and execute a conservation policy act and regulations on livestock diversity related to livestock breeding and selection and mobility
2.2 Implement conservation and utilisation programmes for indigenous animal genetic resources that are at risk or on the verge of extinction in specific pocket areas using a participatory farmers' group approach with selective breeding schemes
2.3 Evaluate the influence of land-use trends on livestock diversity (locally and comparing across regions) by remote sensing/GIS, PRA, ecological assessment, and a description of resource use efficiency (commonly called the 'agro-ecosystem approach')
2.4 Analyse the sociocultural-economic aspects of livestock breeding to look at the demographic pressures resulting from market, transportation, and settlement policies

Topic 4: Livestock policy issues

Sound policies are the key instrument needed to further livestock development efforts and are vital for the improvement of livestock-based livelihoods. Sound policies are needed in the areas of marketing of livestock and livestock products, credit services, and institutional strengthening and other capacity building. Consultation with farmers and local communities is indispensable for the formulation of sound policy. The suggested action plans for the development of sound policies are summarised below.

Issue 1: Market-oriented livestock production

Objectives

1. To assess the environmental impact of livestock intensification
2. To develop and promote sustainable market-oriented livestock production systems

Activities

1.1 Select representative sites in mountain regions in the Andes, Africa, and HKH
1.2 Quantify the bioeconomic, social (including human drudgery), and environmental impacts of livestock maintained in pastoral, crop-livestock, and more intensive management systems

1.3 Assess the bioeconomic, social, and environmental impacts of alternative market-oriented systems

2.1 Design and validate alternative market-oriented systems
2.2 Develop policy options to promote the conservation of existing, sustainable production systems
2.3 Promote the use of improved livestock-based systems
2.4 Monitor and evaluate the improved livestock market-oriented systems
2.5 Promote the exchange of experiences and lessons across different mountain/highland regions

Issue 2: Credit and investment

Objectives

1. To promote cottage, small, and medium-scale industries in the livestock sector and diversify sources of income
2. To promote diversified and intensified livestock production systems
3. To create sources of employment and alternative livelihood possibilities
4. To compensate mountain communities for their role in conserving the environment

Activities

1.1 Form credit groups
1.2 Mobilise rural savings
1.3 Simplify credit delivery systems
1.4 Formulate policies for the promotion of livestock industries
1.5 Create more favourable credit and investment policies for smallholders

2.1 Develop inter-linkages between the crop, livestock, forestry/agro-forestry, silvipastoral, and horticultural sectors
2.2 Explore possibilities for integration within the livestock sector like poultry-pigs-fish and pigs-pasture-cattle/buffalo
2.3 Encourage use of terraces, terrace risers, and bunds to produce additional forage

3.1 Explore location-specific alternative sources (other than livestock) of household income like papermaking and plantation or collection and marketing of herbal and medicinal plants that can employ inefficiently used labour

3.2 Provide additional information on hotel management and tourism

4.1 Allocate some portion of earnings from tourism and the hotel business exclusively to the mountain/highland region as a substitute for compensation (policy strategy)
4.2 Although headwater resources are maintained by highland/mountain people, the greater part is normally harvested by lowland people. Earnings from water tax could be shared by the highland/mountain region (policy strategy).
4.3 Promote investment support for strategic partnerships between the private sector and small farmers
4.4 Ensure the equitable sharing of the benefits from such partnerships

Theme 3: Trade and regional integration

Objective

1. To augment trade and regional integration

Activities

1.1 Assess the status and emerging trends in the livestock sector and formulate policy options
1.2 Study the local impacts of global trade
1.3 Develop policies for strengthening highland-lowland integration
1.4 Promote understanding of the impact of present trade policies on smallholders to enable them to be more competitive

Theme 4: Institutional strengthening and capacity building

Objective

1. To enhance institutional strengthening and capacity building

Activities

1.1 Strengthen livestock development institutions such as the International Potato Center (CIP) and CONDENSAN in the Andes, ICIMOD in the HKH, and ILRI and the African Highlands Initiative (AHI) in the African highlands, and NGOs, farmers' associations, and local communities so that they are better equipped to support participatory, equitable, and gender sensitive smallholder activities
1.2 Promote private sector participation in livestock R&D
1.3 Officially exchange information with governments, and promote activities to locate and mobilise funds for development projects

Pokhara Call for Action

The three days of discussions and deliberations culminated in the formulation of the 'Pokhara Call for Action'. This declaration is intended to form the basis for livestock research and development in the early years of the new millennium. The text is shown in the box. The Pokhara Call for Action was approved by the plenary.

POKHARA CALL FOR ACTION ON THE ROLE OF LIVESTOCK IN SUSTAINABLE LIVELIHOODS IN MOUNTAIN AND HIGHLAND AREAS

Mountain and highland ecosystems are found on every continent and sustain an estimated ten per cent of the world's population. In addition, several billion people living in the lowlands depend on these ecosystems for food and other resources such as water, raw materials, and energy. These areas are also important sources of plant and animal diversity, both wild and domestic. In the past few decades, environmental changes and rapid increases in population density in these highland and mountain areas have meant increased problems for planning effective resource management strategies. Despite the increased importance of these areas and the global recognition they received after UNCED in 1992, many highland/mountain communities continue to live in poverty, and in many countries they are still socially, economically, and politically marginalised.

Livestock are of particular importance in highland/mountain farming systems. They provide direct tangible benefits such as food, fibre, and draught power, as well as the indirect benefit of converting crop residues and other plant biomass into useable nutrients, the key to sustaining smallholder mixed farming systems. They also provide people with a secure form of investment, assets, and a protection against risk. In addition, livestock can enhance biodiversity across the landscape, and can help to balance social inequities, especially for women and the landless.

Changes in world food production and consumption patterns have opened up favourable new opportunities for livestock-dependent people. However, the absence of appropriate infrastructure, technologies, support services, and enabling domestic policies has impeded the expected production increases in many nations.

Rural and particularly urban populations are expected to maintain their growth, thus constraints directly related to the intensification and commercialisation of animal agriculture are likely to increase. Strategies are therefore required to ensure food security for a growing population, to increase income, to promote social equity, to support economic development, and to protect the environment.

Representatives of research, development and donor institutions from the major mountain regions of the world participated in an International Symposium on

"Livestock in Mountain/Highland Production Systems: Research and Development Challenges into the Next Millennium", held from 7 to 10 December 1999, in Pokhara, Nepal.

After four days of deliberations, participants agreed upon the following.

- To prepare a global research and development agenda to improve livelihoods in livestock-dependent mountain and highland communities which emphasises the understanding of the dynamics of evolving livestock production systems, the strengthening of appropriate technologies and strategies, and the contribution of policies and capacity building that link R&D, and focuses on:
  a. utilisation and conservation of production resources,
  b. sustainable market-oriented livestock production systems,
  c. post-production processes, and
  d. trade and regional integration.
- To prepare a livestock agenda for incorporation into the framework for the International Year of the Mountains in 2002
- To encourage collaboration across the different mountain/highland eco-regions
- To encourage governments, and donor and funding agencies to give higher priority in national and international development agendas to the gender-balanced participation, empowerment, and property rights of livestock-dependent mountain and highland populations
- To encourage research and development organisations to undertake activities to improve livelihoods in livestock-dependent communities in mountain and highland eco-regions

Livestock in Mountain Livelihoods

Part Two

Chapter 2

The Sustainable Development of Mountain Regions: A Paradigm Shift and New Considerations

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Introduction

At present society, and especially decision-makers, still appear not to be paying sufficient attention to the development of mountain ecosystems. After the Rio Summit it became clear that we need not only to pay much more attention to the mountains but also to follow up with concrete actions the agreements made in Chapter 13 of Agenda 21 (UNCED 1992). Researchers have organised a number of initiatives. Initially the focus was on linking efforts on a regional basis. Thus the consortium CONDESAN was successfully organised for sustainable development of the Andean ecoregion, and the East African Highland Initiative for the African highlands. Later the interregional 'Global Mountain Forum' was organised through a series of meetings involving NGOs, donor agencies, and other stakeholders. Although the scientific community has been active in following up previous agreements, there is still a need to promote a more concerted approach involving all stakeholders if effective efforts are to be made to ensure the sustainable development of mountain regions. In this paper, we describe the reasons for the urgent need to dedicate substantial research and development efforts to mountain areas, and discuss some of the collaborative research in which ILRI is currently playing a major role. The paper focuses on three topics:

- the sustainable development of mountain ecosystems, key issues, and challenges;
- some research and development experiences, with particular reference to the collaboration between ILRI and ICIMOD, CIP, farmers' associations and NGOs; and

- identification of some appropriate issues for R&D in sustainable mountain development.

The Sustainable Development of Mountain Regions: Issues and Challenges

Mountains and highlands are among the most important, but also neglected, ecosystems in the world. Some 10% of the world's population lives in mountain areas (UNCED 1992, Chapter 13), more than half of these in the Hindu Kush-Himalayas, Andes, and African Highlands. Survival of these people and the cultures they represent is dependent on the effective management of the natural resources in the mountain ecosystems. At the same time, this natural resource management affects vastly more people than those just living in the mountains. More than half the world's population is dependent on mountain resources in some form. Mountain and highland areas are a source of food and other agricultural and livestock products, and of water, energy, timber, and mineral resources, as well as being a major repository of the world's biodiversity.

Mountain ecosystems have certain characteristics resulting from their topography and altitude. In the Andes these have been described as follows (Tapia 1996).

- *Complexity* — mountain ecosystems are complex, in the Andes alone six sub-regions and eighteen ecological zones can be found in the area above 1,500 masl.
- *Diversity* – of the 103 life zones that exist in the world, 60 are present in the Peruvian highlands, indicating the enormous diversity of mountain ecosystems.
- *Lack of accessibility* — mountain regions generally have poor access and act as barriers to the transit of people and goods. This lack of accessibility is related to their high altitude and difficult topography, which hinder the development of transport infrastructure such as roads, railways, and airports.
- *Fragility* — mountain ecosystems are often fragile and particularly prone to soil erosion.

These characteristics are not limited to the Andean Region, rather they are typical of all mountain areas. The problem of soil loss, for example, is common to all mountain areas. In the East African Highlands of Ethiopia it is estimated that about 2.5 million cubic metres of soil is lost per annum. If this trend continues, over one-third of the farmland, belonging to 10 million farmers, will be denuded by 2010. The loss of soil is aggravated by the removal of manure, which is used as fuel for cooking purposes, which in turn contributes to loss of soil fertility. Lack of alternative energy sources for cooking such as electricity or gas, is another critical issue, in Ethiopia as elsewhere. The result of this soil erosion and loss of soil fertility is that agricultural production in Ethiopia is decreasing by 3% per annum, at a time when the population is

increasing by 2.9% per annum. This is a dramatic situation, and one indication of why we need to pay more attention to mountain ecosystems.

Another important characteristic of mountain regions is 'marginality', and marginalisation of the inhabitants. Policy and decision-makers based in lowland areas frequently ignore the needs of the highlands, which are often regarded as backward and unimportant. There is often a tremendous inequity between the incomes of people in the highlands and lowlands, even in countries where poverty is prevalent in all areas. Thus the per capita annual income in the Peruvian highlands is 200 dollars, whereas the national average is 1,200 dollars. In Ethiopia, where most people live in the highlands, the average annual per capita income is only 100 dollars. In Asia, some of the poorest people of the world live in the mountains. In China, 100 million people living under the absolute poverty line are inhabitants of mountainous regions. There is a negative cycle linking natural resource degradation, low agricultural productivity, poverty-driven migration, malnutrition (in particular of women and children), limited education, and poor health which can lead to social disruption and political violence, as witnessed in several Andean countries and elsewhere. It has been estimated that 22 of 34 major armed conflicts during the last 3 years involved people living in mountain areas. Sustainable mountain development is a *sine qua non* for breaking this negative cycle and incorporating mountain regions and people into the mainstream of national and regional development.

The importance of gender issues in mountain regions has been stressed by many observers. It is estimated, for example, that in the Andean countries women produce, process, or sell up to 80% of all food. Gender issues are also important in the context of the role of livestock in mountain systems. Livestock are not only important in terms of food and fibre or wool production, they have multiple functions, many of which are particularly important for women, children, and the aged. Livestock not only provide protein and energy, they are a source of micronutrients like vitamins A and B_{12} and zinc and iron required by pregnant women and children for the normal development of learning abilities. Raising livestock is also one of the main ways in which the poor, and particularly women, can build up assets and savings to finance education, medical care, and other important household requirements. Livestock are also important for the recycling of nutrients (through the use of manure), as well as providing power for traction and a means of transport in the absence of roads and airports.

Quite frequently, research and development endeavours have failed as a result of using a sectoral and top-down approach. Holistic, multidisciplinary, participatory approaches are required. One of the key requirements of any approach is to understand the rationale of the peasants and farmers in the area targeted, which may

frequently appear to be in conflict with common academic knowledge. Failure to understand can lead us to make big mistakes in trying to improve traditional systems. For example, on first view the common practice of farmers in the Andes of cultivating down a slope and sowing a large mixture of low-yielding local potato varieties in a single plot appears technologically unsound. Academic wisdom suggests cultivating across the slope and sowing high-yielding varieties. On closer examination it is clear that the farmers' strategy is primarily concerned with reducing the high and somewhat unpredictable climatic risk by cultivating along a temperature gradient and spreading frost and moisture stress using varieties with a different stress resistance in the same plot. Once we understand what people are doing and why, we are in a better position to propose improvements. Understanding of the farmers' rationale is best achieved by using a truly participatory and unprejudiced research approach.

It is also important to realise that we quite often try to solve problems by introducing technology options without paying attention to promoting an enabling environment for these technologies. Technologies are important, but so are appropriate policies that enable the sustainable development of mountain regions.

Some Research and Development Experiences

Vertisols (heavy clay soils with very poor drainage) cover 43 million hectares of the East African Highlands. These mountain regions have high agricultural potential but the actual productivity is very low, the land is under utilised because the soils are waterlogged for several months a year so that the growing season is short and late. Cultivation is difficult, the manual labour involved creates tremendous drudgery for women and children. ILRI has been working together with the Ethiopian Agricultural Research Organization (EARO), Alemaya University, the Ministry of Agriculture, the NGO Global-2000, and ICRISAT to improve the management of this heavy clay soil. Some successful implements have been developed, such as the broad bed maker currently used by several thousand farmers. With this implement, drainage is improved and waterlogging is reduced, allowing early planting and an extension of the growing season. Yields of wheat and other grains have increased by 50-100% and two crops per year can be grown. In addition, soil conservation and fertility is improved – the better soil conditions allow legumes to fix between 50-155 kg N per ha per year – and erosion is reduced. A further advantage is that more crop residues are available as feed for livestock, an increase of 150% in the areas studied. It seems likely that the same technology can be used in similar areas in the Andes, although this has not yet been tested. This would represent a case of trans-regional technology application.

The impact of new technologies on human nutrition and health is a priority concern. In Ethiopia, ILRI has shown that households that have introduced improved cross-

bred animals have better nutritional levels, particularly of women and children, than those that have kept the traditional local cows. The evidence is provided by the existence of a reduced incidence of xeroftalmia as a result of higher intakes of Vitamin A, and fewer cases of diarrhoea in children. The improved nutrition results from the fact that more milk is produced by the crossbred cows and the women use this to increase household milk consumption and not simply to increase milk sales.

Improved nutrition does not always follow as a result of the introduction of new technologies, however, it is also necessary for informed decisions to be taken by the family, particularly the women. In Kenya a recently completed adoption study on the use of crossbred cows in the coastal region showed that households with crossbred cows had an additional income of 50 dollars per cow per month, but there was no effect on nutrition as most of the additional production was sold not consumed. Crossbred cows do not create additional labour demands for women and children. But the results suggest that educational nutrition programmes, particularly oriented to women, should be used to make people aware of the benefit of using some of their increased production to improve household nutritional status.

Recently ILRI has started a project on Agro Ecosystems Health, funded by the International Development Research Center, Canada. The project uses a participatory approach to link human needs, agriculture, and the environment. It is implemented jointly with EARO, the Ethiopian Health and Nutritional Research Institute, and various NGOs and farmer communities. It is being conducted in two watersheds in Ethiopia. The project links natural resource use with crop production, livestock production, and agro-forestry. A mathematical simulation model is used to predict the economic output of technologies, the impact on income and nutrition, and environmental impacts such as nitrogen fixation and soil conservation. Preliminary results provided by running the model without constraints indicate that current technologies can increase farmers' income by 50% but at the same time would increase soil erosion by 34%. One practical recommendation from this study is that stratification of the watershed should be used to enable incomes to be increased while at the same time reducing soil erosion. Such a stratification of land use would involve agroforestry in the upper hills, livestock production without grazing in the mid-hills, and intensive cereal production in the flatlands. This type of watershed stratification has to be based on both community organisation and policy intervention. Credit is one of the key elements in this particular scheme, it is needed to make sure that farmers have access to the improved technologies.

Some other initiatives have been implemented in other mountain areas. One such is the CONDESAN initiative in the Andean Region, which is coordinated by the International Potato Center (CIP) with strong participation by ILRI as a partner.

CONDESAN is a consortium of about 50 research and development institutions covering a wide range of partners, including international centres, national programmes, NGOs, universities, local authorities, and farmers' associations. A main theme of the CONDESAN agenda is the improved management of natural resources in the Andean eco-regions. One of the methodological approaches used is to combine social and biological sciences to improve understanding of the diverse land use systems and to propose improvements. Consultation round tables are organised with the different stakeholders in order to identify the problems and opportunities and the type of collective action required. CONDENSAN uses computer simulation models in order to assess the feasibility of proposed interventions and the potential biological, economic, social, and environmental impacts. An important aspect of its work is the analysis of policy and technology issues. The research agenda includes studies on the use of credit, on nutrient cycling in crop-livestock systems to improve soil fertility, on the reduction of the risks resulting from climate variability, and on forage availability and milk production. Some of the strategic research makes use of computer-based simulation models for *ex ante* impact analysis. The results of these analyses provide the inputs for policy research such as those related to the use of credit to promote increases in milk production and sales, household incomes, and farm assets. As an example, these studies have shown that use of a revolving credit scheme makes it possible to double the milk production per cow per day with a credit recovery rate of 92%. This information is currently being used for development projects in Ecuador.

ILRI is collaborating with several other international centres in research and development projects in mountain ecosystems. Collaboration with ICIMOD started in 1998. One of the first studies initiated was the characterisation of livestock-based systems, followed later by a rapid appraisal of market-oriented smallholder dairies. The methodology developed by ILRI in Africa is being used in three countries in the Hindu Kush-Himalayas: Nepal, Bhutan, and Northern India. We have also conducted studies to characterise trends in crossbred animals in Himachal Pradesh in Northern India.

Some Issues for Research and Development for Mountain Regions

There is a general agreement that holistic approaches are needed for effective research and development, given the complexity of social, economic, and biophysical interactions. An additional issue that must be kept in mind is that empowerment of mountain communities is an urgent requirement for development. This empowerment can result from participation, education, and information. Participation is a key issue. Quite often we try to solve the problems of others, but

first the people concerned need to identify their own problems and aspirations and consider the possibilities for working together towards solutions.

Transport infrastructure is a key requirement in mountain regions because, without access to markets, development of mountain communities will be almost impossible.

Provision of services such as energy, education, and health is critical.

Policy and technology interventions are required. Experience indicates that technology alone is not enough to promote sustainable development. Policy interventions, some other off-farm solutions, and the development of alternative livelihoods for farmers should complement the introduction of new farm technology. Production to consumption approaches are required that include value-added activities such as agro-industries. We believe that dairy production is one of the best entry points to development because of the many advantages that dairy has in producing a constant income for farmers and improved nutrition.

It is also necessary to understand mountain-lowland relations. Mountain ecosystems produce goods and services and experience demographic and social processes that have a significant spill over effect on adjacent ecoregions. For example, we need to have a much better understanding of the causes and effects of migration. Economists like to think that migration is a way of reducing the pressure on mountain ecosystems, and they look at the economic value of generating additional income for mountain people. However, migration also has social costs as people are displaced to foreign environments. The interaction between regions has to be clearly understood in order to deal with problems at the root.

A wide array of new tools is available to help us in finding solutions for problems in mountain areas, and they should be employed to the full. These new tools include geographic information systems, computer-based modelling, information and communication technologies, and better methods for participatory research and development.

In order to define a crop-livestock systems' research and development agenda, it is important to characterise the mountain ecosystems, promote the trans-regional analysis of experiences, foster community organisation and empowerment, and include gender analysis. All stakeholders, both within and outside mountain regions, should be included in a participatory manner, for if we make the mistake of not taking into consideration all stakeholders we will miss the opportunity to take effective action.

Policy for natural resource management is also critical, and our view of some resources needs to be broadened for this. For example, the narrow view sees mountain grasslands as feed for animals and ignores the role that grasslands and rangelands play in conserving the environment and rendering environmental services. We have to pay much more attention to the role that mountain grasslands play in carbon sequestration, nutrient cycling, and water capture and conservation, as well as in biodiversity conservation.

We have to work much more on developing information systems for extrapolating knowledge from one region to another. One of our proposals is to build synergies among the different institutions attending this symposium. We should not recreate initiatives, we already have some initiatives that are working well and we should use and strengthen these to avoid diluting resources. The Global Mountain Program (GMP) co-coordinated by CIP is one large umbrella that we could use in order to define a joint programme of collaboration.

We should conduct prospective studies on sustainable mountain development. Developing scenarios to analyse the consequences of not initiating immediate action is a compelling way of prompting initiatives. These studies have to be aimed to reach decision-makers as well as investors in research and development to persuade them that unless we do something we will suffer consequences, and these consequences will affect the people in the lowlands as well as those in the mountains.

We have to be much more active in raising public awareness by informing people of the costs and benefits of action and inaction in social, economic, and environmental terms.

Finally, if we do not consider the points mentioned above, we will not be able to provide proper livelihoods for future generations. And we should not forget the importance of native cultures in the mountain regions.

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Chapter 3

Livestock in Mountain/Highland Production Systems: Challenges and Opportunities

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Introduction

Historically, livestock production systems have had a prime place in the economy of mountain and highland areas (in the following referred to simply as 'mountain areas'), because the features of livestock-crop mixed farming systems match to a high degree the constraints resulting from the specific characteristics of these areas (the mountain 'specificities'). However, the economic and environmental contributions and gains of livestock in mountain areas have been very much context specific. As the circumstances change, so does the extent to which these systems fulfil the local requirements. Increasingly, ecologically or biophysically driven livestock production systems are losing importance as a result of the changing, socioeconomically determined, circumstances in mountain areas.

This paper focuses on the role of, and ways to strengthen, livestock-based farming systems in the context of the changing socioeconomic circumstances in mountain areas. Livestock farming is described as a matching response to the features of mountain areas. The emerging trends in livestock production systems and the socioeconomic and biophysical environment influencing them are summarised. The paper concludes by advocating that the emerging positive trends in livestock production systems be identified and used as a basis for the transformation and sustainable development of livestock farming in mountain/highland areas. The focus is on livestock-crop mixed farming situations in areas with improved accessibility where the economic situation is gradually changing as a result of

market links. The paper mainly uses information and observations from the HKH region.

Mountain Specificities and Livestock Farming

Mountain areas are characterised by some specific features that we call 'mountain specificities'. They include limited accessibility, a high degree of biophysical (and social) fragility, marginality, diversity, and specific niche opportunities including human adaptation mechanisms. Table 3.1 summarises these features, the factors creating them, their manifestations, and the implications for human activities and resource-use systems, i.e., the imperatives they set in terms of the

Table 3.1: **Mountain specificities, their imperatives, and the matching attributes of livestock production systems in mountain/highland areas**

Mountain Specificities	Imperatives and Corresponding Features of Livestock Production Systems
1. Inaccessibility Origin: result of slope, altitude, terrain, seasonal hazards (and lack of investment to overcome them) Manifestation and Implications: isolation, semi-closed; poor mobility, high cost of mobility and infrastructures; limited extent and dependability of external links, trade, and supplies	Imperatives: production centred on local resources, diversified production/ consumption activities, local resource regeneration, recycling, focus on high-value and low-weight/volume products Livestock: user and regenerator of local resources; contributor to diversification, high-value-low-weight products, and mobility of products; supplier of services/products in an isolated context
2. Fragility and Marginality Origin: result of combined operation of slope, altitude, geological, edaphic, and biotic factors; (biophysical marginality creating socioeconomic marginality) Manifestations and Implications: resource vulnerable to degradation, suited to low intensity uses; low carrying capacity, low input absorption, offers limited, low payoff, risky options; poverty, livelihood insecurity, and subsistence-oriented economy	Imperatives: focus on low intensity, extensive type of land use; balancing conservation and production needs; diversification by mixed farming; local resource regeneration, recycling; risk reducing practices Livestock: contributor to fulfilling the above requirements; promoter and user of diversified activities; important source of inputs, income, insurance, and livelihood support for poor households; farming-forestry links
3. Diversity and Niche Origin: result of interactions between different factors ranging from slope and altitude to soils and micro-climates, well adapted vegetation and human practices Manifestations and Implications: a basis for spatially and temporally diversified and interlinked activities, favouring smaller over larger scale activities; source of niche products with a comparative advantage (e.g., timber, horticulture, hydropower)	Imperatives: focus on diversified resource use and products and services with a comparative advantage; integrated use of temporally and spatially variable resources and opportunities; human adaptations shaped by above Livestock: production systems as user and promoter of diversification and means of harnessing niche opportunities • High-value low-volume livestock products • Product mobility based niche micro-enterprises

Table 3.1: Mountain specificities, their imperatives, and the matching attributes of livestock production systems in mountain/highland areas (cont'd)	
Mountain Specificities	Imperatives and Corresponding Features of Livestock Production Systems
4. Human Adaptations Origin: sustenance strategies in fragile high risk, low pay-off production environment; two-way adaptations sustainable under low demand conditions Manifestations and implementations: temporally and spatially diversified, location specific complex of activities with strong multiple complementarities, local institutional arrangements, group action	Imperatives: promotion of resource use management systems facilitating adaptation of human needs to constraints and opportunities in mountain areas; balancing production and conservation needs. Livestock: production/management systems responding to the above imperatives through a range of multiple complementarities in which livestock play a key role.

response required to ensure productive and sustainable use of mountain resources.

The table shows that livestock production, as a part of mixed farming systems, offers several opportunities and options that match well with the imperatives of mountain specificities. For example, a key requirement resulting from the isolation imposed by limited accessibility is for diversified activities based on local resources and regeneration and recycling of these resources. Livestock within mixed farming systems help meet these requirements. The focus on high-value, low-weight/volume products, and movement of products through animal migration, are other features of the semi-closed mountain situation in which livestock play a key role.

Similarly, the fragility of mountain resources calls for a low intensity, extensive type of land use, and the combination of intensive and extensive types of land use. Resource regeneration and upgrading are other ways of combating fragility. Raising livestock as an integral part of mixed farming systems fulfils these requirements and if properly managed represents the best user of the fragile resources. The functions of livestock as a provider of energy (draft, fuel, nutrients) and of organic matter for crops are also well recognised.

Finally, diversification of resource use and production and consumption activities is a key requirement of sustainable resource use in mountain areas. Livestock can be both a promoter and user of diversified opportunities and production systems. Raising livestock is one of the diversification strategies used by farmers and contributes towards reducing risk and enhancing income and livelihood support. Livestock also offer certain niche opportunities for mountain areas and are an important component of human adaptation to diverse mountain conditions.

The above examples illustrate the high degree of convergence between the imperatives of mountain conditions and the features and functions of livestock production systems which have led to the prime position of livestock raising in mountain farming systems.

Livestock as a Facilitator and User of Multiple Complementarities

There is another more concrete way of understanding the crucial role of livestock in mountain resource management and production systems. This approach sees the sustainability of environmental resources and the security of community livelihoods in mountain areas as being facilitated by a range of 'complementarities' between different resource-use systems and their associated activities. Traditional livestock production systems have facilitated and harnessed these complementarities. In order to understand this aspect better it is useful to consider what is meant by the term 'complementarity'.

Broadly speaking, complementarity between two (or more) entities, activities, or resource-use systems implies a relationship in which conditions such as the following are fully or partially satisfied.

- The sum of the outputs (or performance levels) of the two activities (entities) is higher than the total of the two conducted separately.
- The output of one activity serves fully or partially as an input for the other and vice versa.
- The input needs and output flows of the two activities are non-covariate, i.e., they do not vary in the same direction or degree in space or time and thus do not compete.
- The two activities make use of different components of the same natural or economic resource base.
- The two activities through their structural and operational features are able to meet the different concerns and objectives of the agency/entrepreneur undertaking them and thus to satisfy the overall basic goals.

There are multiple complementarities that play a crucial role in ensuring environmental stability and the security of people's livelihoods in mountain areas. They can be identified by looking at features in mountain areas like resource-use systems and people's adaptation strategies (including farming systems) in terms of the features outlined above. A few are listed below.

- Complementarity or convergence between the situations determined by the specific characteristics of mountain areas and features of the resource use systems, including livestock production and farming systems

- Complementarity between production activities; institutional arrangements directed towards meeting environmental concerns and the need to secure livelihoods through diversification and inter-linked activities; resource regeneration and recycling; and other measures facilitating production and resource protection
- Complementarity between production activities based on common property resources (CPR) like pastures and private property resources (PPR) like private farm lands
- Complementarity (balancing) between intensive and extensive land uses (examples include linking of annual and perennial plant-based activities, crop-fallow rotation, and indigenous agro-forestry)
- Complementarity between activities and enterprises and the seasonal and spatial variability of resources and production flows
- Complementarity between activities with a subsistence orientation and production of niche-based cash crops

These complementarities show the ways in which the systems for using mountain resources have evolved traditionally to ensure both environmental stability and security of livelihoods in mountain areas. Their extent and manifestation varies from region to region, but the broad thrust and patterns can be seen in many different mountain areas and countries (Yadav 1992; Hagos and Pender 1999; Delgado et al. 1999; Tulachan and Neupane 1999).

The above list can be illustrated with many examples. For the purposes of this chapter, we have selected examples showing situations in which livestock production plays a crucial role in promoting and harnessing the complementarities. These are summarised in Table 3.2. The main aim is to identify shifts in the complementarities and their causative factors that are affecting the role of traditional livestock production systems in mountain areas.

The Changing Scenarios: Emerging Imbalances

Traditional livestock production systems acquired their prominent position in mountain areas as a result of their central role in promoting and harnessing the complementarities described above. Thus, if there are changes in the factors and processes creating the above complementarities, the role and importance of the livestock production systems in mountain areas will also be affected. Similarly, if the structure and function of the livestock production systems are altered, this will affect their dependence on and contribution to the different complementarities. For example, the complementarity between extensive and intensive land use is reduced through intensive cropping supported by increased

Table 3.2: **Livestock production as a promoter and user of multiple complementarities in mountain areas**[1]

Complementarities that are strengthened and used by traditional livestock production systems	Factors and processes causing a breakdown of the complementarities
Convergence between the situations determined by the specific characteristics of mountain areas and features of livestock production systems (see Table 3.1) Manifested in production and consumption systems focusing on local resource use, regeneration, recycling, diversification and interlinkages, crop-fallow rotation, and low resource-use intensity that are conducive to and supported by livestock based mixed farming	Improved accessibility; lower land per person and land:livestock ratios; intensification of resource use; reduction in diversification; changes in niche opportunities Consequences Reduced dependence on local resources and inputs, accompanied by a reduced need for recycling; reduced diversification; shift from subsistence to market orientation; changes in livestock management systems; demand-driven changes
Mutual satisfaction of environmental concerns and livelihood security through production practices and institutional arrangements for extensive, but productive, land use Ensured by balancing intensive and extensive land uses; farming-forestry livestock links; diversified, biomass dominated, production systems; the role of livestock in facilitating and harnessing the above	Increased pressure on resources; priority of short-term production gains over conservation; public interventions delinking livelihood security from environmental stability Consequences Reduced role of biomass and grazing-based livestock production systems; increased use of external inputs; availability of other sources of sustenance; emerging narrow specialisation
Complementarities between CPR and PPR based activities Manifested by moisture and nutrient flows from CPRs as support lands for private crop lands and a source of fodder for draught animals; complementary use of annual and perennial plants; supplementary employment and income from other CPR products; crop-fallow rotation; livestock productively helping in facilitating the above links	Land distribution policies and other interventions leading to a decline in CPRs and traditional management systems, and availability of alternatives that substitute CPR functions Consequences Decline in both the area and productivity of the grazing base for livestock causing shifts in management practices that are reflected in the changed size and composition of animal holdings; increased stall feeding; use of external inputs; and changed economics of livestock farming
Complementarities between seasonally and spatially varied activities to make use of resource diversity Manifested by different land uses and different crops in different seasons; different categories of animals with grazing rotations and seasonal migration; the role of animals as both an asset and a source of income to meet seasonal variability and risks	With the changed economic and institutional situation, availability of substitutes for traditional strategies (like diversification) to meet variability and risk and to harness diverse opportunities Consequences Role and operation of livestock production systems changed, focus on livestock as a source of perennial income insurance; reduced seasonal variability in animal production as a result of intensive management practices

[1]Based on inferences from different studies cited in this chapter.

external inputs, or a reduction in crop-fallow rotations, and this will lead to marginalisation of the role of livestock in productively balancing extensive and intensive land use. Similarly, if the livestock production system is transformed by intensive management and, for example, increased use of processed external feed, the system will become less dependent on extensive grazing and local biomass (a dependence which is helpful for productively balancing conservation and production needs).

The types of changes outlined above appear to be taking place in a number of more accessible mountain areas (Tulachan and Neupane 1999). They are leading to changes in the nature and magnitude of the factors and processes that create and require the described complementarities, and this in turn is influencing the traditional role and importance of livestock production systems in these areas. At the same time, the structure and functions of the livestock systems themselves are slowly changing, which is tending to reduce both their dependence on and contributions to various complementarities. In the following, I will describe some of these changes in more detail as a basis for identifying the future directions for livestock development strategies in mountain areas. First I will summarise changes in the objective circumstances that affect traditional livestock farming and production systems, and then I will focus on the implications.

- The falling degree of convergence between the situations determined by the specific characteristics of mountain areas and features of livestock production and farming systems

There has been an increase in the intensity of land use, at the cost of diversification, as a result of improved accessibility and the associated market linkages, public interventions, and population growth. As a result several systems of resource use in mountain areas in which livestock occupied a prime place have been marginalised or discarded. These include the primacy of local resources in production and consumption (resulting from the semi-closed situation), and the associated focus on such things as diversified interlinked enterprises, resource regeneration, and recycling. There has been a marginal shift from a subsistence orientation to a market orientation of activities, with production of horticultural and other high-value crops as well as livestock. The changes in livestock production can be seen in terms of the changing size and composition of animal holdings, feeding practices, the use of external inputs, output disposal patterns, and an overall decline in the dependence of livestock on complementarities.

- Decline of environmental concerns and common property resources

Livestock farming has been both a facilitator and a user of the complementarities between the activities and practices related to environmental protection and securing livelihoods on the one hand and CPR-PPR based activities on the other. These

complementarities are manifested in the balancing of intensive and extensive land-use systems, seasonally and spatially diversified land-based activities, the use of commons as support lands for nutrient and moisture flows for crop lands, the existence of supplementary sources of biomass for fuel and fodder, and the generation of income and employment.

Following the introduction of various land distribution policies and related public interventions, with programmes encouraging land-use intensification and a greater focus on short-term production gains compared to resource conservation, local concern for environmental resources has declined. This has led to a decline in the availability and extent of CPRs and shrinkage of the resource base for livestock (Jodha and Shrestha 1990). At the same time, the changes in livestock production systems (holding size, composition, input structure and output destinations, intensive management practices) have reduced the need for local biomass and its regeneration or recycling for livestock production.

- Changing motives and mechanisms

The changes indicated above reflect aspects of an overall transformation process that has characterised mountain economies and societies in recent decades and is a response to the gradual changes in objective circumstances in mountain areas resulting from their increased physical, administrative, and market integration with the outside world. The goals, structure, and function of production, consumption, and exchange activities (including those involving livestock) are slowly changing. Some of these changes may not be fully compatible with the traditional patterns of resource use and the role of livestock production systems therein. At the same time restoration of the traditional patterns may not be possible in the rapidly changing context. In order to retain the benefits of the traditional systems in the changed context, future strategies for livestock development in mountain areas should focus on the rationale of the traditional arrangements rather than their specific forms or practices (which are rooted in subsistence-oriented low productivity systems) and try to integrate these into new approaches to livestock development. It is helpful to look first at the comparative features of the traditional and newly emerging livestock production systems in mountain areas (Table 3.3).

Harnessing the Emerging Trends

Table 4.3 broadly summarises the emerging changes associated with livestock production in the mixed farming context in mountain areas. Various field-level studies (Jodha and Shrestha 1990; Negi 1990; Saini et al. 1996; Chand 1996; Tulachan and Neupane 1999) document these changes in different parts of the HKH region. The key inferences from these changes, which form the basis for thinking about future livestock development strategies, are summarised in Table 3.4 and discussed in more detail below.

Table 3.3: **Features of the traditional and new livestock production systems in mountain areas**

Key features	Production systems involving livestock	
	Traditional	Modern
Key driving forces	Multiple complementarities between resource use and production systems for security of the environment and of livelihoods in a subsistence context; livestock as an integral part of mixed farming systems	Shift towards market orientation; high income-generating approach to animal production; livestock a part of mixed farming systems but with changing components and management patterns, reduced dependence on grazing
Objective circumstances	Semi-closed, subsistence-oriented adaptations to the constraints and opportunities created by the mountain conditions, livestock as a part of the adaptation strategies	Changed circumstances in terms of the external physical and market links influence the goals, structure, functions, and management of animal-based enterprises
Structural and management aspects	Higher animal-land ratios; larger animal holdings (both as an asset and a defence against risk); mixed categories (cattle, buffalo, goats, others); high proportion of unproductive and less productive animals, high dependence on open grazing	Gradually reduced animal holdings; changed structure; smaller proportion of unproductive and less productive animals; focus on high yields; stall feeding; external, processed inputs; improved product processing and marketing
Inputs	Crop by-products; biomass from CPRs; limited external feed; low private costs; labour as main family input	Shift towards use of external processed feed and external services
Outputs/ services	Source of organic manure and draught power for farming; supplier of food, fuel, fibre, and cash income for families	Traditional contributions continued with increased emphasis on high-value products and cash income
Functions in a wider context	Key role in satisfying environmental concerns in fragile mountain areas while contributing to sustenance needs by maintaining extensive, biomass-centred land uses and contributing to resource regeneration and protection; (visible decline of above services with increased numbers and overgrazing).	Livestock emerging as a high payoff component in slowly transforming mountain economies and becoming less a part of conscious efforts towards environmental conservation; economic benefit becoming the key concern

Table 3.4: **The emerging trends in livestock farming in mountain areas**

Major changes	People's responses	Implications for future strategies
Reduction in grazing space, overgrazing, and resource degradation; reduced possibility of support from forests and common lands	Reduction in size of animal holdings; changes in composition of animal holdings with diversification and focus on more productive animals such as high milk yielding animals; increase in stall feeding; production of fodder crops; use of external processed feed	Need to enhance the process by promoting high productivity animals (e.g., upgrading breeds, new introductions); to improve fodder production, quality and availability of feed, and local processing of feed; to provide health facilities; to develop the infrastructure needed to support the above; and to build human capacity and organisations of producers

Table 3.4: **The emerging trends in livestock farming in mountain areas (cont'd)**

Major changes	People's responses	Implications for future strategies
Incompatibility between the land-extensive, local resource centred, subsistence-oriented, low productivity and earning livestock production systems and the emerging transformation process led by increased accessibility and increased desires and need for cash income following exposure to the outside world.	Market orientation, changes in management involving selection of high-yielding animals; changes in inputs and outputs; processing; and market links Focus on high payoff opportunities and value-adding options; new set of complementarities (e.g., intensive livestock management and intensive high-value crops)	Need for infrastructural support systems, human skill enhancement, and support of institutional arrangements to help sustain market orientation and high level of efficiency and productivity Infrastructural, institutional and extension support and technologies for crop-animal links must be appropriate in the changed context
Focus on making livestock production an effective component of a high payoff mix of family enterprises	Changed management and choice of animals and inputs; demand-driven outputs; processing and marketing through group activities	Need to integrate high payoff crop and fodder varieties and high payoff animal enterprises, and to evolve new forms of complementarities
Non-viability and reduced efficacy of practices based on natural biomass and centred on local resources only	General indifference towards and disregard of traditional practices focused on natural biomass and environmental concerns	Need to search for positive environmental elements in the new systems (complementarities between the systems and environmental needs)

Shrinking grazing space

The traditional resource base, that is the grazing area for livestock, is shrinking rapidly as a result of the rising population and the extension of crop growing to areas hitherto occupied by grass and shrubs. This trend will lead to further degradation of the remaining grazing land unless the actual amount of grazing is reduced, either by lowering the number of livestock or increasing stall feeding. Evidence from the field shows that farmers are slowly beginning to respond to the emerging crisis in the following ways.

- Reducing the size and changing the composition of animal holdings (e.g., reducing the proportion of less productive animals like cows with low milk yields and draught animals, increasing the number of buffaloes and goats, introducing rabbits and poultry)
- Increasing the extent of stall feeding, increasing own production of fodder and feed, and using external inputs such as processed feed, nutrients, and veterinary services. These trends have been seen in several areas with better access. The intensively-managed livestock production systems have positive links with other new market-oriented components of farming systems such as horticulture, vegetable production, and planting of high-yielding fodder crops.

Future strategies should build upon these trends by strengthening the links described and improving the quality of animals and of inputs like fodder and processed feed. Promotion of quick maturing and high-yielding fodder species is an important element in the promotion of intensive livestock management systems and should be given high priority.

Emerging market orientation of livestock farming

The second major set of changes characterising mountain livestock is closely related to the above and stems from the increasing market orientation of the livestock production systems. This market orientation is reflected in such things as a 'profitability approach' to the intensive management of livestock, the increased marketing of products such as milk, the development of small, local processing units, and the use of external inputs. It is both a result and a cause of the changes indicated above and represents the farmers' response to the changing situation in mountain areas that have become accessible. These changes are a part of the overall process of transformation in mountain areas following their improved physical and market integration with wider areas.

Future livestock development strategies in mountain areas should also focus on strengthening these trends. In particular they should help ensure the viability of market-oriented livestock production systems in the competitive market context whilst ensuring that any negative environmental side effects are minimised. Some of the elements that should be given priority are

- improvement of the quality of animals (choice of animals and breeds) to ensure high productivity;
- improvement of the quantity and quality of both unprocessed and processed inputs;
- development of processing and marketing facilities and an overall infrastructural and institutional support system to overcome the constraints imposed by mountain specificities;
- promotion of the organisational and institutional arrangements and enhancement of the human capacities and skills needed to run livestock production as a modern market-oriented enterprise; and
- promotion of group action and federating arrangements involving different groups and areas (essential to overcome the limitations created by the unavoidably smaller scale of the individually-run enterprises in mountain areas).

Bypassing of environmental concerns

One important aspect of the present transformation process is a general disregard for or indifference to the environmental services offered by traditional farming systems, and in particular livestock production systems, in mountain areas. The new livestock

production systems tend to offer fewer 'environmental services'. In traditional systems, these 'services' are related to facilitation of the maintenance of fragile slopes under natural vegetation (by offering a productive use through grazing and thus reducing the likelihood of resource degrading use-intensification by growing crops); production of organic manure to maintain soil fertility; production of an alternative fuel supply (reducing the need for wood as fuel); and acting as a medium for ensuring effective farming-forestry linkages. The new market-oriented livestock production systems are still integrated in crop-livestock mixed farming, but the extent of the environmental services is generally lower. Future livestock development strategies will need to address this area of concern.

The new systems also have some positive environmental effects, however. For example, increased stall feeding is likely to reduce the pressure on overcrowded grazing land. This may help in regenerating the pastures and commons. The overall reduction in and changed composition of animal holdings (with fewer but better quality animals producing more) is likely to have a similar effect since most of the new, more-productive animals are stall fed to ensure high productivity and profitability. Stall feeding should also increase the availability of organic manure as a fertiliser for farmland.

In order to ensure that the sum of environmental effects is positive, it will be necessary to strengthen the new initiatives through infrastructural, institutional, and technological measures that make small and diversified animal holdings with intensive management (through stall feeding) more attractive and profitable options. The specific areas in which R&D can play an important role include the promotion of high-yielding, early maturing, multi-season fodder species; the promotion of fodder feed processing; and improvement in the animal breeds responsive to intensive management.

Sensitising Market Oriented Livestock Production Systems to Mountain Specificities

In order to increase the degree of compatibility between the new intensive market-oriented livestock production systems and environmental concerns, it is necessary to go beyond the issues mentioned above. One way of approaching this is to try to make the market-oriented livestock production systems sensitive to or compatible with the mountain specificities described at the beginning of this chapter. Whereas the socio-economic (including demographic and institutional) circumstances in mountain areas are changing rapidly, the basic biophysical condition of these areas has remained broadly unchanged. New developments need to be sensitive to these unchanged conditions or they may prove environmentally and economically non-sustainable. The factors that make activities more durable and productive in the mountains can be

identified and internalised on the basis of past experience and evidence (Jodha 1997). These should be taken into account when designing new livestock development strategies in mountain areas. Three important issues are discussed below.

- Diversified and interlinked resource-based activities have been a key attribute of sustainable production systems in mountain areas. In the context of market-oriented livestock systems, this would require integrating cropping, livestock, and agroforestry activities, with diversification, more intensive management, and high productivity. Intensification of only one component whilst disregarding the others might not prove sustainable. In other words, all the components of farming systems will have to be made more management intensive if the intensified livestock systems are to remain compatible with the other components. R&D has an important role to play in developing such new diversified and inter-linked production systems.
- The dependence of livestock on local resources will continue to be an important factor, notwithstanding improved accessibility and market links. Thus conservation and efficient use of resources, including recycling and processing, will continue to play an important and integral role in the management of livestock production systems. R&D efforts should be focused on the improvement of the traditional methods related to these. The quality of animals and composition of animal holdings are important when considering the efficient use of scarce resources, and an area in which R&D and institutional support can play an important role.
- The last issue relates to harnessing of gains from external links – through market and other accessibility. A number of policy and programme interventions will be necessary to ensure fuller and equitable gains from market links, and ensure there is no backlash from unequal highland-lowland economic links. These include creation of a physical infrastructure that includes processing and marketing facilities; institutional arrangements, including local ownership of local commons; group action and federating arrangements for input disposal and output supplies (including price support); and capacity building of the local communities. These changes will help in reducing the marginality and vulnerability of mountain communities while enabling them to participate in the competitive market.

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Chapter 4

Markets and Livestock in the Coming Decades: Implications for Smallholder Highland Producers

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Introduction

It is well recognised that people living in highland regions depend particularly on livestock for their livelihoods. Where crop production is feasible, livestock are an essential component of farming systems. They provide food, traction, manure, income, and fibre and perform other social and economic functions. Where extremes of climate and terrain make crop production especially difficult, livestock can often live and flourish on available resources and provide livelihoods. What is less well recognised is the importance of livestock markets, and also the special constraints that such markets face in highland and mountain areas to furthering the contribution of livestock to livelihoods.

This paper reviews recent research, first to present a picture of coming trends in livestock product consumption and production in developing countries, in general, and second to derive some of the market implications of these for smallholders in the highlands. Evidence is also presented concerning the linkages between livestock, agricultural intensification, and markets. Finally, several highland case studies are presented that show in detail some of the major market constraints facing highland livestock producers.

The Continuing Livestock Revolution

Clear evidence is now available that smallholder livestock producers in developing countries are being presented with growing market opportunities. A recent study by

Delgado et al. (1999) examined the trends for livestock demand and production to 2020, with a focus on developing countries. Based on a global food model, they predict where and to what degree demand for livestock products will grow, and simultaneously predict where the increased production needed to meet that demand will occur.[1]

The projected changes are dramatic. Particularly because of increases in per capita income in Asia and elsewhere in developing countries, but also as a result of growing human populations and urbanisation, consumption of animal products will increase significantly in all developing countries by 2020. Consumption of meat and milk is predicted to grow by about 50% in the period from 1993 to 2020 in developing countries, to some 30 kg/capita and 62 kg/capita annually, respectively (Table 4.1). Much of the growth in meat consumption will occur in pork and poultry, although beef consumption per capita is expected to grow by more than 30% as well.

Table 4.1: **Per capita consumption of livestock products in developing countries** (kg per capita per year)

Commodity	1993	2020 (projected)
Beef	5	7
Pork	9	13
Poultry	5	8
Meat	21	30
Milk	40	62

Source: Delgado et al. 1999

Further, significant growth in animal product consumption can be expected to occur in all regions of the developing world (Table 4.2). The largest volume increases are expected in China where total milk and meat consumption will more than double. Overall, milk and meat consumption in developing countries is projected to grow at a rate of about 3% annually, with the highest rate of growth in Sub-Saharan Africa (3.5%), although from a low base. In sharp contrast, consumption in developed countries is expected to change hardly at all. This phenomenon is centred entirely in the developing world.

These dramatic changes, which are already well on their way, have been described as the 'Livestock Revolution' (Delgado et al. 1999), which in value terms is larger than the Green Revolution of the 1960s and 70s. From the point of view of smallholder producers, however, the important questions remain: where will the increased production needed to meet this demand take place, and will smallholder livestock producers be able to participate in this market opportunity?

[1]The IMPACT model is a global food model of 18 commodities including 7 livestock commodities, covering 37 separate regions/countries, and with annual iterations to 2020. It incorporates expected growth in population and income and changes in productivity (Delgado et al. 1999).

Table 4.2: **Projected growth in total meat and milk consumption for selected regions, 1993 to 2020** (million tonnes)

Region	Meat			Milk		
	1993	2020	Annual growth rate (%)	1993	2020	Annual growth rate (%)
China	38	85	3.0	7	17	2.8
India	4	8	2.9	52	160	2.9
Latin America	21	39	2.3	46	77	2.3
Sub-Saharan Africa	5	12	3.5	14	31	3.5
World	184	303	1.8	412	654	1.7

Source:Delgado et al. 1999, p. 24

The answer is that increased production is expected to occur generally in the same areas where the increased demand is expressed, in other words the additional meat and milk will be locally produced not imported. This follows the current pattern: 10% or less of value of livestock production is traded internationally (FAOSTAT 1998). In spite of the public attention sometimes given to livestock product trade issues, livestock products are not easily traded, requiring extensive transformation or high cost to preserve and transport, after which they may not share the level of quality of local fresh products. Thus the model predicts that countries deficit in livestock products will generally import feed rather than meat and milk, leading to rapid increases in feed grain imports in some areas (Table 4.3).[2]

Table 4.3: **Projected growth in total cereal use as feed** (million tonnes)

Region	1993	2020	Annual growth rate (%)
China	84	178	3.4
India	3	14	5.0
Latin America	55	92	2.0
Sub-Saharan Africa	3	5	3.5
Developing World	194	409	2.8
Developed World	442	519	0.6

Source: Delgado et al. 1999, p. 26

As a result, livestock production in developing countries will increase approximately on a par with consumption. By 2020, developing countries will produce some 60% of all meat and 52% of all milk globally, up from some 47% and 32%, respectively, in 1993. This increased production is expected to place a new stress on extensive livestock production systems and those relying on peri-urban grazing, and to create the potential for concentration of production.

[2] In spite of increased use of grain for feed, the IMPACT model predicts that grain prices will not rise significantly, and would remain in real terms below the levels seen in the 1980s. This is because of expected continued productivity increases (Delgado et al.1999).

The Livestock Revolution also means new market opportunities for smallholder livestock producers. Important constraints remain, however, that will impede the ability of smallholders to participate. These include the following.

- Small scale of production and marketed output implies low bargaining power and inability to capture economies of scale in marketing
- Poor access to livestock services and credit
- Policies that favour capital-intensive livestock production
- The growing commercialisation of livestock production, particularly through the industrial production of poultry and pork

In the highlands, these constraints are likely to be even more severe. Will highland livestock producers and communities be able to participate in the Livestock Revolution?

The Link between Livestock and People

In considering the future of livestock markets and their likely impact on highland communities, it is useful to look at patterns of linkages between people and the livestock they keep. In short, not only will production growth occur in the same areas as demand growth at the global level, but locally market constraints and other factors will also lead to livestock living near to people.

An important indicator of potential market constraints to livestock products can be seen in the spatial link between human and livestock population densities. Historically, the evolution of agricultural production systems shows that there was a positive relationship between human and livestock population densities – areas with high human population densities also had high livestock population densities. A number of previous and recent studies at country, regional, and global levels have confirmed this historical pattern (Mukherjee 1938; Jabbar and Green 1983; Wint and Bourn 1994; Sere and Steinfeld 1996; Slingenbergh and Wint 1997; Lapar 2000). Wint and Bourn found that in Sub-Saharan Africa, in areas with less than 500 mm annual rainfall, 70-90% of the ruminants occur in rural systems.[3] The remaining animals are in villages or within settlements. However, as rainfall increases, the proportion of animals in rural areas falls, to 50-60% in areas of 500-2000 mm annual rainfall, and to 10-15% in the wettest areas. This seems to occur because, where rainfall is more plentiful, the availability of adequate feed resources allows the transport of feed and fodder into urban areas. Livestock are then kept as close as possible to the centres of demand in order to reduce the constraints in marketing livestock products. Given that many highland areas also experience relatively higher rainfall, these same trends could occur in those settings. Sere and Steinfeld found

[3] These figures refer to the percentage of ruminant biomass, not numbers of animals.

that among the different agroecological zones, highlands have the highest livestock population densities and sometimes very high human population densities. Slingenbergh and Wint found in their global study that, spatially, livestock population densities occur at a rate approximately double that of the human population density. Approximately the same results were found in Sub-Saharan Africa (SSA), and a slightly lower level of relationship in Asia.

This positive relationship between human and livestock population densities normally occurs until urbanisation and industrialisation lead to a steady decline in the rural population depending on agriculture. However, where urbanisation is not accompanied by adequate development of market infrastructure to connect rural producers and urban consumers, livestock production continues in urban/peri-urban areas. For example, in the mid-19th century, most European cities depended on urban/peri-urban dairies for much of their milk and beef. By the turn of the century, these urban/peri-urban dairies had disappeared because of health regulations, improved infrastructure, and economies of scale leading to larger production units, which in turn required more land (Phelan and Henriksen 1995). In the newly emerging economies of East and Southeast Asia, a combination of rapid income growth, urbanisation, and population growth led to a rapid increase in the demand for livestock products, particularly meat and meat products. Traditional rural livestock production systems were slow to respond to these demands, which led to an increase in imports and in the role of urban/peri-urban industrial production systems, particularly for non-ruminant livestock. Lack of adequate infrastructure, the high transport cost from distant areas, and lack of regulations on the one hand; and policies supporting trade, prices, and subsidies by different governments on the other, have led to the establishment of production enterprises in urban/peri-urban areas. A recent study has identified these concentrated livestock production systems in East and Southeast Asian countries as one of the ' hot spots of livestock-environment interactions' (de Haan et al. undated).

Dairy is a major enterprise in highland areas because of the climate, which is more suitable for raising animals than is that in humid and arid/semi-arid areas. On a global basis, highlands produce 25 kg milk per ha compared to 17 kg in arid/semi-arid and 10 kg in humid/sub-humid areas. Milk output per capita is 34, 49, and 8 kg, respectively, in these ecozones (Sere and Steinfeld 1996). However, markets are particularly susceptible to infrastructure. In highland areas infrastructure is expensive to build and maintain and is liable to disruption, so that investment in it is often uneconomic even with moderate to high population densities. Yet, without a proper market infrastructure, highland livestock producers are unlikely to be able to benefit from the national and global market opportunities for their products.

Smallholder Access to Markets: the Example of Dairy

Dairy product consumption is expected to grow considerably in the developing world, for example in SSA by 3.5% annually between 1993 and 2020, and domestic production has the potential to meet this demand and generate additional income and employment. However, smallholders will only benefit if they can participate in the market, which will be globally related and influenced. Some producers sell home processed products as a result of lack of access to fluid milk markets in distant urban areas.

Several barriers remain to smallholder participation in dairy production. Prominent among them are the following.

Availability and cost of animals – Without better quality animals that offer potentially higher milk yields, the ability and probability of market participation is reduced significantly as the small quantities of milk from local cows are inadequate to justify the investment in time and labour necessary to reach the market. But better quality animals are not always easily available due to lack of breeding stock production programmes, and the cost may be beyond the reach of many smallholders. Credit can relax such constraints, but as a result of the criteria usually used for judging credit worthiness many smallholders are left out of the formal credit market. Identification of farmers with real credit constraint and extending credit to such farmers has a much greater effect on production and market participation than simply extending credit to those who meet traditional criteria such as the ability to provide collateral and apparent repayment capacity (Freeman et al. 1998).

Seasonal feed availability and quality – inadequacy and poor quality of feeds is a major constraint for livestock in the highlands, particularly for dairy animal production. Even when improved dairy animals are raised, lack of quality feed still limits the milk yield potential of the animals; thus the volume of milk entering the market is also less than the potential volume.

Market and spatial factors – Traditional smallholder livestock producers are generally scattered in rural areas that are often characterised by inadequate access to roads and transportation facilities. This raises transaction costs and limits market participation in two principal ways. First, milk is a bulky perishable commodity, so needs quick disposal. The distance, time, and effort required to reach the market and the associated risks of spoilage are thus important factors determining producer participation in the market. Second, inadequate access to inputs and services (such as veterinary services, drugs, artificial insemination, and feed) serves as a disincentive to the adoption of improved dairy cows, which also reduces dairy market participation (Staal et al. 1997).

Regulations restricting participation – In some countries governments have established a dairy processing and milk collection infrastructure to give small producers access to a stable market outlet for their products. While such parastatal organisations initially played a positive role in expanding smallholder dairy production, in time they became a principal disincentive to further expansion because of their monopoly behaviour and resulting inefficiency. The informal milk markets that emerge to bypass these inefficiencies offer less reliability, and are often limited in scale. Policies towards marketing, and institutional roles, thus affect smallholder livestock access to reliable, supportive markets (Staal et al. 1997).

Constraints to Livestock Market Participation: Two Case Studies

Case 1: Smallholder dairy in highland Kenya (1500-2500m)

Kenya is one of the few success stories for smallholder dairy development in the African continent, particularly in the highland region. European settlers originally started medium to large-scale dairy farms with exotic and cross breeds to meet the growing urban markets and the rapidly expanding tourist industry. Beginning in the 1950s, crossbred dairy cattle began to be acquired by indigenous smallholder farmers. These were eventually supported by government-established milk processing facilities, milk collection centres, and a federation of dairy cooperatives of producers called Kenya Cooperative Creameries (KCC). These cooperatives played an important role in smallholder dairy development during the 1970s and 1980s, such that smallholders now supply about 80% of the milk marketed nationally. However, the KCC had a monopoly on the purchase of fluid milk from local cooperatives and on all urban milk sales, using prices set by the government. By the early 1990s, these policies resulted in a high producer-consumer price spread, leading to declines in milk deliveries to KCC as producers diverted milk to private informal traders at higher prices. The 1992 deregulation of the milk market followed a similar liberalisation in veterinary and artificial insemination (AI) services. These led to a dramatic change in the nature and extent of market participation (Table 4.4). There has been a large increase in the rate of the unregulated raw milk market and a decrease in the relative share of sales to KCC outlets; furthermore rural dairy co-operatives have started providing veterinary and AI services alongside the private sector. A significant rise was also observed in the real prices received by producers, with emergence of a price gradient by distance from urban centres: the further away the milk producing farm, the lower the price they receive.

In order to verify more systematically how spatial, household resource, and agro-ecological factors in the highlands affect market access (measured as the farm-gate milk price) and the ability to take up dairy technology (measured as the probability

Table 4.4: Pre and post-reform status of dairy farmers' cooperatives (DFCS) in three districts in highland Kenya

	1990	1995	% Change
Registered members	58,428	83,751	43
Active members	22,078	35,248	60
Milk sales ('000 litres)			
Retail outlets	8,702	17,785	104
KCC	17,712	15,295	-14
Middlemen	4,848	5,972	23
Private processors	486	1,499	208
Total	*31,748*	*40,551*	*28*
Numbers of DFCs providing service			
Milk marketing	27	30	11
Sale of veterinary drugs	9	13	44
AI service	1	22	2,200
Sale of feed	13	23	77

Source: Owango et al. 1998

of having a dairy cow), a detailed study was conducted combining farm survey and GIS-derived variables in an econometric analysis (Staal et al. 1999). A random survey was conducted among 1,389 households in the central highlands of Kenya, about half of which were small dairy farms that depend on both formal and informal markets. In the latter the farm-gate milk price is 10% higher, but more risky as seasonal demands vary and informal market agents sometimes fail to pay. Each household was geo-referenced using global positioning system (GPS) units. GIS tools were then used to derive least-travel-time distances from each farm by road to urban areas and milk market points, by road type. Additional GIS data on rainfall, temperature, and human population density were also included to determine the factors influencing the adoption potential for improved dairy cows.

The results of this analysis confirmed that there is a milk price gradient by distance from urban centres: the further the distance, the lower the price in both formal and informal markets, although the effect is much more marked in the latter (Table 4.5 and Figure 4.1). The negative effect on farm-gate milk price of a kilometre of tarmac from the largest city is about double in the informal market. This difference does not necessarily suggest, however, that informal markets operate less efficiently per kilometre than formal markets, only that the informal market prices paid to farmers more explicitly reflect the actual transport costs and associated risks. This is because the formal market tends to offer uniform prices at the main collection centres, regardless of distance.

The other important difference between the formal and informal market results was seen in the effect of the size of the dairy herd on the farm-gate price (Table 4.5). In the formal market a larger herd (and so more milk delivered) leads to higher prices;

Table 4.5: **Effects of selected variables on farm-gate milk price in the Kenyan highlands: estimated OLS model for farm-gate milk price formation**

Variable	Formal milk market price	Informal milk market price
Household transaction characteristics		
Dairy herd size (number of cows)	0.17[1]	-0.36[2]
Market infrastructure		
Distance to largest city by tarmac (km)	-0.07[1]	-0.14[2]
Distance to largest city by all weather loose surface roads (km)	NS	-0.28[2]
Distance to largest city by dry weather only roads (km)	NS	-0.37[2]
Distance to nearest milk collection centre by tarmac (km)	-0.41[2]	NS

[1]significant at 0.05 level, [2]significant at 0.01 level, NS= not significant
Source: adapted from Staal et al: 1999

in the informal market the price effect is significantly negative and large. This can be seen as a clear indication of the inability of the informal market to capture economies of scale in milk transport as a result of the technology used, but is also a result of existing government policies. Currently, if traders increase their scale of operation from bicycles to pickups they face increased risk of harassment and fines from law enforcement, because the informal milk trade for sale of raw milk in urban areas is illegal.

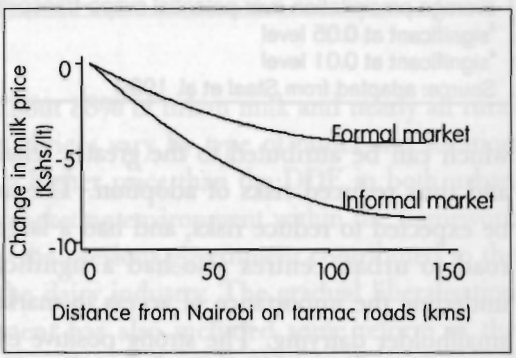

Figure 4.1: **Estimated distance decay functions for change in farm-gate milk price with distance from Nairobi (the largest city) by all-weather road in formal and informal milk markets in the Kenyan highlands**

A profit analysis was made for the adoption of dairy cattle. The results are shown in Table 4.6. The variables with a significant and positive effect on the probability of dairy cattle adoption were years of education, total household land, availability of a veterinarian and formal market locally, and agro-climate. The human capital parameters were highly significant and indicate about a one per cent increase in the probability of adoption with one additional year of formal education. The total land parameter was weakly significant whereas rainfall and temperature were strongly positive, indicating that land size is less important than agro-climatic potential. The local market and services' access parameters were very significant and large. An increase of one per cent of the proportion of local sales to formal markets was associated with a more than three per cent increase in the probability of adoption,

Table 4.6: Effects of selected variables on the probability of dairy cow ownership in the Kenyan highlands: estimated probit model for the adoption of dairy cattle technology

Variable	Marginal effects[1] (%)
Household characteristics	
Years of education of household head	1.1[4]
Total land owned (acres)	1.0[3]
Local area characteristics	
Availability of veterinarian locally	2.2[3]
Availability of formal market locally	3.4[3]
Rainfall and temperature[2] (PPE)	2099[3]
Market infrastructure (GIS)	
Distance to nearest urban areas by tarmac (km)	-1.0[3]
Distance to nearest urban areas by all-weather loose surface road (km)	-1.0[3]

[1]marginal effect is the % change in the dependent variable (probability of dairy cow ownership) of a 1% change in the explanatory variable
[2]rainfall and temperature were represented by a combined index, PPE, which is the annual average precipitation over potential evapo-transpiration
[3]significant at 0.05 level
[4]significant at 0.01 level
Source: adapted from Staal et al. 1999

which can be attributed to the greater reliability and lower risks in milk marketing and thus reduced risks of adoption. The availability of a veterinarian can similarly be expected to reduce risks, and had a large positive effect. Finally, the distances by road to urban centres also had a significant impact. These last three variables underline the importance of access to markets and services in this case of highland smallholder dairying. The strong positive effect of agro-climate has implications for highland systems, which generally have relatively higher levels of rainfall and lower temperatures, and underlines the significant comparative technical advantage of production in these areas for major types of livestock products, including dairy.

Case study 2: Smallholder dairy farming in highland Ethiopia (~2000 m)

Mixed smallholder farms predominate in the highlands of Ethiopia. The large cattle population, mostly indigenous Zebu, perform many functions including providing traction, manure, and milk and milk products. However, sale of fluid milk is insignificant in the rural areas outside the Addis Ababa milk shed, which covers a 120 km radius principally along the main roads. Dairy is a major activity in Addis Ababa city and its surrounding areas and most of the country's crossbred dairy animals are located here. The government has established a Dairy Development Enterprise (DDE) to provide market and other physical and service facilities to promote dairy development. The DDE has established a processing plant in Addis Ababa and milk collection points along the main roads to provide a stable market outlet for producers, and veterinary and AI services and other inputs. There are also

milk producers' cooperatives, which provide selected services to their members, but their activities are concentrated primarily in Addis Ababa city. The DDE collects milk at fixed prices. These have not changed for several years although prices in the informal market vary both between seasons and between years. The nature and extent of market participation by urban/peri-urban and rural producers are limited by distance and road infrastructure (Table 4.7).

Table 4.7: **Dairy sales pattern and distance to markets in highland Ethiopia**

Sales (per household per day)	Distance to milk collection centre	
	0-3 km	3-10 km
Milk (l)	3.2	0.1
Butter (g)	7.0	97.0
Cheese (g)	0.0	11.3
Total milk equivalent (l)	*3.2*	*2.4*

Source: Debrah and Anteneh 1991

In spite of the support from the DDE, about 88% of urban milk and nearly all rural milk is handled by the informal market. Prices vary by type of outlet and location (Table 4.8). In general, all outlets paid a higher price than the DDE in both urban and peri-urban areas. This rather rigid marketing environment within the framework of the overall command economy run by the previous government contributed to the slow and less than expected growth in the dairy industry. The gradual liberalisation of the economy by the present government has also included some reform in the dairy sector. Recent reform measures have allowed formal private milk traders and cooperative farmer milk groups to appear alongside the DDE. It is too early, however, to assess the full impact of these reform measures and emerging institutions on the dairy industry and the extent of farmer participation in market.

Policy reform may not be enough to improve market access for smallholder highland dairy farmers. A study among a stratified sample of 144 farms, in an area where milk groups have emerged after the introduction of the new regulations, showed that transaction costs are a major determinant of the probability of market participation

Table 4.8: **Pre-reform sales outlets and price received by producers in and around Addis Ababa, Ethiopia (in Ethiopian birr per litre)**

Sales outlets	Peri-urban		Urban	
	Large	Small	Large	Small
Individuals	0.95	1.05	1.63	1.65
Hotels and restaurants	2.00	1.30	1.60	1.35
Other retailers, traders	NA	1.22	1.54	1.21
DDE	1.00	NA	1.00	NA

Source: Staal et al. 1997

by dairy farmers. Only 15% of the sample had sold milk to the milk groups at any time during the five-month survey period, and market participation (i.e., sales of milk to milk groups) was determined significantly by marketable surplus and distance. Distance was measured by the time to transport milk to the group's purchase point, and thus served as a proxy for an important component of transaction costs. It was estimated that current non-participants in the milk market are likely to participate if, other things being equal, they can increase their daily marketable surplus by 9.8 litres, and have either 2-3 crossbred cows or 6 local cows, or have about 10 extension visits per year, or if their return journey to the market could be reduced by about 2 hours (Holloway et al. 2000). Therefore, the transaction costs determined by the market infrastructure seem to be a major constraint to smallholder participation in dairy marketing and the adoption of improved cows to produce more milk.

Conclusions

Global trends in livestock demand and production point clearly to a strong growth potential, especially in the developing countries. The questions are whether smallholder mixed farmers will be able to compete with growing industrial systems and participate in the domestic and global market, and what the particular constraints are facing those in the highlands. The constraints that policy-makers will need to address include small scale of production and marketed output, poor access to livestock services and credit, policies that favour capital-intensive livestock production, and the growing commercialisation of livestock production. One means of addressing these constraints may be through farmer organisations that allow better bargaining power and vertical integration of activities. Other factors favour smallholder livestock production, particularly the greater nutrient cycling possibilities in mixed farms and consequent increased returns to livestock production.

Broad regional studies and case studies show that livestock production is particularly constrained by market and spatial factors. In highland and mountain regions these constraints are likely to be relatively greater as a result of the high costs of infrastructure and risks of disruption. On the other hand, in some cases, highlands offer a lot of potential because of the existence of mature mixed farming systems, high human and livestock population densities, and the climatic advantages for raising more productive dairy animals like crossbred cows. The selected case studies show that the primary constraints to the participation of highland smallholders in dairy farming are the remnants of restrictive policies and regulations, high transaction costs due to poor infrastructure and information systems, and poorly developed markets for inputs and outputs. These case studies also show that recent reforms

have eased some of these constraints with good results for both producers and consumers. Further reform and investment in supporting infrastructure, including farmer group development, can help provide good growing opportunities for smallholder livestock producers in highland systems.

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Chapter 5

Livestock Biodiversity in the Mountains/Highlands – Opportunities and Threats

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Introduction

In the following the subject of 'livestock biodiversity' is approached from a holistic perspective that includes ecosystem and cultural components and is not restricted to genetic-biological features. Thus livestock biodiversity is considered in terms of the diversity of, and interrelationships between, genes, species, and ecosystems including a cultural perspective.

The first focus is on remote mountain areas of more than 4000 masl, where herders with multifold traditions and cultures live and unique genetic resources with highly adapted species and breeds can be found. The second focus is on tropical highlands of intermediate altitude that are prone to intensive production with high-yielding breeds with a resultant high pressure on local breeds. References are made to examples from my own research in the High Andes and inter-Andean valleys of Bolivia and in the Northern Highlands of Vietnam. The paper covers rangeland-based animal farming in the subnival and upper montane zone (Troll 1968, p 35) as well as livestock-crop mixed farming in upper montane valleys, and includes a discussion of a breeding programme for autochthonous micro-livestock as a contribution to the characterisation of biodiversity and its conservation through systematic utilisation.

The 'opportunities and threats' for research and development are discussed in terms of the need for applied and committed research involving the skills and the will of

farmers and herders in specific regions, and contributing to the solution of present day problems deriving from global climatic, demographic, and socioeconomic changes.

Harnessing the Potential of Mountain Livestock Resources

Guinea Pigs in the Andes

In the late 1980s, a long-term breeding programme was set up in the Andean Valleys of Bolivia for guinea pigs, which are used traditionally for meat. The underlying aim was to characterise the local guinea pig biodiversity and then to conserve it by means of systematic utilisation. Specifically, the main objectives were to investigate the local genetic resources for their potential for meat production and to identify the genetic base for breeding strategies (Valle Zárate 1996a).

The breeding programme comprised the following.

- Screening of regional ecotypes in comparison with improved exotic lines and establishment of a national gene pool
- Implementation of a selection programme à crossbreeding programme
- Testing of genotype-environment interactions à production of improved breeds for use under different conditions

Figure 5.1 shows details of the comparative evaluation process for the local population with comparisons between purebred and crossbred groups and with high yielding exotic stock from Peru.

Table 5.1 shows the results of the evaluation of various performance traits of the Bolivian ecotypes (sampled across the country), the Bolivian gene pool, and the selected Peruvian line. On first sight the advantages of the exotics over the locals appeared striking with average weight at birth, weaning, and slaughtering higher by 32% to 67%. The exotics were also better than the locals in terms of number and weight of offspring produced in the first litter. However, long-term evaluation of reproduction revealed a different pattern. The locals excelled the selected exotic line both in the number of offspring born and weaned per year and in the total weight of offspring born and weaned per year.

Systematic comparisons between breeding groups kept under different ecological and socioeconomic conditions revealed a clear superiority of purebred locals under harsh environments and crossbred animals kept under improved field conditions. Purebred exotics were only superior when kept under conditions of intensive feeding and husbandry, which are inaccessible for the majority of farmers in mountainous areas.

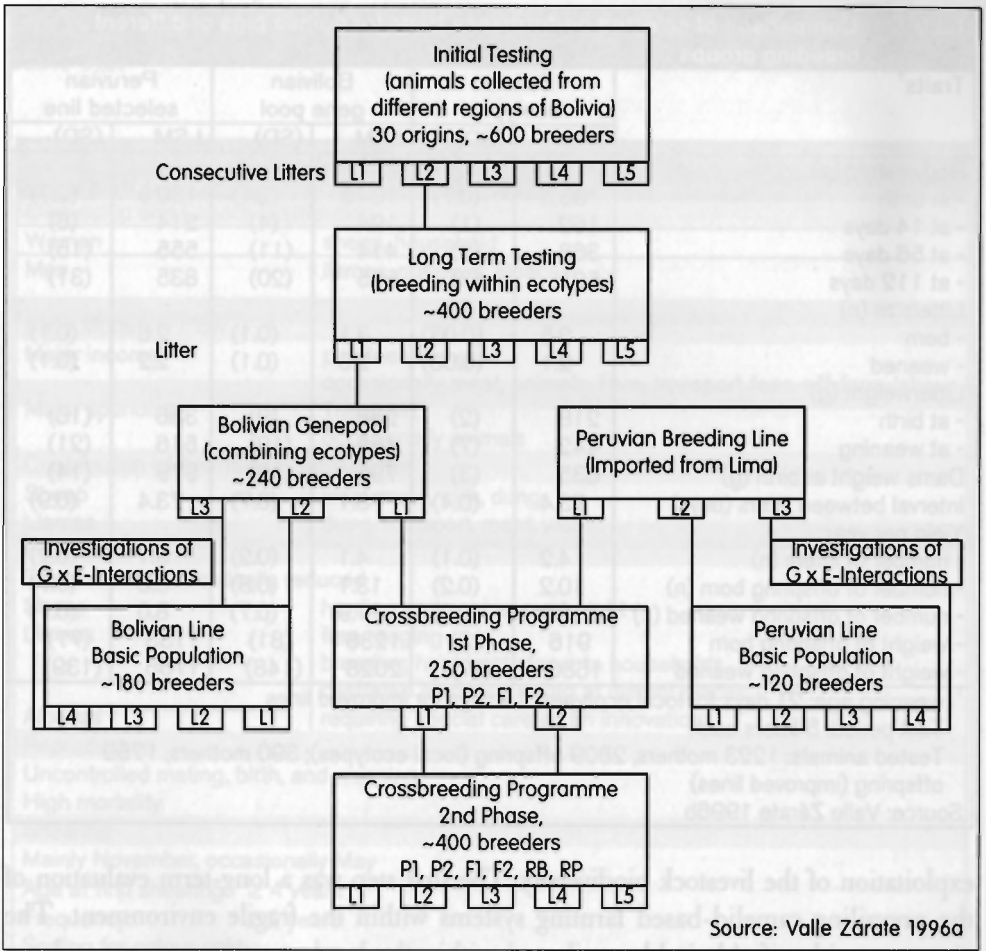

Figure 5.1: **Evaluation of the local genetic resource of guinea pigs in Bolivia as a basis for choice of an appropriate breeding programme**

The results show that local genetic resources play an important role in producing optimised breeding stock for distinct production conditions. Displacement of these resources can best be prevented by identifying environments where they are superior and by combining them systematically with exotic germplasm according to the specific conditions. A prerequisite for the success of the breeding programme was the strict orientation towards the needs of the prevailing farming systems and thorough consideration of aspects of breeding organisation.

Camelid-based farming systems in rural communities of the Bolivian Andes

The second example relates to specialised livestock production (camelids and sheep) on rangelands at altitudes where cropping is strictly limited or completely impeded, the target was conservation of local genetic resources through appropriate

Table 5.1: **Comparison of selected performance traits for guinea pigs of different breeding groups**

Traits[1]	Bolivian ecotypes		Bolivian gene pool		Peruvian selected line	
	LSM	(SD)	LSM	(SD)	LSM	(SD)
Bodyweight (g)						
- at birth	85.5	(0.7)	104.9	(2.1)	130.5	(2.7)
- at 14 days	162	(1)	194	(4)	214	(6)
- at 56 days	368	(2)	414	(11)	555	(15)
- at 112 days	501	(3)	595	(20)	835	(31)
Littersize (n)						
- born	2.5	(0.03)	3.1	(0.1)	2.6	(0.1)
- weaned	2.1	(0.03)	2.8	(0.1)	2.2	(0.1)
Litterweight (g)						
- at birth	218	(2)	288	(9)	336	(10)
- at weaning	442	(7)	485	(19)	516	(21)
Dams weight at birth (g)	635	(3)	795	(12)	979	(14)
Interval between litters (days)	73.4	(0.4)	70.1	(0.7)	73.4	(0.9)
Yield per year						
- number of litters (n)	4.2	(0.1)	4.1	(0.2)	3.1	(0.2)
- number of offspring born (n)	10.2	(0.2)	13.1	(0.8)	9.0	(0.7)
- number of offspring weaned (n)	8.2	(0.2)	11.9	(0.7)	8.0	(0.7)
- weight of offspring born	916	(23)	1236	(81)	1133	(77)
- weight of offspring weaned	1680	(47)	2028	(148)	1756	(139)

[1] weaning age: 21 days for local ecotypes, 14 days for improved lines
Test period: 5 litters each
Tested animals: 1223 mothers, 2809 offspring (local ecotypes); 390 mothers, 1759 offspring (improved lines)
Source: Valle Zárate 1996b

exploitation of the livestock biodiversity. The first step was a long-term evaluation of the prevailing camelid-based farming systems within the fragile environment. The aim was to identify 'desirable attributes' within the local genetic resources and use these to design breeding programmes for their conservation by utilisation (Valle Zárate 1996b). Respect of the herders' culture and special ways, and inclusion of the herders from the first steps of planning and preparation, is paramount for the success of this type of breeding work. The methods used and results of the long-term study are summarised briefly below.

The study was conducted over 14 months in Bolivia in the Wallat 'ani Communityarea (16° 56' S and 66° 32' W), Cocapata Canton, Ayopaya Province, Cochabamba Department, and covered 2,000 hectares at 4,400 masl in the Cocapata Cordillera. The study focused on 5 families owning 150 llamas, 400 sheep, and 70 alpacas. The methods used included participant-based observation; interviews with questionnaires and on a range of topics; physical measurement of climate, soil and water; determination of vegetation; measurement of reproduction performance, weight gain, milk yield, and fibre and meat production; and analysis of hygienic status.

The results of the investigation of livestock husbandry patterns are summarised in Table 5.2.

Table 5.2: Livestock husbandry patterns in a community of herders in the Bolivian Andes

Ownership and Labour Distribution	
Women	sheep, household
Men	llamas, potatoes, alpacas
Main Monetary Flow	
Major income	potatoes, dung occasionally meat, animals, fibre, transport fees, off-farm-labour
Major spending	Transport occasionally animals
Contribution of Animals to Subsistence	
Sheep	wool, meat, milk, dung
Llamas	dung, transport, meat, wool
Pastoralism	
Transhumance drastically reduced	
Sheep	herding and enclosure at night
Llamas	free ranging breeding herd kept closer to households castrated animals grazing at distant places
Alpacas	requiring special care as an innovation
Reproduction	
Uncontrolled mating, birth, and weaning	
High mortality	
Shearing	
Mainly November, occasionally May	
Age at first shearing: ≥ 4 years	
Frequency: ≥ 2 years	
Sorting for colour only	
Prospects for marketing unclear	
Slaughtering	
Seasonal pattern	
Old or ill animals	
Animal health and hygiene	
Infestation by coccidioes (sarcocystiosis)	
Scabies (*Sarcoptes scabiei*)	
Lice	
High occurrence of diarrhoea in foals	
Traditional and chemical treatments	
Treatment sporadic and never on all animals affected	
Indifferent attitude towards animals' well-being	
Product utilization	
Low extraction rates of animals, meat, milk, and fibre	
Dung the product used most systematically and extracted most frequently (fuel, market, products, fertiliser)	
Sheep dung and potatoes the major products exploited commercially	
Mainly household consumption of milk, fibre, and meat, and home use of llama dung	
Declining importance of llamas for transport	

Source: Nuernberg and Valle Zárate 1999

Various characteristics of the fleece quality of the local llama population in Ayopaya were studied and compared with those of a flock from the Andean plains (Condoriri). The results are shown in Table 5.3.

Table 5.3: **Significant differences (LS means) between llama fleece traits in mountain and plains region animals**

Region	Number of animals	Mean fibre diameter (µm)	S.D. of fibre diameter (µm)	Fine fibre (%)	Mean diameter of fine fibres (µm)	Kemp (%)
Condoriri	96	28.0 a	11.7 a	73.3 a	22.8 a	15.2 a
Ayopaya	861	23.2 b	8.0 b	89.3 b	21.2 b	0.8 b

Significant differences are indicated by different letters (Tukey-Kramer $p < 0.05$)
S.D. = standard deviation
Source: Delgado et al. 1999

The Ayopaya llama stock had a very high quality fleece with a high percentage of undercoat and fine fibre of small diameter. The quality was much higher than that of the llama population in the Andean plains, but this advantage has remained virtually unexploited. Currently, breeding activities are in progress with the aim of planning breeding for conservation and further development of the unique Ayopaya ecotypes of llamas.

Organisation of on-farm conservation programmes for autochthonous pig breeds with small farmers in mountainous regions of Northern Vietnam

The third example of a research project aimed at the maintenance of livestock biodiversity in mountainous regions is concerned with the conservation of autochthonous pig breeds in mountainous regions of Northern Vietnam (Lemke et al. 2000). This project is being carried out in collaboration with scientists of the National Institute of Animal Husbandry in Hanoi and focuses on the organisation of on-farm conservation of indigenous breeds. Purebred reproduction is accomplished by means of contracts between farmers and the research station. Different types of contracts are studied, for example with logistically favoured farms, who receive higher prices for their services in reproducing breeds economically not best suited to their farming conditions, and with logistically disadvantaged farms in remote mountainous areas, where the breeds make sense in the farm context but the costs of gathering performance records are increased. This example highlights the necessity of an interdisciplinary approach with a permanent interaction between researchers and the herders and farmers indispensable to programmes for the conservation of livestock biodiversity, especially in mountainous areas. Scientific approaches will only prove useful and sustainable when they are placed in the proper context, incorporating scientific analytical tools and technical skills in local processes of decision-making.

Factors Influencing Livestock Biodiversity

The following discussion focuses on the interrelationships between livestock biodiversity and nature conservation, sustainable development, indigenous knowledge, and property rights.

Livestock biodiversity as a component of nature

As yet, little has been done to characterise livestock resources, whereas continuous attempts are being made to replace them.

- Government policy is to upgrade and replace local types with improved stock.
- The purity of native types is being lost in some areas through informal programmes carried out by the farmers themselves (Wilson 1997).

Livestock biodiversity versus nature conservation

The worldwide assumption underlying the focus on conservation can be expressed as follows.

Human land use for subsistence leads to degradation and is incompatible with the maintenance of high levels of biological diversity. Therefore more inclusive conservation policies within and beyond protected area boundaries are imperative while recognising

- the difficulties associated with implementing restrictive policies, and
- the fact that human land-use practices may not lead to degradation or to a decline in biological diversity (Saberwal 1996).

Livestock biodiversity pro nature conservation

- Advantage must be taken of the valuable interaction between livestock and natural resources.
- At present, overgrazing of some mountain pastures and undergrazing of others (as a result of the depopulation of animals in environmentally difficult areas) have resulted in land degradation.
- Ecological studies to determine optimum stocking densities should be carried out in each region in order to facilitate sustainablity, biodiversity, and nature conservation measures. Appropriate adjustments should be made in pastureland management regulations and appropriate incentives given to farmers (Zervas 1998).

Livestock biodiversity and sustainable development

The general compatibility of on-farm conservation efforts with livestock development approaches has been shown recently by

- Joshi and Rasali (1998),

- own results and experiences as cited above, and
- Somlo (1997), who reported the results of two projects in Argentina showing the possibility of conservation of environment and biodiversity by means of sustainable development. The projects were concerned with pasture management and livestock production, and livestock and forestry development, respectively, and were aimed at improving food production in an area with special problems and providing opportunities to change from a condition of absolute poverty to one of self-sufficiency with dignity.

Conservation of livestock biodiversity must be included when defining 'sustainablity' because

- the maintenance of the natural capital stock is a minimum condition for sustainable development (Orlove and Brush 1996), and
- sustainability includes aspects of ecological sustainability such as environmental sustainability and maintenance of biodiversity, as well as ethical and economic sustainability (Torp-Donner and Juga 1997).

Livestock biodiversity, indigenous knowledge and property rights

The following are already common practice.

- The use of indigenous knowledge for rapidly assessing trends in biodiversity (e.g., Hellier et al. 1999)
- Recommendations of the sort given in the study on 'The importance of genetic diversity in livestock populations of the future' by Notter (1999): "Maintain an aggressive program of sampling and evaluation of exotic breeds with potential for immediate use." This basically means looking for favourable alleles in otherwise lowly productive stocks. The intention is to use this cryptic variation as a contribution to future selection response.

Pertinent considerations are as follow.

- Distance measures describing similarities resulting from common ancestry should be used only as an initial criterion in making breed conservation decisions (Barker 1999).
- Biodiversity and indigenous knowledge systems should be recognised under a new intellectual property regime (Dobhal 1999).
- Much depends on the local knowledge of agriculturalists about the importance of different species and the conditions for their survival. Thus it is not only important to preserve this diversity, but also to avoid the acquisition of local knowledge by developed countries becoming expropriation of this local knowledge without proper reward (Gomez Benito 1995).

Threats and Opportunities: Conclusions

Threats (challenges)

- There is still a very powerful tendency to replace local livestock resources with ill-adapted high-yielding exotics.
- Much work remains to be done in the characterisation of the performance and special traits of local breeds.
- Genetic impact analysis is not yet routine in areas where exotic breeds are used, neither in the choice of the appropriate level of intensification of breeding and production, nor in the re-evaluation and worldwide diversification of breeding goals.
- There is a common belief in the competence of the international scientific system to come up with simple solutions for the complex problems of specific local people and ecosystems. However, the solutions offered are often technically narrow and short-term and result in
  - the investment of available funds mainly in (aggressive) programmes for sampling and evaluation of exotic breeds with potential use elsewhere; and
  - decisions about which breeds, strains, or ecotypes should be conserved being taken on the basis of mostly questionable, narrow approaches to the description of genetic diversity.
- The importance of livestock biodiversity as an integral part of nature conservation and sustainable development, particularly in fragile and globally important ecosystems such as the mountain areas, still tends to be overlooked and the implications neglected.

Opportunities

- There is increasing recognition of the important role of livestock keepers in safeguarding domestic animal diversity through their animal husbandry (Hall 1996).
- After decades of development debacles with alien breeds, scientists and developers have at last come to appreciate the vast animal genetic resources that ordinary farmers and herders have developed through the ages, especially in the South (McCorkle 1999).
- Many rural societies are confronting the loss of biological diversity and culture. Fortunately, there are also many examples of rural people strengthening their knowledge, traditions, and spirituality to meet the needs of the next millennium (Dankelmann and Ramprasad 1999).

In order to encourage and empower local people to continue keeping their unique genetic livestock resources in ecologically fragile, globally important environments, it is necessary that herders and farmers in programmes of biodiversity conservation and regeneration are directly involved and supported in the following.

- Decision-making, planning, and implementation
- Direction of funds to the specific sites of action
- Provision of legal support and assistance for problems related to property and utilisation rights
- Provision of subsidies for such things as landscape protection services in situations where farmers and herders are encouraged to develop extensive production systems with local genetic resources on the basis of local fodder rather than opting for individually more profitable intensive high-input, high-residue production systems

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Chapter 6

Technological & Institutional Changes Affecting Mixed Crop-Livestock Production Systems in the Andes

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Background

The economic opening of the Andean countries (Colombia, Ecuador, Peru, and Bolivia) at the beginning of the 1990s led to a substantial modification of the mixed crop-livestock production systems of small producers in the mountain regions. Many of the basic crops (corn, wheat, and barley) went out of production as a result of increasing imports. The area previously used for mixed crops with livestock production was not replaced with any specific crop and became fallow. In the case of Colombia, the cultivated area decreased by 1 million hectares between 1990 and 1998.

The theory of economic liberalisation includes mechanisms to support the primary sectors that are most affected. However, the dislocation was so significant, that none of the countries was able to allocate sufficient resources to cope with the effects, leaving the mixed systems in a disadvantageous position with respect to other production systems. Contrary to what was expected, the governments actually increased their public expenditures creating fiscal deficits that will be impossible to handle rationally in the next 10 years (gross domestic product debt service jumped from 1% to 6% GDP). The limited availability of resources makes the political cost of investing in poor areas very high, drastically limiting the willingness of governments to invest directly to help small producers.

During the 1990s pressure from the service and industry sectors ensured that the rates of exchange were maintained below their equilibrium levels, thus favouring the

import of crop-livestock products and showing a clear bias towards local producers (Table 6.1). As a result of this management of the exchange rates, the debts of the countries increased disproportionately and there were no possibilities for exporting crop-livestock products. For example, Colombia's debt increased from US$ 13,000 to US$ 40,000 million, without any increase in the export volume of US$ 6,000 million.

Table 6.1: **Factors affecting the prices to farmers in Colombia: annual average over the period 1990-1998 (%)**

Commodity	Price to farmers	International price	Real currency exchange rate	Tariffs	Others
Maize	-11.29	-0.59	-8.16	-0.28	-2.26
Sorghum	-8.89	0.99	-8.16	0.32	0.58
Rice	-1.82	0.08	-8.16	0.98	7.24
Wheat	-12.4	0.83	-8.16	-1.26	-3.8
Sugar	-2.22	-2.88	-8.16	1.48	7.34
Cotton	-7.62	-1.83	-8.16	0.0	2.38
Coffee	-4.09	3.76	-8.16	0.85	-1.58

Source: Jaramillo (1998)

Other structures created during the modernisation process of the states with the intention of contributing to development have had a limited effect. Semi-fiscal fund managers are interested in state-of-the-art technology and very few are willing to invest in infrastructure and/or support small-scale production systems or, even less, mixed crop-livestock production systems.

In addition to the economic aspects, nature has been a very important factor in the sectoral performance of agriculture. The last El Niño was one of the strongest events in the last 40 years, and investments to repair infrastructural damage and compensate for harvest loss have affected both government financial resources and producers' savings.

These macroeconomic conditions have had a direct impact on poor producers. The studies at field level show that

(1) small and medium size producers are under capitalised;
(2) the current interest rates (Figure 6.1) are higher than the profitability that is being obtained in the production systems;
(3) the differences between credit terms and effective durability significantly reduce the possibilities of embarking on the production of long-term crops and/or livestock (Figure 6.2); and
(4) the current production systems do not, and will not, generate the surplus capital necessary to graduate to more intensive systems, which is the only way to modernise the area of small producers and to increase incomes.

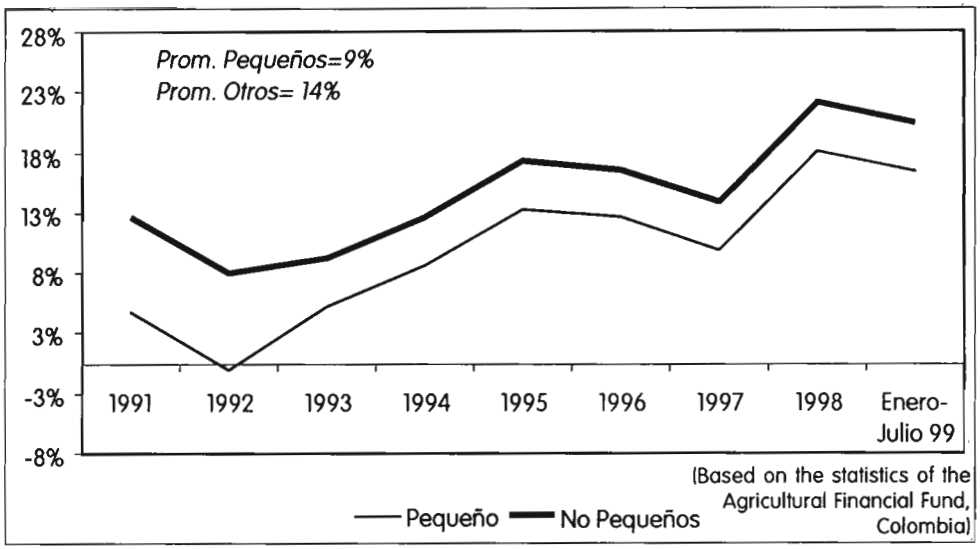

Figure 6.1: **Real interest rates in the agricultural sector of Colombia**

The objective of this paper is to present an analysis of the situation and to suggest steps related to agriculture in general and mixed systems in particular that can be implemented in order to improve the quality of life of the small producers. The CONDESAN experience in the Andean countries is reviewed and the following points are discussed.

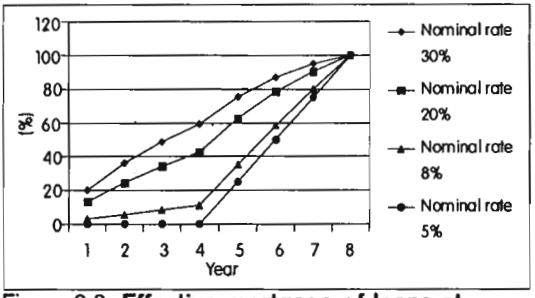

Figure 6.2: **Effective mortgage of loans at different nominal interest rates**

- The stability in the medium term (10 years) of the changes introduced by the economic liberalisation. Greater emphasis is placed on the possibility of financing through the formal system and the political willingness to invest public resources in mixed systems of small producers.
- The impact these changes could have on the evolution of the rural sector and mixed systems in particular
- The clearly defined steps followed by CONDESAN in some selected sites in Andean countries in order to improve the quality of life of small producers and to promote mixed farming systems
- Determination of the mechanisms of support that should be strengthened and the needs for research that could contribute to a better performance of these systems

The subjects that are presented are complex. Although they are widely discussed in forums for development they are seldom analysed comprehensively or evaluated in

terms of the different trade-offs between different hierarchical levels. This presentation is intended to contribute to the integration of research and development activities.

The additional mortgage (M) was estimated as $M=C*I_n/(1+I_f)^n - C(I_n - I_f)$; where C is the capital, I_n, the nominal interest rate, and I_f, the inflation rate.

The Stability in the Medium Term (10 years) of the Changes Introduced by the Economic Liberalisation

Notwithstanding the possibility of changes in policy in the different countries, clear scenarios can be foreseen in the following.

The power and size of the state

The magnitude of the fiscal deficits, the impossibility of collecting new taxes, the excessive size of the Andean states, and the increasing reluctance of foreign capital to invest in these countries all indicate that in the next 10 years the different states will have little ability to affect the markets of inputs and products, even if there is political commitment. As a result, the state resources intended to benefit defined target populations will be reduced and will have little impact on investment decisions at the field level. Thus the push needed by mixed farming systems will have to come from the private sector, and the great challenge will be to convince the private sector that these alternative methods of production are profitable when international market prices are taken into consideration.

The financing system: the basis of financing and the economic backing

Until 1995, eligibility for obtaining credit was based mainly on the value of the land equity. The quality of the investment projects submitted was of little importance. This was a very safe system for bankers since the value of land kept rising. This system was based on several negative principles that later prevented the agricultural sector from competing in an open economic scheme.

The principal limitations of this approach were as follow.

- The determining factor for credit approval was the accounting balance of capital, and not the quality of the project with respect to risk, cash flow, or generation of employment.
- Since the banking operation incurred little risk, credit allocation was related to aspects such as the average amount in checking accounts and friendships.
- The guilds and producer associations were not concerned about showing the bankers the efficiency of their businesses, or their limitations and opportunities. In turn, the bankers were not concerned about grading their clients according to the seriousness of the investment.

- There was a reduced emphasis on monitoring the investment in the field. In practice, many of the loans were diverted to other sectors of the economy in several Latin American countries.
- The bankers, as partners in the agricultural operation, were not concerned about adoption of technologies and even less with training of the workers.
- The producers were under no pressure to facilitate strategic alliances in order to reduce costs and achieve long-term price stability.
- No importance was given to cash flows and hence no project analysed the difference between the term and the effective duration of the credit.
- Producers were led to incur large debts (80% of the value of their land) in a system where land represented more than 70% of their assets. The viability of these systems relied on a continuous scheme of high inflation, high internal protection, and the valuation of land.
- This approach left the small producer sector in the hands of an official bank that proved to be the least transparent in the management of credit and in the process of identifying the possibilities of investment.
- It eliminated credit as a flexible and efficient mechanism that could be used by governments to orient policy changes.

New volumes of capital

With the economic opening, important volumes of capital arrived. A great proportion of this capital was used for short-term investments that helped increase the expenditure on industrial goods. This increase in expenditure reduced national savings, thus creating a structural problem and affecting long-term investments. This caused the banks to limit financing to urban consumption activities, with very little priority given to short-term agricultural and livestock investments, and elimination of long-term investments from their portfolios.

Rates of interest and indebtedness of agricultural and livestock producers

The profitability of investments to promote consumption was very high which led the banks to set high interest rates in order to capture private savings. These rates were applied to agricultural and livestock credits at the same time as there was an effective reduction in the prices for their products. This brought about generalised bankruptcy in the rural sector and a rural mass of over 500,000 people who could not be given credit.

The following factors combined to create a vicious cycle.

- As a result of limitations in funds, credit was allocated to short-term projects few of which were in agriculture.
- Long-term projects were faced with short-term credit rates, making them non-viable, even though these types of projects offer better opportunities for investment.

- The governments did not have the resources to contribute as counterpart to credits for international development; the private sector was willing to give this backing but only for urban investment.
- The governments did not want to devalue their currencies to the point of balance because of pressure from industrialists who had acquired debts in dollars and entered into a process of modernisation based on the expectation of a market expansion that in fact never arrived.

Given this background, it is reasonable to predict that there will be a very deep barrier between the agricultural and the capital market for at least the next five years. This implies very little backing from the formal financing system for the agricultural and livestock sector.

The Impact of the Changes on the Evolution of the Rural Sector and on Mixed Farming Systems

The countries of the Andean area were in a process of expansion between 1970 and 1990. With the new macro-economic scenarios and possibilities of financing, investments concentrated on those crops with a high profitability, which led to a significant reduction in the area under traditional crops, and limited agricultural production to those sites with a competitive advantage.

This evolution had been foreseen and discussed for more than 10 years, but few analysts imagined the large amount of unemployment, and the associated problems, that would be generated. The intensive cropping did not compensate for the great displacement of the labour formerly utilised in growing the traditional crops that began to be replaced by imports. The countries were not prepared for rural unemployment (20% direct unemployment and 50% underemployment), and this in turn has led the governments to propose the need to approach rural development as a problem of equity rather than productivity.

The least capital-intensive operations, such as the mixed-farming systems, will have little opportunity to be relocated to sites with a greater comparative advantage. However, there is a strong possibility that small farmers will be able to increase their landholdings (agricultural area) because for the first time in the last thirty years the price of land has gone down — by more than 60%.

CONDESAN's Efforts to Help Small Farmers in the Andean Countries

The operation sizes of farms could be improved if the opportunity to expand the area under mixed farming systems could be exploited, but this will only be possible

if concrete steps are undertaken. The following paragraphs summarise the activities being implemented in several benchmark areas by the Consortium for the Sustainable Development of the Andean Region (CONDESAN). The main objective is to help the governments solve the problem of ensuring equity and management of natural resources while focusing on technical and economic efficiency.

Under the present circumstances, the big challenges of the rural sector will be the use of under-utilised land to generate new jobs, ensuring adequate handling of natural resources, and guaranteeing food security. For mixed farming systems, the discussions should focus on their economic competitiveness with other forms of employment generation (like tourism, agroindustry, and construction of roads) and other forms of management of natural resources (like forests to protect water sources and capture CO_2 and construction of terraces). It will be easier to convince governments if the mixed systems are more efficient per invested dollar than the alternatives. This implies quantifying the trade-off between generation of employment and the value of the environmental externalities.

The CONDESAN strategy is based on the premise that there is available land that is under utilised and now low cost. As mentioned above, lack of land for exploitation by mixed farming systems is no longer the limitation that it was before the 1990s. Furthermore, there are capitalists and landowners who want to enter into strategic alliances to ensure their possession of the land and/or production of raw materials

The current scenario can be summarised briefly as follows.

- There are few small producers who can finance the establishment of mixed farming systems on a scale that guarantees an equivalent wage with the rest of the society.
- Even though the value of land has dropped, many producers still cannot accumulate enough capital to purchase land and thus expand the size of their operation.
- With the increased levels of unemployment, farming families have fewer off-farm opportunities to gain cash income, so the cash cost of capital has increased for the small producer.
- The states are neither willing, nor have they the capital, to finance the establishment of mixed farming systems completely, even if it is shown that this is one of the better alternatives for investment.

Given this scenario, the most viable solution is to enter into commercial alliances with entrepreneurs and/or large producers, who are in turn supported by the state with levels of investment in the order of 30%. These alliances should be

administered initially by the private sector, and subsequently evolve towards administration by producers with a greater business capacity.

There is a consensus about the need to make the change through strategic alliances. This is the result of recognition of such things as the likelihood of better administration, the advantages of vertical integration of the production chain, and the likelihood that agreements will be reached on prices at critical moments. However, it is absolutely necessary to have objective criteria so that the investment can be prioritised in such a way that it fulfils the expectations of the partners.

CONDESAN's approach is illustrated by an example: the Livestock Fund for Development in the town of Pensilvania, Colombia (CONDESAN 1999). The results of the ongoing case study are summarised below.

Initial conditions

- Low-producing farms on hillsides - 2.5 kg of milk per day, 0.8 AU (animal units) per ha
- Cows with low milk production potential
- High rainfall, high erosion
- Technology validated under similar ecological conditions
- No funds to buy grass and legume seeds or improved cows
- Short-term profitability not enough to pay loans
- No matching funds to have access to Government Guarantee funds

Challenges for CONDESAN

- Design a project that would be attractive to farmers and others
- Encourage the creation of a farmers' association and a livestock fund
- Create a strategic alliance including the local government and the private sector based on actual revenues for all the partners
- Help negotiate the financial support
- Create the financial mechanisms that would stimulate participation

Project highlights

- Designed to increase milk production from 300 to 1,200 kg of milk per lactation
- Increase stocking rate from 0.8 to 1.5 AU/ha
- Increase parturition rate from less than 55 to 70%
- Provide farmers with up to 1000 improved cows (up to 8 cows per household)
- Benefit 250 farmers
- Investment required : $887,000 (80 % from a loan and 20 % from the private sector)

- Revenue in net present value (NPV): a) farmers $709,000; b) livestock fund $349,000 (private sector)
- Negative cash flow during the first four years $221,000. Two thirds covered by farmers from the profits and one third by the livestock fund.

Each member of the alliance plays a complementary role. The foundation Darío Maya was given the responsibility of creating a farmers' association to manage the fund. The local government, through the municipal extension agency, has the obligation of providing technical assistance to the farmers at different stages of the project, including marketing of the final products. The Federation of Coffee Growers was asked to organise the community and become the main private sector partner to provide the initial funds needed to create the livestock fund. The Banco Cafetero was the financial source of the loan. CONDESAN is providing funds and backstopping and facilitating the process. Farmers sign an agreement of co-responsibility to pay the loan and to share 50% of their profits with the livestock fund.

Some Lessons Learned

- Strategic alliances with the private sector require government funds in the order of 30% of the total amount required. In order to achieve this, the project must focus on including governmental priorities such as generation of rural employment or protection of the environment.
- The fund should be managed initially by the private sector and then transferred to farmers. The process should include training of farmers in managerial skills.
- The operational size of the participating farms is critical. The size should be sufficient to minimise fixed costs and for efficiency.
- Fast implementation should be a priority. Thus the product selected should be one that has a high demand from the private sector partners. Having partners from the private sector who have strong links to local and international markets facilitates fast implementation of the project.
- The geographical coverage should be selected in such a way that as many small farmers as is economically viable are included. The alliance must be able to be effective over a wide area without its profitability being significantly reduced. This is necessary so that the alliance can select areas with biological potential, since this guarantees productivity, and enables the inclusion of an adequate number of small farmers working in areas where a large impact on environmental factors is expected.
- It is of utmost importance to generate income within a short time frame. This is the most attractive bait for the private sector to ensure future investment that will benefit a larger rural population. Products with production periods of less than 18 months have a clear advantage.

- A very important part of the economic and social benefit is related to the potential evolution of the alliances. It is expected that one by-product of the alliances would be an increasing evolution towards niches where the population is poor and a large environmental impact can be expected. The government is willing to invest in order to achieve this change. The ex ante analysis shows that alternative approaches may produce a large total benefit (economic and social). Some products are more suitable than others for this evolution, but in most cases it depends on the capacity of the convocation and leadership of the entrepreneurs and managing partners.
- Long-term products currently have better profitability. Timely investment can make use of cyclic prices in both the national and international markets. The profitability of the investment and the cash flows are closely related to the starting time of the activity. Thus current and future prices should be regarded as a key element in identifying the niches for investment in Andean countries. For example; the prices of livestock have been low for the last 40 years. This suggests that the region is at a stage of liquidation of inventories that will be compensated for in the future by higher prices, even for domestic consumption. Judging the right moment for investment requires long-term information and involves studies of cycles of production and prices. Entering these businesses without good knowledge of these fluctuations is very risky. For many of the products analysed, the present moment is not the time to invest.
- Alternative sources of finance — The large export companies have access to credit in dollars. It would be impractical to allocate resources to them through the internal system when only the endorsement of the government will make it possible to attract new capital to the sector.
- Maintaining/creating rural employment — The investment necessary for generating permanent employment is a major issue. Unemployment is one of the principal problems that we are facing in rural areas and is a valid indicator for identifying the niches where government investment would be more effective. There are good opportunities to invest in small producers who can increase their profitability with minor changes of management.
- Equivalent income of the producers that enter into the alliance — The shadow prices for farmers adjusted for the costs of basic services would be an indicator that would show the regional niches where investment should be focused. The shadow price of wages is one of the most decisive factors in the profitability of the alliances. The critical economic situation in the Andean countries is making farmers enter into alliances where they contribute labour for 12 months without receiving any payment in cash, only receiving any income at the time of harvest.

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Chapter 7

Challenges and Opportunities for Livestock Development in the Highlands of Ethiopia

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Introduction

Ethiopia lies between 3° and 18° N and 33° and 48 °E. It covers a total of 122.4 million hectares. The altitude varies from a depression of 120m below sea level to mountain peaks of over 4,600m above sea level. The country is endowed with a mosaic of agroecological zones that provide opportunities for different production systems with various types and degrees of constraints. Most of the crop production is dependent on rainfed agriculture. Currently, it is estimated that about 160,000 ha of land is under irrigation. However, the country has an estimated three million hectares of potentially irrigable land.

There are several definitions of the term highlands, in this presentation it is used to denote areas above 1,200 masl with more than 400 mm of rainfall in five consecutive months. Most of these highland areas consist of high plateaux and mountain ranges. The highlands of Ethiopia account for about 36% of the total land area and 95% of the cropped area, and are home to 81% of the population, with an average population density of 64 persons per square kilometre, and two-thirds of the livestock population. Landholdings vary – almost 60% of agricultural land is in smallholder holdings of less than 2 ha.

The influence of man and his domestic animals has profoundly altered both the ecology and landscape of the Ethiopian highlands. Ecological degradation is one of the main challenges in this region. The following sections highlight the state of the

resource base, R&D investments and the scope to improve livestock research efforts, and future research directions to improve the productivity of the eco-regions.

The Highlands of Ethiopia

The Great Rift Valley separates the western and south-eastern highlands of Ethiopia. Semi-arid lowland areas lie to the east and west of both these highland areas. About 86% of the land surface area lies between 1,200m and 2,400m (Table 7.1). In general, the climate is cool; and temperatures vary with altitude. The mean temperature is approximately 20°C. The annual range of temperature is relatively small, but the range in average daily temperature is wide. The mean daily temperature drops by about 0.6°C for each 100m increase in altitude.

Table 7.1: **Altitude of highland areas**

Altitude range (masl)	Percentage	Altitude range (masl)	Percentage
1200-1500	21	2100-2400	16
1500-1800	26	2400-2700	8
1800-2100	23	>2700	6

Annual rainfall varies considerably with elevation from 1,000m to 1,800m and much of this precipitation falls between June and September. In the southern and eastern highlands, the rainfall is bimodal, with peaks in April and September. The dry season extends from October to February. Frost occurs in areas above 1,800m and becomes severe above 2,000m. The main growing season in most parts of the highlands is between June and October.

The wide range in climate topography, parent material, and land use has resulted in the formation of different types of soils. The major soil types are cambisols (23.9%), nitosols (21.8%), lithosols (14.2%), vertisols (13.5%), and luvisols (10%). Vertisols are the main soil type in the shallow valleys, and in these areas waterlogging as a result of poor surface and internal drainage is a limiting problem for crop production. Soil erosion is a problem in all parts of the Ethiopian highlands with a major loss of fertile topsoil. It is estimated that Ethiopia loses about 2 billion tonnes of soil every year, with the major contribution from the highland areas.

The estimated population in 1996 was nearly 56 million, growing at an annual rate of 8.3%. About 80-85% of the population is employed in agriculture. The population density in the highlands varies in different areas, the percentage area with different population densities is shown in Table 7.2.

Table 7.2: **Population density in the highlands**

Range (persons per sq.km)	Percentage
0-25	17
25-75	30
75-175	40
>175	12

The human population is increasingly at about 3% per annum and the demand for land is increasing. Smallholder farmers predominantly undertake agricultural production; landholdings are small and becoming increasingly fragmented. The increasing demand for agricultural land is largely being met by the expansion of agriculture into new areas and through intensification of land use in cultivated areas, which has shortened the fallow period. Landholding sizes vary, and almost 60% of all agricultural land is in smallholder holdings of less than 2 ha.

In the crop-livestock mixed farming areas, natural pastures are being taken over for cropping and crop residues and by-products are becoming important in the animal diet. Nationally, crop residues provide 10 to 15% of the intake of feed by livestock, but in some areas they provide up to an estimated 50%.

Livestock in Production Systems

Animal Resources

Ethiopia has almost 80 million domestic grazing animals equivalent to at least 35 million TLU (tropical livestock units), or about 0.62 TLU per person. Ethiopia ranks first in Africa in the number of cattle and equines and second and third in sheep, goats, and camels. Some three million traditional beehives in the various farming systems produce about 25,000 tonnes of honey per year, which represents one-third of the total honey production of the African continent.

The highlands contain about 95% of the cropped area and support two-thirds of the livestock population. It is estimated that the highland areas contain 75-80% of the national cattle and sheep flocks and about 30% of the national goat flocks. Wildlife and national parks form an important part of the natural resources of the highlands. Over 100 species of wildlife and 800 species of birds are found in the country.

Animals and their products account for 30% of agricultural GDP, excluding the value of draught and manure. Animal power is very important to the agricultural sector and more than 90% of the cropland is cultivated using about 6 million draught animals, mainly oxen. Provision of draught power is the most important function of livestock in the mixed farming systems of the highlands. In real terms the value of draught power and manure is estimated at about 57% of the total output from cattle. Data from some highland areas suggest that draught power constitutes about 40% of the total gross income derived from bovines, meat, and manure about 20% each and milk 14%.

Equine power has been an integral part of the agricultural production system. Donkeys are used for over fifteen kinds of farm operations. They are also an important source of

income for many rural households, allowing farmers to diversify their sources of income. Donkeys are used to transport farm implements, farm inputs, and farm products. They are also used to pull carts carrying such things as water, humans, and building materials.

Livestock are also used as an important buffer in times of drought and crop failure, while milk is increasingly important in urban and peri-urban areas. Livestock contribute about 80% of cash income in the central highlands.

Dung is used as a source of fuel; animal dung and by-products contribute about 16.5% of fuel energy sources. The use of dung for fuel is promoted by the increasing scarcity of fuelwood.

Constraints

The major environmental challenges in the highlands include severe deforestation, too intense cultivation, and a reduction in grazing area. There is little industrialisation or economic diversification – population growth is the driving force for environmental degradation. Soil fertility problems are inherent as a result of the soil type, soil depth, and soil fertility management system. Soil fertility management is based on the use of cow manure, crop rotation, and leaving fallow. However, manure is only applied to a limited extent as it is used as fuel in most highland areas. Leaving land fallow is also decreasing as a result of the scarcity of land with the ever-increasing population.

The livestock sector has been impeded by technical constraints, such as disease challenge and poor nutrition, and other factors such as inadequate investment, poor extension support, and lack of appropriate policies.

Ongoing Research Strategies

Research in livestock dates back more than three decades. The Institute of Agricultural Research (IAR) was established in 1967 and given the responsibility for guidance and coordination of national agricultural research. Considerable progress was made by the IAR in terms of capacity building and research in such areas as crop and livestock production, soil fertility and management, and socioeconomic conditions and policy. This was achieved under rather difficult conditions as a result of limitations in capacity and financial resources. In 1997, the IAR was re-organised and the Ethiopian Agricultural Research Organisation (EARO) was established to coordinate agricultural research at national level.

Dairy production

There is great potential for the development of smallholder dairy production systems in the highlands of Ethiopia. Various research efforts have been undertaken in the

areas of breeding and genetics, feed and nutrition, animal health, and processing and marketing of dairy products. Market-oriented urban and peri-urban dairy production systems are evolving in and around major cities and towns.

The major feed resources in the highlands are natural pastures and crop residues. Industrial by-products, such as bran and oil seed cake, are also available. Research into feed resources has focused on developing management options for grazing areas, improving the nutritive value and utilisation of crop residues, and integration of forage legumes and multipurpose trees into the farming systems.

Small ruminants form an integral part of the livestock production system in the highlands. Research into small ruminants has focused on improving wool production from sheep through crossbreeding local animals with exotic breeds, feeds and nutrition, disease problems, particularly parasite control, and other management issues.

Poultry production

Backyard poultry production using indigenous birds is a major smallholder occupation in the Ethiopian highlands. Research on poultry has focused on the development of management options for smallholder production systems, feeding and nutrition, and health.

Natural resource management

Soil and water management, conservation of biodiversity, and environmental protection are also concerns of the national research programme. Land fragmentation, an increasing human population, poor management of communal grazing areas, soil erosion, poor water management practices, and reduced crop and livestock productivity are all typical of the Ethiopian highlands. In order to address issues relating to soil and water management, a Joint Vertisol Project (JVP) was set up. The JVP is a collaborative research project of the Ministry of Agriculture (MOA), the Institute of Agricultural Research (IAR), the Alemaya University of Agriculture, the International Livestock Research Institute (ILRI), and the International Crops Research Institute for Semi-Arid Tropics (ICRISAT). This project has developed various tools and technologies to manage vertisols and increase crop and livestock productivity. Currently, the project is intending to address the issues at a bigger watershed level and in a more integrated manner.

Adoption of technology

The impact of agricultural research on the productivity of the sector has been low. There appear to be many weaknesses in the national research systems. In the sphere of agricultural service provision, the government has never given sufficient emphasis

to livestock. On the research side, there has been criticism of the use of improper methodologies for identifying, prioritising, and developing technologies to overcome production constraints. The country has not used the environmental approach as a tool for defining national research priorities. Research and development efforts were advocated in favour of uptake of a given technology on a broad basis; improvements were recommended for all farmers over a large geographical area despite the fact that biophysical and socioeconomic conditions vary across the region. This was the result of a lack of knowledge of the complex socioeconomic and biophysical issues of the farming system. Dispersion of efforts and inadequate linkages also led to inefficient use of the research capacity.

Future Research Directions

The current challenge of sustaining agricultural productivity to meet exigencies into the next century is complex and multifaceted. Achieving an accelerated growth rate of agriculture depends heavily on the availability of improved technologies, stimulated by institutional and policy changes. The change has to be built on an understanding of the system from the grass roots' level up, with a firm base on better management of human and natural resources.

The role of animal agriculture in the different agro-ecological zones and the factors affecting productivity are complex and vary to a large extent between zones and production systems. This has resulted in a wide array of choices for research to alleviate these constraints. Future livestock research should be based on an appreciation of the constraints and options in each major agro-ecological zone, and selection of researchable issues that try to take full advantage of the existing animal resources and their distribution and production potential.

The current government policy is to make agriculture the main driving force of the economy for generating employment and income for the poor, and a springboard for the development of other sectors. The Agricultural Development Led Industrialisation Strategy (ADLI) has been devised with the following major objectives:

- attainment of food self-sufficiency;
- improvement in the quality of life of the rural population through employment creation, poverty reduction, and improved nutrition; and
- reversing ecological degradation.

The overall goals of the national livestock research programmes are designed to respond to the overall agricultural policy of the country. Accordingly, the objectives of livestock research in the Ethiopian Agricultural Research Organisation (EARO) are

- to contribute to poverty alleviation and food security;
- to contribute to increased income and opportunities for employment through enhanced production and productivity;
- to contribute to the improvement and effectiveness of the technology transfer system;
- to formulate appropriate research-extension-farmer linkages to create opportunities for interaction between the different stakeholders and farmers;
- to develop production system appraisal through participatory methods; and
- to develop multi-disciplinary research programmes to address the complex issues of the farming community

Accordingly, livestock research in EARO has been organised into the following research programmes.

- Cattle milk
- Cattle meat
- Small ruminants
- Camels
- Animal power
- Fisheries and aquatic resources
- Poultry
- Apiculture
- Feed resources and animal nutrition
- Animal health
- Socioeconomics and policy
- Biotechnology

These research programmes have been organised in such a manner that they respond to needs of the different agroecological zones in the country. The following research themes have been delineated for the highlands.

Increased productivity and sustainability of crop-livestock production systems

- improvement of feed resources
- improvement of animal traction
- nutrient cycling and management
- health management at the farm level
- options for diversification of animal power

Improvement of market-oriented smallholder production

- development of feeding packages
- appropriate breeding schemes and recording systems

- efficient processing and handling methods
- health management and delivery services
- health standards for export of meat and live animals
- policy and institutional adjustments
- marketing

Conservation and utilisation of animal and forage genetic resources

- characterisation and evaluation of the genetic resources
- selection of animals for disease and parasite resistance

A number of research centres has been established to address these issues in a multidisciplinary manner. Various national and international institutions, NGOs, and other stakeholders also participate in the implementation of the research programmes.

Chapter 8

Highland Livestock Production Systems– Is there a need for specialised livestock product processing and marketing?

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Introduction

It is imperative for livestock production in highland areas that the local land and feed resources can be sustained. For this reason, the challenge of coping with the growing demands of the rising population in highland areas for livestock and livestock products cannot be met by simply increasing the herd size or the total livestock population in the area. In fact it is necessary to reduce the livestock population since grazing land is becoming scarce as a result of the expansion of settlements and use of land to grow crops. Thus the growing demands can only be met by increasing the productivity of single animals. Livestock production in the highlands will focus increasingly on higher yielding meat and dairy animals, more stall feeding, and utilisation of species particularly suitable for specific local conditions (e.g., buffaloes, small ruminants, rabbits, and poultry).

This situation must be taken into account when evaluating the potential in the highlands for the production of livestock products – meat and milk and processed products made from meat and milk - for local consumption and for more distant but economically attractive consumer markets in the lowlands.

Traditionally, livestock products in the highlands cater to the needs of the local population. In highland areas where food crops are scarce, the share of livestock products in the diet may even be above the country average and/or exceed the overall average in developing countries. For example, in Mongolia, the annual per capita

meat and milk consumption is very high (approximately 80 kg for meat and and even more for milk and dairy products) but the consumption of food crops is low.

In the highlands, as in other areas, livestock products are most commonly consumed in the form of fresh meat and fresh milk. However, certain processed products with an extended shelf life are prepared for the winter months when fresh meat and milk may not be available. Inedible animal by-products, especially wool, hides, and skins, are used less as highland populations now have access to industrially fabricated items that meet their requirements for clothing, shoes, and the types of housing made from animal products. Many by-products are sold as raw materials for industrial processing if there is a functioning collection system.

Meat Processing

At present only a limited range of processed meat products is manufactured in highland areas. Processing at high altitude is generally done on a small scale, although the processing methods used are the same in principle as in lower more populated and consumer-oriented regions. The higher altitudes favour certain processing techniques, however. A well-known example is the famous dried beef product originating in Switzerland – 'Buendnerfleisch'. This product is cured and fermented over a long period (up to 4 months). It is considered a delicacy and has the best quality when produced at about 1,500 to 2,000 masl where the air humidity and temperature pattern are ideal. Nowadays, drying in an artificially produced 'highland climate' is also common – but the best quality products still come from natural highland drying. This rather costly product is not appropriate to cater for nutritional needs in developing countries, but the product could be of interest for the tourist trade and for export.

Solar drying of buffalo, beef, or goat meat, which takes a few days to a week or so only, is a cheaper method of meat preservation. Some highland areas have a long tradition of preparing such products (e.g., 'sukuti' in Nepal, pemmican in North America). These dried products can be used for various meat dishes and soup. The advantage is that they can be stored and transported without refrigeration. Semi-dried processed products have also been developed, in particular from pork, using the natural conditions in highland areas. The most popular product in many parts of the world is semi-dried ham, which in its origins is a product of highland processing, such as jamon Serrano (from Spain), prosciutto di Parma (from Italy) or Jinhua ham (from China). The processing technology for all these products is similar, and in all cases the favourable climatic conditions in the highlands were significant for the development of the technology.

In general, drying is the preferred method of food processing and preservation at high altitudes. The low temperature and low air humidity prevent fast microbiological spoilage. The products quickly achieve values of water activity (a_w) and acidity (pH) that are sufficient to make them shelf-stable even when brought down to lowland areas with a higher temperature and humidity.

Simple but physically adequate methods have been developed for food drying for commercial purposes like the so-called solar cabinet and tunnel drying. These methods are used widely in developing countries with an abundance of sunshine for drying fruit, in particular for export. FAO has modified the method for drying meat with very good results. Meat cut into flat pieces or in strips or chips can be dried easily and hygienically. Refrigeration is not required for storage and transport of the dried meat. The construction costs for the solar dryers, a solar collector, and a drying cabinet are low. The only materials needed are transparent plastic foil and timber, and the energy for the process is free as it comes from the sun.

People in highland regions, as in most rural areas in the developing world, have little knowledge of basic meat processing methods other than simple drying of meat through direct exposure to the sun, which is widely practised. Meat processing using crop/meat mixes can help make meat affordable for the rural poor and considerably upgrade rural diets. FAO has initiated the dissemination of such simple meat processing methods to rural areas, particularly addressing rural women. Assessment of the meat supply practices in different highland regions could lead to the introduction of new meat processing methods that make better use of the locally available meat resources.

Dairy Processing

Product processing and marketing in highland areas are in many cases better developed in the dairy than in the meat sector. Successful dairy processing depends on a variety of factors including:

- the accessibility and nature of markets;
- the availability of milk, surplus to homestead requirements, from a sufficient number of milk producers;
- economies of milk collection and rural infrastructure; and
- the suitability of available processing equipment and training.

There are some highland regions where considerable progress has been achieved in infrastructural development for dairy producers. For example, in the Kenyan highlands more than 400,000 mainly small-scale milk producers not only supply local communities but now access rapidly expanding urban markets, facilitated by

milk collecting systems based on producer groups and a relatively good rural infrastructure (milk collecting centres, electricity, access roads). Since the dairy industry was deregulated in the early 1990s, over 100 small and medium-scale milk processing enterprises have emerged to challenge successfully the monopoly of a parastatal dairy cooperative. These enterprises collect, process, and market a diversified range of specialised dairy products. The shorter life products include pasteurised milk and cultured products while longer life products include butter and cheese – one well-known brand even goes by the name of Highland Cheese.

FAO assisted with a project to develop and introduce short-term vocational and outreach training for these new dairy entrepreneurs and their staff. Women are especially involved, both as owners of processing enterprises and as employees. Small-scale producers and processors are starting to obtain a larger share of the consumer price, even so as much as half the milk marketed in Kenya is still sold through informal markets by intermediaries.

In the high hills of Nepal, the terrain is more difficult. As a result, the rural infrastructure is not as well developed. Producer groups and milk collecting systems are now the backbone of the milk processing industry with over 100,000 small producers delivering milk daily to dairy enterprises. The dairy products have developed along different and more traditional lines. Historically, the key need was to convert milk into products for consumption during the long winter months. Products include 'ghee' or 'ghiu' (clarified butter), made by churning soured milk from cows or buffaloes into butter or from cream after skimming; and very hard cheese-like products such as 'churpi' – usually made from skimmed milk solids. These products are later used in food preparation.

More recently, more specialised western type cheese-making from cow and buffalo milk has been introduced into the high hills, driven in the main by the rapidly expanding tourist market. At even higher altitudes, up to 4,500 m, yak and chauri milk is converted into an increasingly popular niche cheese brand – yak cheese. Here also local 'nauni ghiu' butter is produced, mainly for the traditional butter salt tea – a staple in the high Himalayas.

'Channa' and 'khoa' are very important products in the mid-hills in Nepal, usually produced from cow or buffalo milk, often after full or partial skimming. These are really intermediate products that preserve the milk solids and reduce the volume and weight for transport out of the hills. Channa is then further processed into the local Indian sub-continent soft cheese called paneer, which is also used universally in cooking. Khoa is usually used as the base ingredient for traditional sub-continental sweets such as 'rasagolla' and 'gulabjamun'.

By organising themselves into self-help organisations at the primary or village level to collect milk, smallholders in highland areas in both Kenya and Nepal are now benefiting from regular income from the sale of surplus milk. FAO is contributing by developing a low-cost alternative for collecting milk from remote rural areas with little or no infrastructure. This method is known as the **lactoperoxidase system**; two chemicals are used to boost the naturally occurring enzyme preservation mechanism in milk. Treated milk can be kept for up to six hours before subsequent cooling or processing. Untreated milk starts to sour within one to two hours of milking. The system was developed with Swedish support and has been tested extensively in the field. It is safe and inexpensive and is now used commercially in 10 countries. It has recently received WHO/FAO Codex Alimentarius approval for use when supervised by trained staff at communal collection points such as those used in highland areas. Under certain conditions it also cuts out the need for expensive stainless steel milk chilling equipment.

In the past, intermediaries or middlemen have taken the lion's share of the consumer price for processed dairy products. It is only recently that producers are becoming aware of the opportunities for higher returns from the value added by processing their own milk into longer life products for direct marketing. This is being achieved through collective ownership of secondary level processing and marketing organisations.

Access to Urban Markets

For livestock production in the highlands to be really profitable, farmers will need to focus on providing livestock products to consumer centres in the larger cities in the lowlands, not only on supplying the local population. The dairy sector is more advanced than the meat sector in this respect. As already mentioned, highland dairy producers in some countries where the necessary infrastructure is available supply urban centres with traditional dairy products, and with intermediate products and raw milk channelled through established milk collection systems. Nevertheless, the infrastructure for collection and marketing is not yet satisfactory for many small-scale dairy producers and processors, and there are also many unsolved problems related to equipment. Much of the equipment currently available for milk processing comes from developed countries. It is very expensive, often too complicated, and requires recurrent outlay of foreign exchange for expensive imported packaging materials for the products. It is also unsuitable for processing small quantities of milk efficiently, a requirement for small and medium scale processing units. Furthermore, there is a need to provide the skills and knowledge required to run the processes and the equipment as well as to manage the processing enterprise as a commercial business.

In the meat sector the situation is less favourable for profitable supply to the lowlands. Given the ecological constraints in the highlands, there is often no surplus livestock available to be used for supply to urban centres.

Where meat and or milk are available, there are two main options for the supply to urban centres:

- to carry out processing locally; and
- to transport the livestock/milk to the consumer centres and process there.

The first option has technical and hygienic limitations, although there may be exceptions for some niche products such as traditional cheeses or dried beef and ham. The first problem is that it is often not viable to install adequate slaughter and processing facilities in the highlands. Slaughtering of livestock to provide the raw material for processed meat products would be possible in small-scale abattoirs in the highlands and the meat could also be kept for a certain period without refrigeration facilities as the ambient temperatures are low and the water is generally unpolluted. But it is difficult to transport the products to consumer centres without spoiling. Only dehydrated meat products or products rendered shelf-stable through other preservation methods can be transported without refrigeration. Fresh meat products need refrigeration to prevent them from spoilage. In view of the current infrastructure in most places, and the lack of a cold chain, it is still preferable in most cases to transport the live animals.

Transport of livestock from highland areas to consumer centres also poses certain problems, however. Livestock must first walk to reach roads. Road transport may be complicated by poor road conditions, high mountain passes, and changing weather. In many highland areas, use of unsuitable transport vehicles constitutes a major problem. Improper handling of livestock during transportation, often combined with long transport periods, results in injuries and bruises to the animals as well as weight loss and even death because of the lack of space on the vehicles. There is also the threat of high or low temperature and lack of drinking water. Improving the transport systems is probably one of the main challenges to be tackled in the marketing of highland livestock.

Despite the above constraints, there are clear possibilities for making raising of livestock for meat in the highlands attractive for national and international trade. These include the superior meat quality in terms of good flavour, lean, and the absence of residues and contaminants.

Chapter 9

Research and Development Challenges in Livestock Production Systems: A Report of the E-Conference

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Background

FAO, ILRI (SLP), CIP (GMP), and ICIMOD decided to organise an email discussion to provide a forum for those who could not be present at the Pokhara Symposium to contribute to the development of a comprehensive livestock research and development agenda for mountain and highland areas. This electronic conference, hosted on the FAO mail-server, ran for eight weeks. The list had nearly 600 subscribers (including other mailing lists) from Africa, Asia, Latin America, Europe, and the United States.

The conclusions taken from the email contributions stress the need to increase household income and human welfare in mountain/highland areas, whilst at the same time ensuring the sustainability of common natural resources. They also emphasised the need for holistic approaches and gender-balanced, participatory planning to ensure socially equitable development.

Strengthening of local institutions is essential to guarantee the empowerment and property rights of mountain and highland populations dependent on livestock, as well as the sustainable provision of services for effective development and research initiatives in these areas.

Highland ecosystems are found on every continent and an estimated ten per cent of the world's population derive their livelihood directly from them. In addition,

billions of people living in the lowlands depend on these ecosystems for resources such as water, building materials, and energy. Highland ecosystems are also important sources of plant and animal biodiversity. In the past few decades, environmental changes and rapid increases in population densities in these mountain areas have meant increased problems for planning effective resource management strategies. Despite the global recognition that these ecoregions received after UNCED in 1992, many highland communities continue to live in extreme poverty, and in many countries they are still socially and politically marginalised.

Livestock are of particular importance to these marginalised mountain farming communities for sustaining their livelihoods. They not only convert crop residues and other plant biomass to products that can be eaten or used by humans like milk, meat, eggs, wool, hides, and draught power, they also play a vital role in mediating nutrient transfers and provide a secure form of investment.

Since the UNCED endorsement of Chapter 13 of Agenda 21– Managing Fragile Environments: Sustainable Mountain Development – FAO, as the Task Manager of this Chapter, has facilitated a number of inter-agency and inter-governmental meetings. These meetings recognised the importance of livestock in highland farming systems. However, there was no clear vision as to how livestock should be utilised best to develop sustainable agricultural systems. The meetings did recommend that any action taken should be participatory, integrated, and interdisciplinary, to encourage interactions between policy-makers, scientists, development agents, and local people. It was in this context that FAO, ILRI, CIP-GMP, and ICIMOD decided to organise the four-day international symposium in Pokhara, Nepal, and set up the electronic discussion group whose results are reported here for the many people working on these issues who would not be able attend in person.

Reports of the contributions were edited and distributed daily during the eight weeks that the list was open. The email conference was devoted to four separate themes. The results of each are summarised below.

Theme 1: Resource Use and Management Strategies in Highland Mixed Farming Systems

The specific questions raised under this theme were as follow.

- What are the trends in agricultural production and productivity in highland systems where livestock is an integral part of the farming systems?
- How has the growing human population affected the livestock population, animal productivity, and agricultural landholding and productivity?

- What are the linkages among livestock, crops, common property resources, and private land in these highland systems?
- What are the changes taking place in terms of livestock holdings and resource management practices because of the high pressure on land and increasing cropping intensity?

Contributions from the Central South Ethiopian highlands and Southern African highlands stated that significant increases in population have had a significant effect on the availability of communal land (as more land gets taken for crop production) and that this has become the major factor limiting livestock numbers. There has also been a reduction in landholdings per family and a conversion of marginal land for crop production. As a result of the overall reduction in the availability and productivity of resources, animal production has decreased significantly. The intensification on marginal lands has also increased dependency on crop production.

Previously, fallow periods were used to regenerate soil fertility. Manure was used only on vegetable and perennial crops. Currently, however, fallow periods are no longer used, and not even the application of artificial fertilisers can maintain crop yields. Farmers are forced to destroy the natural resources they depend on, as they struggle to survive.

The number of draught cattle has also gone down, as the small plot size and/or the lack of feed resources does not justify owning a pair of oxen. With the loss of these animals, however, other benefits connected to keeping these animals are also lost.

Lack of the development of a rental market, fears of owners that lessees will not treat oxen well, and peak demand problems make access to draught animals in certain areas of Ethiopia even more problematic. It seems likely that these problems will be even worse for female-headed households, as the use of work oxen by females is not generally accepted. Although the use of zero-tillage in these situations could be promoted, stubble grazing is widely practised and tillage is required because of the resultant soil compaction. There are benefits associated with this practise as a result of the voiding of manure and urine by cattle during grazing.

A number of papers and comments dealt with livestock production systems in the Himalayan and Andean regions. Although the specific situations may have differed slightly, these contributions clearly indicated the problems caused in fragile environments through intensified and inappropriate resource use by a growing population. It also highlighted the potential conflicts that may arise between different societal groups that depend on the same declining resource base.

There were also reports that, in some countries, population increase and the expansion of tourism have taken up areas that used to be part of the main grazing areas for ruminant livestock. A project in Nepal, which leases blocks of degraded forest to the poorest farmers and gives these households assistance to regenerate the land in order to increase the natural resource base for the households' exclusive use, has had encouraging results. The number of less productive animals has decreased, and income from livestock products and related products such as fodder has increased. In addition, there has been a massive regeneration of forest species at most of the sites. The system has a positive influence on adjacent forest areas and reputedly halts forest encroachment and shifting cultivation in the areas of implementation.

A number of contributions from Slovenia advocated the introduction of organic agriculture and livestock production to protect the natural resource base and to ensure the sustainability of food production. The same authors also stressed the importance of grass roots' Agenda 21 initiatives, which in their opinion should become the applied framework for any future initiatives in highland areas to protect the environment, and of paying due attention to the social welfare of all people.

The influence of climate change on highland ecosystems was also investigated. The most important changes that may occur in highland areas if current predictions do not significantly change were thought likely to be the following:

- increases in population pressure through the further influx from people from lower altitude areas as the climatic changes make these lower altitude areas less appropriate for human habitation;
- areas at 600 to 1000 masl will become more productive;
- the tree-line will shift upwards;
- weather 'events' will become more severe; and
- there will be continuous changes in nature as a result of the introduction of life-forms from lower altitude ecosystems.

(Reference was also made in other contributions to the occurrence of tsetse flies and malaria mosquitoes at higher than normal altitudes as a result of increases in ambient temperature.)

Farmers in Nepal often sell (or kill) their buffalo calves (even females) so that they do not have to feed them any milk and because feed resources are often limited. This practice, however, reduces the room for selection within local animals. Combined with the lack of systematic work on buffaloes in highland systems per

se, this has made improvements in the prevailing production systems difficult. Nevertheless, when given credit, farmers will preferentially invest in livestock, which shows their importance. Risk, however, is often the overriding factor in any decision farmers make.

Although many local systems of resource management have a proven track record in the protection of communal areas, these systems were not able to protect other forest/pasture areas because of the high population pressure. As a result, tree lopping and grazing of forests in some areas of Nepal have become so intensive that trees are degraded and there is no forest regeneration.

Intensification of some highland production systems in Latin America is based on the use of imported concentrates, upgrading from local to exotic cattle, and the extensive application of chemical fertilisers. These systems obviously require large investments and use little local resources. Nevertheless, there are several opportunities in the expanding local markets for the replacement of imports (both inputs and livestock products) and the more efficient incorporation and use of local resources.

With respect to the use of suitable livestock species, there is often a resource mismatch in the highlands and a climate mismatch in the lowlands if exotic species are used. In addition, apart from all the problems related to services and feed resources when highly productive animals are introduced into highland areas, the animals may also experience specific health problems. This was described in a contribution from Colombia, which reported the difficulties that exotic broilers and dairy grade cattle experienced as a result of the sudden and large diurnal variation in ambient temperatures. Introduction of these animals into these environments should be carried out with caution otherwise it may result in high mortality.

A number of papers based on the experiences with poultry development schemes in Bangladesh, stressed the importance of vertically integrated production models (covering the whole production chain) that are based on the grass roots and on indigenous livestock. These contributions also stressed that poultry may be a good 'entry point' as poultry are gender neutral. They do not compete for feed resources with other livestock and thus it may be one of the more immediate ways out of the poverty spiral. The introduction of this 'market-oriented' activity also created experiences and awareness in many other areas. It was stressed, however, that the introduction of these types of models is dependent on the availability of the appropriate infrastructure.

Theme 2: Resource Use and Management Strategies in Mountain Farming Systems

This theme dealt with the same specific questions raised under theme 1, but as they apply to mountain production systems.

The break-up of the Soviet Union in the high altitude areas of the countries that formed part of the communist block has led to privatisation of livestock keeping. This not only resulted in people actually owning the animals but it also meant that all services and the supply of inputs became private overnight. This obviously caused many problems and livestock numbers have decreased significantly. Higher altitude summer pastures in these areas are still underused, as they are far away from the towns, markets, and services. The lower altitude winter pastures, on the other hand, have a very dense grazing pressure.

In the alpine regions of Nepal, the yak population is declining as a result of the following.

- Access to the alpine meadows which used to serve as one of the major feed resources in yak production systems has been restricted as a result of the creation of national parks (tourism).
- Due to the lack of reliable marketing systems, many farmers have given up yak farming and sought employment in towns or the tourist industry.
- Cross-border restrictions do not allow herders to enter the areas that for centuries were a part of their winter grazing lands.

All the above also applies to many other livestock production systems in the alpine regions of other countries in the Himalayan region.

Other contributors suggested that yak owners, who are few, cause damage to a large number of people in the community who depend on the same resources. This is just one example of the conflicts that may arise when the resource base becomes limited. However some people also suggested that the damage caused by yaks has been grossly exaggerated and mentioned new studies that suggest that yak grazing affects only extremely stressed forest areas

The untapped potential of small ruminant production in many remote, high altitude areas was also highlighted. Not only are small ruminants easy to transport, but they can also provide multiple products such as meat, milk, and fibre, although the local markets for these products are often not well developed.

Theme 3: Optimisation of the Use of Nutrient Resources in Mountain/Highland Production Systems

The contributions on this theme related to specific issues of feed and animal nutrition (feeding systems/strategies, cultivated fodder, by products and residues, feed imports from other areas). Integrated and systems-oriented topics dealt with the scope for management of livestock to create more effective linkages between on-farm and off-farm nutrient resources and arable land, and gave a scenario of changing access and availability of common property nutrient resources.

There were contributions that described the constraints posed by the presence of anti-nutritional factors in highland vegetation. In one of these contributions, specific reference was made to tannins, which can reduce intake of roughage as a result of their negative influence on protein digestibility. Tree fodder is often an integral part of feed in highland areas, and most of these leaves have a high tannin content.

Bracken is a ubiquitous plant in the world's highlands. Its consumption causes many syndromes in livestock such as thiamine deficiency and acute haemorrhagic disease. It also affects humans in the Americas and New Zealand through the consumption of toxins via animal products. There are also recently established links between bracken toxins in animal products and certain types of cancer.

Theme 4: Policy, Services and Gender

The specific questions raised under this theme were as follow.

- What are the specific issues/constraints related to the delivery of livestock services in highland/mountain environments?
- What have been the key policy issues in the development of the livestock sector in the highlands?
- How have gender issues been addressed in livestock policy formulation, e.g., in extension service delivery systems and research?
- How has gender contributed to livestock management at household level (gender role in livestock management) and how has this role changed?

Social aspects in general and gender issues in particular have been ignored. Women, however, carry out the most crucial livestock tasks. Livestock are often the only option for poor and landless people to produce a marketable product, and women are generally disproportionally represented in these groups. Women still have very limited access to all types of services (from credit to veterinary services).

With respect to this, the Agricultural Perspective Plan of Nepal envisages a huge change from the norm. It recognises women as the principal managers of natural resources as they play a key role in their sustainable development and exploitation.

In the highlands of South Africa, the withdrawal of subsidised extension and veterinary services has had a significant effect on the adoption and the correct use of technologies. In general, delivery of both veterinary and other services is inadequate or non-existent in highland areas. Although this may be due in part to the lack of infrastructure, many areas are also just neglected by the urban-based policy-makers. From a development point of view, however, it is important to realise that livestock-dependent people are often risk averse, unless good services are made available.

Protection of some areas without benefits of these measures accruing to the community at large, has led to the further exploitation of non-protected areas. There are also significant problems in these areas with what has been called the 'free-rider' effect, in that the benefits that people obtain from collectively managed resources are not being influenced by their actual contribution.

Conclusions Taken from the Email Contributions

Mountain and highland areas have been marginalised in mainstream development. There is a need to recognise the heterogeneity of the different highland/mountain systems and this requires a heterogenic and pragmatic approach. We need both a better understanding of why farmers make the choices they make, and an assessment of resource potentials. This assessment can be used to formulate conservation proposals that balance the requirements of people and resources (optimisation and not maximisation).

Another essential ingredient of the new approach to future developments in highland and mountain environments should be recognition of the multiple roles that livestock perform. The challenge will be to increase household income and human welfare, whilst at the same time ensuring the sustainability of common property resources (CPR). Balancing CPR with private property calls for a holistic approach and participatory planning.

Participatory planning begins with community participation; all stakeholders must be involved from the start. Women need to be included in these planning exercises, which calls for recognition of their unique skills and knowledge. For effective community development, it may be necessary to show the obvious benefits

of what is proposed before people will be convinced. This requires specific strategies that need to be worked out well in advance. In addition, it will be necessary to use a future oriented strategy, i.e., future generations should be involved. Educational and curricular changes may be a way of realising this.

There is an increasing need to look for sustainable and profitable technologies that can reverse the negative trends. To be successful, any development intervention has to take the local situation and the indigenous knowledge base into account. Success also requires an improved understanding of the whole production chain (from education to marketing) and the development of agricultural policies through direct contact with the grass roots' level.

There may be a need to use local animals to fully utilise the genetic variation available within the local livestock populations, to use local resources and decrease reliance on imported products, and to stimulate multipurpose production systems.

Properly functioning services are thought to be an essential requirement to ensure the sustainable development of livestock production systems in highland and mountain areas. Current levels of services are often inadequate and there is a need to formulate simple, integrated programmes that have multiple functions (from extension to the effective marketing of products). Farmers need to be involved in the planning of this. Effective provision of services will be impossible, unless the road infrastructure is developed.

There is also a need to preserve and promote ethno-veterinary practices so that farmers are less dependent on conventional veterinary services. Development of minimum animal health packages and investment into research and development of self-sustaining extension services will be required. In addition, there is an urgent need to further develop human capital through the formulation of a basic plan for education at different levels using existing community-based organisations.

More work will be required to circumvent the inherent nutritional constraints in order to exploit the huge potential of fodder containing tannin and other toxins.

Leasehold forestry has extensive potential in areas from 500 to 2,000 masl. Some comments, however, suggested that this system be integrated with the wider aspects of community forestry to balance the benefits of a few with those of the community at large. It may be necessary to stress the importance of these community approaches and to develop and strengthen local institutions in support of these

initiatives. Franchising of land or forest to a small group of people may be another system worth investigating.

List of Contributions Made to the E-Conference

Abiye Astatke. Constraints to the sustainable development of highland areas in Ethiopia. 22 October 1999

Askov Jensen, H. Poultry as an integral part of the highland ecosystem. 7 October 1999

Brower, B. Comments on the issues raised with respect to yak farming. 3 November 1999

Contreras, V. Modules of technological applications. 21 November 1999

Dhakal, B. Comments on Frits Ohler's and D. D. Joshi's papers. 1 November 1999

Dwivedi, S. K. Livestock health concerns in the Central Himalayan region of India. 7 November 1999

Ecimovic, T. *et al.* The earth's highlands – today, tomorrow, and organic agriculture – the road to a sustainable future of the earth's highlands agricultural systems in the third millennium. 9 October 1999

Falvey, L. Comments on Bob Orkov's contribution. 4 November 1999

Gautam, K. Tree tenure: an opportunity to develop private fodder resources on communal land in Nepal's hills. 9 November 1999

Hammond, K. Comments on Krishna Gautam's contributions. 22 November 1999

Hassan Raza, S. *et al.* Small-ruminant production on the alpine ranges of the Trans-Himalayan mountains. 13 October 1999

Jeggo, M. Comment on Temesgen Samuel's contribution. 11 October 1999

Joshi, D. D. Impacts of national parks and tourism on yak farming in the alpine Himalayan region of Nepal. 29 October 1999

Mallia, J. G. Management and disease of small-ruminants in the Maltese agroecosystems. 10 November 1999

Manrique M., J. and Teran D., M. Animal health lab contributions to the sustainability of dairy systems in mountain areas. 23 Nov 99

Nell, W. T. Impact of population pressure on natural resources in the mountainous areas of Qwaqwa, South Africa. 14 October 1999

Ohler, F. M. J. Poverty alleviation through livestock rearing in combination with leasehold forestry in the middle hills of Nepal. 20 October 1999

Orskov, B. General comments. 4 November 1999

Pender, J. General comments on policies. 2 November 1999

Ramirez Nader, L. M. *et al.* A participative research programme to improve the sustainability of cattle production systems in the tropical high Andes of Colombia. 1 November 1999

Rangnekar, D. V. General comments. 23 November 1999

Rasali, D. P. Response on comments by K. Gautam. 31 October 1999

Regmi, P. Comments on the contributions from Hans Askov Jensen. 8 October 1999.

Saleem, M. Comments on the contributions from Frits Ohler and Temesgen Samuel. 19 October 1999

Singh, B. Importance of tannins in highland feed resources. 21 October 1999.

Smith, B. Bracken fern (genus Pteridium) toxicity in mountain regions. 22 October 1999

Temesgen Samuel. General remarks on the debate of highland issues. 23 October 1999

Uribe Peralta, A. Comments on the contributions from Hans Askov Jensen. 8 October 1999

Velez, M. Comments on Bob Orkov's contribution. 7 November 1999.

Wageningen, N. van. Privatization of animal production in Kyrgyzstan, the Tajik Pamir and the Qinghai-Tibetan plateau. 18 Nov 1999

Zapata Cadavid, A. system of milk production in the Andean region of Colombia. 21 November 1999

Livestock in High-Pressure Mountain Regions

Part Three

Chapter 10

Livestock Production and Management Strategies in the Mixed Farming Areas of the Hindu Kush-Himalayas, Asia

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Introduction

The Hindu Kush-Himalayas (HKH) is a diverse region, both physically and socioeconomically. It is inhabited by many people of different ethnic origins with different social and cultural values. The region extends 3,500 km from east to west. A majority of the farmers in the HKH region practise mixed crop-livestock farming, particularly those with farms at altitudes below 2000 masl. This paper focuses on those 'high pressure' areas of the HKH (places where livestock densities are high in terms of the area of cultivated land, grazing land, and forest) where mixed crop-livestock farming systems predominate.

The last few decades have seen considerable changes taking place in livestock population, structure, and management systems in the areas of the HKH where mixed crop-livestock farming systems predominate. These changes have altered the relationship of livestock to the overall farming systems and to natural resources' management. In addition, changes in the natural resources themselves have also had an impact on how livestock are managed. In general, the change has been greater in the 'hill' or mid-mountain regions of Nepal and in the western Himalayas, where there has been rapid population growth leading to decreased farm size and increased land fragmentation.

This paper describes the results of a study that was carried out in high population pressure areas of Nepal and India. The key objectives of the study were to examine

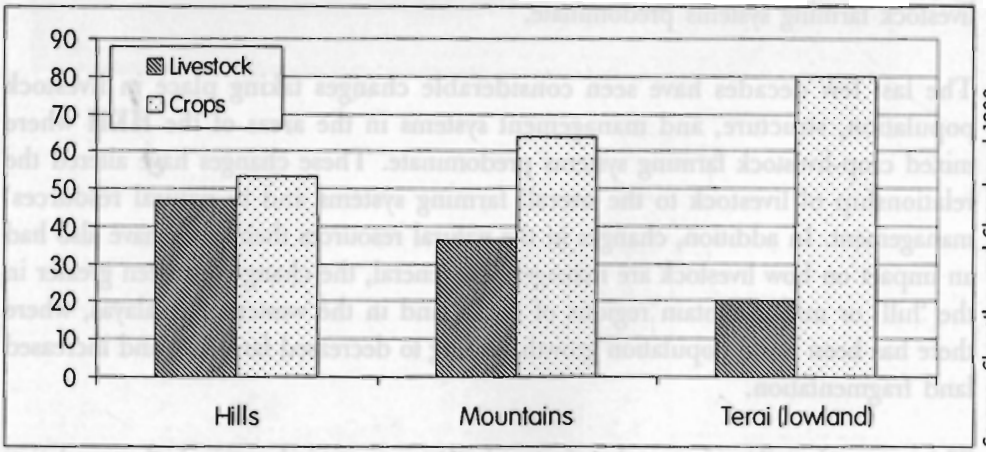
the present trends and patterns in the livestock population and composition, and to compare subsistence and commercial production systems. The study also tried to identify the processes leading to adoption of improved livestock; to explore linkages between livestock management, the environment, and soil fertility maintenance; to identify issues of gender in livestock management; and to outline the key constraints and strategies for the management of livestock production in mixed farming systems in the HKH. The main geographic focus was on the hills and mountains of Nepal and the central and western Indian Himalayas. Informal and key informant surveys were conducted in Parbat and Kaski districts of Western Nepal and Dolakha district of Central Nepal.

Information was gathered from other parts of the HKH, in particular Bhutan, the Yunnan and Sichuan provinces of China, and the North-West Frontier and Balochistan provinces of Pakistan, to enable analysis of trends in livestock population and composition mountain areas across the HKH.

The Value of Livestock in Mountain Areas

An important source of income

Livestock are an important source of income in the hills and mountains. Figure 10.1 shows the share of agricultural income that comes from livestock in different regions of Nepal. Livestock contribute proportionately more to agricultural income in hill and mountain areas than in lowland areas. In the hills and mountains, this income is mainly from fresh milk and meat, and to a lesser extent from products like wool and hides.



Source: Shrestha and Sherchand 1988

Figure 10.1: **Percentage contribution of livestock and crops to total agricultural income of farm households in three ecoregions of Nepal**

Key source of organic manure

Chemical fertiliser is not easily available or affordable for the large majority of farmers in the hills and mountains of the HKH, thus farmyard manure (FYM) is crucial as it is the only input available in abundance to maintain soil fertility. An average 5-10 tonnes per hectare of FYM are applied annually to maize, millet, and wheat fields. Livestock are the key source of this manure and will continue to play an important role in supplying it. Dung from livestock is also used as a cooking fuel in many households in higher altitude areas.

Source of draught power in the hills and mountains

Landholdings in the mountains are small and fragmented and mechanisation of agriculture is difficult. Draught animals are the most economical and easily available source of energy in rural mountain areas. Livestock provide the draught power for ploughing fields and are also used in post-harvest activities like threshing.

Trends in Livestock Population and Household Livestock Composition

Large livestock

Table 10.1 shows the results of an analysis of trends in the population and composition of livestock kept under mixed farming systems in different areas of the HKH over the last 10-20 years. Overall the number of cattle has either declined or remained stagnant in most places whereas the number of buffalo has increased. Similarly, the number of goats has increased while the number of sheep has gone down. Similar trends were seen in terms of

Table 10.1: **Trends in livestock population and composition in mixed farming systems in the HKH**

Province/ State/Region	Population				Composition				Year
	Cattle	Buffalo	Sheep	Goats	Cattle	Buffalo	Sheep	Goats	
Balochistan (Pakistan)	◆	↑	↑↑	◆	↓	◆	↑	↓↓	1984-94
NWFP(Pakistan)	◆	◆	↓	↓	◆	◆	↓↓	↓	1976-86
Himachal (Western Indian Himalayas)	↓	↑↑	↓	↑	◆	↑	↓	↑	1982-92
Uttarkhand (Central Indian Himalayas)	↓	↑	↓	↑	↓	↑	↓	↑	1978-88
Nepal (mountains)	◆	◆	↓	↑	◆	◆	↓	↑	1988-96
Nepal (hills)	↑	↑	↓	↑↑	↓	↑	↓	↑↑	1988-96
Bhutan (whole country)	↓	-	↓	↑↑	↓	-	↓	↑↑	1986-96
Sichuan (China)	↑	↑	◆	↑↑	↓	↓	↓	↑	1986-97
Yunnan (China)	↑	↑↑	↓↓	↑↑	◆	↑	↓	↑	1986-97
Tibet (China)	◆	-	◆	↑↑	↓	-	↓	↑	1986-97

↑ increase, ↑↑ significant increase, ↓decrease, ↓↓ significant decrease , ◆ stagnant
Source: Tulachan and Neupane 1999

overall herd composition, overall there is a higher proportion of buffaloes and goats, and lower proportion of cattle and sheep. Thus it seems that overall buffaloes and goats are becoming more important in HKH mixed farming systems.

Micro-livestock

Table 10.2 shows the growth rate of populations of poultry and pigs in the hills and mountains of Nepal from 1984/85 to 1989/90 and from 1991/92 to 1997/98. There was a significant growth in the populations of both pigs and poultry in both the hills and mountains up to 1990, but the growth rates fell considerably thereafter to almost zero for poultry in the hills and only one per cent for pigs in the mountains.

Table 10.2: **Growth rate (%) of populations of poultry and pigs in the hills and mountains of Nepal**

	1984/85 to 1989/90	1991/92 to 1997/98
Poultry		
- Hills	10.4	0.2
- Mountains	7.1	2.5
Pigs		
- Hills	2.1	1.4
- Mountains	3.4	1.1

Source: Statistical Information on Nepalese Agriculture Series (1984/85 to 1997/1998), HMGN Ministry of Agriculture, Nepal

Livestock Production Systems in Accessible and Inaccessible Areas

Livestock production systems in mixed farming areas in the hills and mountains differ according to whether the area is connected to the market by road or not. Figure 10.2 illustrates some of the basic differences between the two systems. Livestock

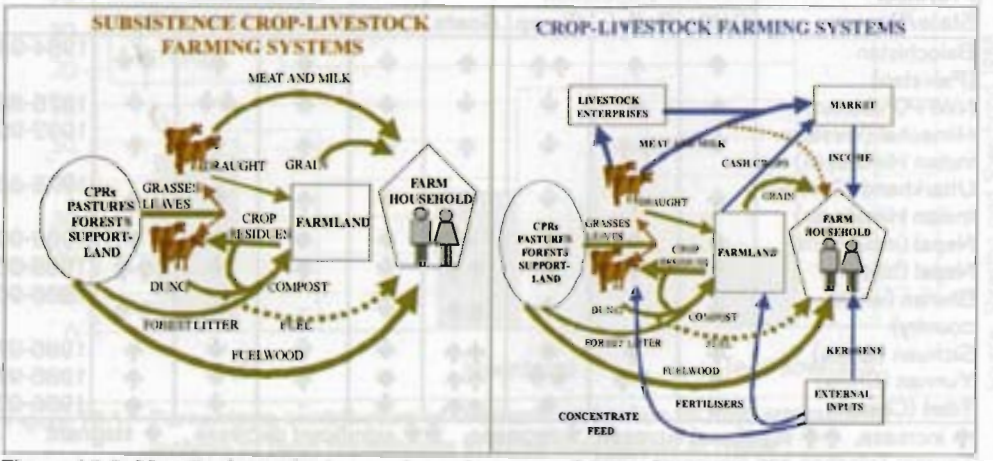


Figure 10.2: **Livestock producing systems in accessible and inaccessible areas**

production in inaccessible areas is usually part of a 'closed' or integrated subsistence type of farming system. In these places farms depend on livestock for soil-fertility and draught power, and the livestock depend on farmland for crop residues as a feed to supplement feed from common property resources (CPRs). Most of the meat and milk produced is consumed by the household; if there is any surplus, it is sold in the market.

In contrast farms in accessible areas are better linked to the market, and thus farmers are more able to sell their produce for cash and to buy inputs from outside. In these areas livestock are fed more concentrate feed, and chemical fertilisers are used in addition to farmyard manure. There is increased sale of milk and meat products for cash income. For these households, cash security leads to increased food security.

Adoption of Improved Livestock

Promotion of improved breeds needs to be based on the appropriateness of the animals in the situation prevailing in a particular area. This includes factors like access to support facilities and markets, available feed supplies, climate, and culture. Two cases, one from Nepal and one from Himachal Pradesh, provide an example. Blanket promotion of a single type of improved cattle, as has happened in the past, does not work in the diverse conditions prevailing in the mountains.

Buffaloes in Nepal

The Nepal livestock statistics for 1996/97 (Table 10.3) show that the overall milk productivity of buffaloes is higher than that of cows. Although there are only half as many buffaloes as cattle (although slightly more milch animals), they produce more than twice as much milk. Almost 70% of the milk in Nepal is produced by buffaloes. The average annual milk yield for buffaloes is almost two and half times that for cows (807 kg and 317 kg, respectively).

When mountain farmers in Nepal are given the opportunity to adopt improved livestock, the majority of those practising mixed crop-livestock farming choose improved buffaloes rather than improved cows. This is in part a response to the lack

Table 10.3: **Production and productivity of buffaloes and cows in Nepal, 1996/1997**

	Total Population	Milch animal population	Milk production (tonnes)	Share of total milk produced	Milk yield (Av. of district values)(kg/year)
Buffalo	3,362,000	857,000 (25%)	702,000	69 %	807
Cattle	6,932,000	816,000 (12%)	310,000	31 %	371

Source: Statistical Information on Nepalese Agriculture, 1996/1997, HMG Nepal

of veterinary health support and constraints in availability of quality feed. Table 10.4 summarises some of the key factors influencing the choice. Essentially, improved buffaloes are more appropriate because they are hardier than crossbred cows, and adapt better to the locally available feed, as well as giving better milk yields than local cows.

There is an interesting relationship between road access and buffalo population in the mountain district of Dolakha in Nepal. The buffalo population is concentrated around the road network indicating that buffaloes are gaining importance in the livestock economy in areas with market access. The soaring demand for buffaloes among farmers has also increased the trade of buffaloes from the lowlands of India to the hills and mountains of Nepal. At present 200-300 buffaloes are sold monthly in one area in Kaski district, Nepal; a two-fold increase over the last decade according to one trader.

Crossbred cows in Himachal Pradesh

Crossbred cows have been doing well in some areas of Himachal Pradesh. Although the population of local cows still exceeds that of crossbred cows, the proportion of crossbred animals has increased over the last decade. In 1982 less than one quarter of cows in milk were crossbred cows, by 1992 nearly half of all cows in milk were crossbred. The increase in crossbred animals is particularly noticeable in the more accessible areas where there is better access to the necessary support services and inputs as well as to markets. The distribution of crossbred cows within HP is clearly correlated with the existence of veterinary service facilities, which is also a measure of access (Figure 10.3). Access to such facilities encourages farmers to adopt crossbred

Table 10.4: **Reasons for preferring improved buffaloes**

Improved buffaloes	Improved cows
• Milk has higher fat content (1.4% higher) and fetches a higher price per litre	• Low fat content so milk fetches lower price per litre
• High salvage value: old buffaloes sell for Rs. 8000 to 10,000 per head	• No salvage value for cows or bulls
• Well adapted to local feed sources, such as poor quality roughage and agricultural residues	• Require quality fodder (legumes) and higher amounts of concentrates
• Comparatively more resistant to disease	• Comparatively more vulnerable to disease
• Provide more manure than cows	• Less manure output
• Irrigation and cultivation of quality fodder not a prerequisite	• Irrigation and diversion of scarce land resources to fodder production
• Affordable	• Expensive

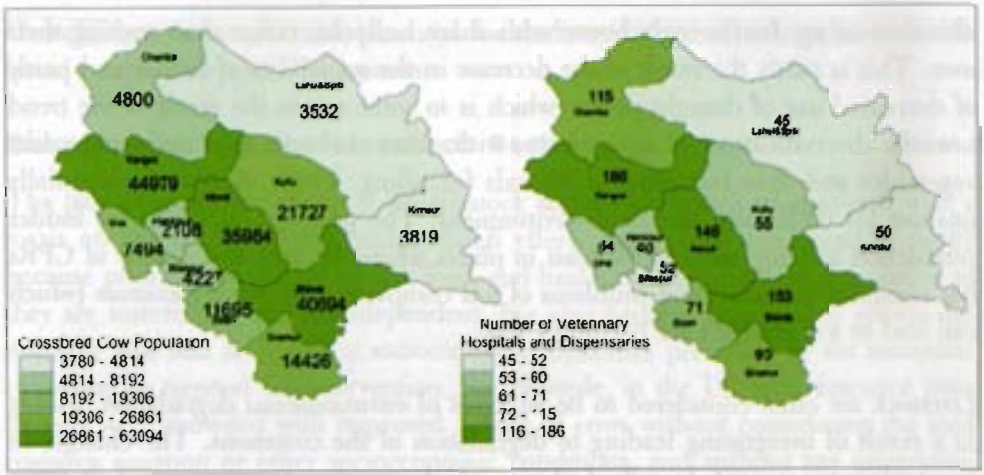


Figure 10.3: **Distribution of crossbred cows and availability of veterinary services in Himachal Pradesh**

animals, and the presence of such animals in a district provides more opportunities for veterinarians to set up practice.

Changing Livestock Management Strategies and the Implications for Common Property Resources and the Environment

There are many changes taking place in livestock management systems across the HKH. This is particularly evident in those areas that have increased access to markets and inputs as a result of having a better road infrastructure. The effect of the changing strategies for livestock management on CPRs and the environment is an important concern for policy-makers. Some of the main trends and their likely impact are summarised in Table 10.5. One clear trend seen in the more accessible areas is the diminishing size of herds; farmers are keeping fewer animals, but of better quality. The emphasis has shifted from open grazing to stall-feeding, and farmers are making increasing use of external inputs (purchased feed, particularly concentrate from the lowlands). Keeping animals in stalls has also encouraged farmers to make use of wasteland and plant fodder trees around their fields to facilitate easy collection. Although draught animals are important in mountain agriculture, their numbers are

Table 10.5: **Effects of changes in livestock management on CPRs and the environment**

Factor	Trends	Implications for	
		CPRs	Environment
Herd size	Decreasing	Less use	Positive
Management	Stall feeding	Less use	Positive
Quality of animals	Improving	Less use	Positive
Draught animals	Decreasing	Less use	Positive
Concentrate feeds	Increasing	Less use	Positive

also decreasing. Increasingly households share bullocks, rather than owning their own. This is partly the result of the decrease in the availability of fodder and partly of decreased use of draught power, which is to some extent the result of the trend towards diversification of agriculture, with more orchards and cash crops like vegetables and thus less need of animals for tilling. These trends are essentially positive for CPRs and the local environment. The pressure on CPRs for fodder production is being reduced (at least in places where the area and quality of CPRs has remained constant) and problems of soil compaction by grazing animals (which can lead to soil erosion) are becoming less.

Livestock are often considered to be an agent of environmental degradation, mainly as a result of overgrazing leading to degradation of the commons. The changes in livestock management described above, which are already pronounced in some accessible areas, should help to avoid this in the future.

Gender Concerns in Livestock Production Management

Although it is clear that women play an extremely important role in livestock management in mountain areas, there have been very few studies of this. Studies in Nepal have shown that women contribute 70% of the work in raising livestock and are more knowledgeable than men about treating sick animals (Sharma and Awasthi 1993; Tulachan 1994). Women contribute about 62% of the total labour for collection of fodder and bedding materials, 52% of that for cleaning sheds and making compost, 68% of that for application of FYM, and 61-75% of that for crop production as a whole (HMG/ADB 1993). In spite of this, women are excluded from extension, marketing, credit, and other activities critical to increasing livestock productivity and income.

Women's needs (for time-saving technology, for example) are not considered when conducting research, nor is the extension education system tailored to women farmers. Despite the fact that women farmers contribute the most work in raising livestock, their knowledge of and ideas about problems have hardly entered the mainstream perception; it is only men who have a say.

In the past, there was less empowerment of women; most of the income from livestock went to the male head of household. Nowadays women increasingly take control of cash earnings. They can be seen walking for three hours or more to sell milk, and with the money they earn they buy what they need for their children and their households. Women also play a significant role in raising micro-animals such as goats, poultry, and pigs, and are receiving a considerable cash income from sales of these animals. This is true to some extent over the entire HKH, and is particularly common in Nepal, India, Bhutan, and China.

Overall, there is considerable potential for the involvement of women in livestock-based micro-enterprise development.

Development in the Livestock Sector

The past development efforts in the livestock sector took a sectoral approach with a focus on breeds, feed, and health. Such efforts were often unsuccessful, partly because problems of animal breeds, feed, and health cannot be solved in isolation as they are interrelated and interdependent, but also because intervention efforts did not fully take into account the socioeconomic dynamics prevailing in the mountain communities targeted for intervention. For example, in the UP hills, resource poor farmers were provided with improved breeds of cows without considering the feed resource situation or other socioeconomic conditions, and without any integration with the market. As a result, the animal breed improvement programme failed.

Clearly there were many gaps in the priorities set in the past by those concerned with policy, research, and development in the livestock sector. Since the focus was on breeds, feed, and health, many conservation and socioeconomic issues were overlooked. The potential of indigenous species of animals and forage plants was not studied in depth and no attempts were made to preserve them. Species that performed well in other parts of the world were vigorously promoted in the mountains. This process not only failed to provide the expected results, it also contributed to the loss of animal and forage biodiversity. Similarly, livestock niches were not taken into account to any great extent – blanket promotion was more commonly practised than specific intervention based on location. Planners and policy-makers failed to recognise the crucial roles of extension (through farmers' groups), of the efficient supply of inputs (credit and veterinary services, irrigation), and of integration with markets, all of which need to proceed hand-in-hand for improved practices to be adopted. The important role of women in livestock rearing and the need to ensure that they benefited equally from livestock development was also overlooked. The unique characteristics of mountains – the mountain specificities – need to be recognised by those concerned with mountain livestock development.

The Main Constraints to Livestock Development in the Mountains and Highlands, and Issues and Challenges for R&D

The main constraints to livestock development in mountain and highland areas and the challenges these set for R&D are summarised in Table 10.6. The first and foremost constraint in the Himalayas is the shortage of feed and fodder, especially in

Table 10.6: **The priority constraints, and R&D challenges**

Priority constraints	Primary reasons	R&D challenges
Shortage of feed/fodder	- Small farm size - Limited access to CPRs - Limited use of CP land for growing fodder grass - Lack of group action on CP land	- Efficient use of available feed resources - Planting of grass/fodder trees on very marginal land (private land) - Participatory management of CPRs to improve animal feed resources - Better understanding of land intensification and farm economics
Low productivity (in terms of milk production)	- Poor feeding - Inappropriate breeds of animals - Low milk price	- Genetic improvement of indigenous animals - Improvement of management practices and feed technologies - Price incentives for milk and milk products - Product diversification
Shortage of veterinary services, medicines, and vaccinations	- Lack of private enterprises dealing with veterinary medicines and vaccines - Poor upland-lowland linkages	- Provision of veterinary training to local people - Sustainability of paraveterinary enterprises
Lack of quality animals	- Inaccessible/expensive - Government restriction on animal trade (esp. improved cattle) in some areas	- Encourage private sector in trade of live animals - Remove restrictions to movement of animals across borders
Rising price and poor quality of concentrate feed	- Lack of quality control - Increasing price of feed ingredients - Lack of competition in the animal feed market	- Monitoring of feed quality - Market intervention - Promote competition
Stagnating price of milk	- Excess use of improved milk powder - Limited private processing facilities - Lack of product diversification	- Discourage excessive use of imported milk powder for processing - Encourage maximum use of raw milk for processing - Dairy product diversification through extensive training
Shortage of farm labour	- Poor niche assessment - Out-migration, increasing off-farm wages - School education	- Use of drudgery reduction technologies
Lack of credit and savings	- Too few field-based government credit institutions - Cumbersome and time-consuming process for credit collectors - Inadequate group credit/savings' mobilisation	- Encourage/mobilise community - Provide concessional loans to community credit and savings' schemes
Poor harnessing of livestock niches and under utilisation of niche opportunities	- Poor niche assessment - Lack of product diversification	- Identify specific niche areas for specific livestock - Integrate livestock farming with agriculture and horticulture
Risk, uncertainty, instability of livestock	- Lack of marketing - Natural hazards - Lack of animal insurance	- Formation of milk producers' associations (MPAs) - Community-based savings and credit mobilisation - Promote marketing/widen market areas

Table 10.6: **The priority constraints, and R & D challenges (cont'd)**

Priority constraints	Primary reasons	R&D challenges
Lack of gender concern	- Insensitivity of planners - Insensitivity of local institutions to gender needs and concerns - Lack of participatory approach	- Better understanding of issues related to livestock and gender development in the context of changing socioeconomic conditions - Sensitise planners - Sensitise local institutions to gender needs and concerns - Involve women staff/ formulate programmes based on knowledge of gender concerns
Lack of mountain sensitive policies	- Lowland perspective - Misperception of livestock and environmental interactions - Lack of understanding and knowledge of mountain farming systems	- Better understanding of emerging socioeconomic conditions, natural resource management concerns, and livestock niches - Sensitise policy-makers to mountain perspectives - Make policy-makers aware of the fact that livestock are an integral part of mountain farming and livelihood systems
Food insecurity of marginal farmers	- Small farm size - Marginal land - Limited opportunities	- Explore appropriate livestock management options for marginal farms - Better understanding of how the income from different livestock options can be used to improve the food security of marginal farm households

winter. This is mainly the result of small farm size, limited access to CPRs (including common land for growing fodder grass), the lack of group action on common property land, and the increasing needs of the growing population. Thus, one potential issue for R&D is the identification of fodder (grass) varieties that provide a maximum output from marginal lands, which at present are underutilised. Participatory management of common property resources has worked well in many parts of Nepal. As yet, however, these programmes have not given due attention to fodder resource development, and this is another issue that should be addressed.

The low price of milk in the market is a disincentive for farmers to pursue dairy farming. While this issue needs to be looked into, there is a lot of scope for farmers to diversify into milk products like cheese, flavoured milk, flavoured yoghurt, and condensed milk, in order to get better value for the milk they produce.

Poor animal health poses a great threat to animal productivity. The adoption of improved breeds is severely affected by inaccessibility of veterinary services. Improved breeds are an expensive investment, and if animals die of disease (often

partly as a result of their relative vulnerability) farmers are discouraged. In the past, animal heath improvement programmes focused on basic science and technology. The challenge for the next millennium is to widen the scope of research and tackle the enormous problems faced in the dissemination of technology, treatments, and knowledge already generated in the field. In Nepal, the chief problem is the dearth of trained veterinary technicians. In the hills of Nepal, the ratio of veterinary doctors to livestock is 1:42,000 (Shrestha and Sherchand 1988). One possible approach to overcoming this problem would be to encourage the private sector to become more active. At village level, the concept of village animal health worker should be promoted, and more village-level animal health workers trained.

It is clear that livestock will remain an integral part of mountain agriculture. Their importance for mountain households is generally more than for households in the plains that have crop-dominated systems and better accessibility to inputs and markets. Even so, policies for the livestock sector are largely oriented towards the plains; they are not framed with the mountains in mind. Blanket policy recommendations fail to consider the unique problems or potential of mountain areas like inaccessibility, niche areas, and diversity. Research and development in the livestock sector need to focus on the mountain situation if they are to be of benefit to the large majority of mountain households.

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Chapter 11

Livestock Production in Areas of High Pressure Crop-Livestock Farming Systems in the East African Highlands

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Introduction

Although highland environments (areas above 1,500 masl) only cover 4% of the total African continent (around 1 million sq.km), they are of significant importance in East Africa (Table 11.1). Not only can the majority of the highlands be found in this region, but they are also home to approximately 60-90% of the human and livestock population in the countries in which they are found (Table 11.2). Furthermore, as a result of their relatively high production potential and the importance of agriculture, they constitute the economic backbone of these countries.

In the majority of countries in the East African Highlands (EAH), human population is increasing at a rate of circa 3.5%. Although there is a gradual trend towards

Table 11.1: **Highland area compared to total land area of selected East African countries**

Country	Total land area sq.km	Highlands	
		Area, sq.km	% of total
Ethiopia	1,221,900	489,700	40
Tanzania	939,701	190,000	20
Kenya	583,000	110,000	19
Uganda	243,000	30,000	12
Rwanda	243,000	22,250	9
Burundi	27,834	12,750	46

Sources: Jahnke 1983; Getahun 1991

Table 11.2: **Estimated percentage of total population in highland zones of some selected East African countries**

Country	Percentage of total population
Burundi	90
Ethiopia	90
Kenya	50-60
Rwanda	70-75
Uganda	60-65

Source: Getahun 1991; ILCA 1993; FAO 1998

increased urbanisation, 80 to 85% of the population can still be found in rural areas (Turner and Hyden 1993) (Figures 11.1 and 11.2). More people require more resources, and in most of the EAH the room for expansion is limited. The result is fragmentation of land and/or cultivation of marginal areas at the expense of grazing and forest land (Downing et al. 1990).

The situation with respect to changes in livestock numbers, however, is less uniform. The changes in livestock numbers between 1987 and 1997 in six EAH countries are shown in Table 11.3. The only country with sustained growth in numbers for all types of livestock is Uganda.

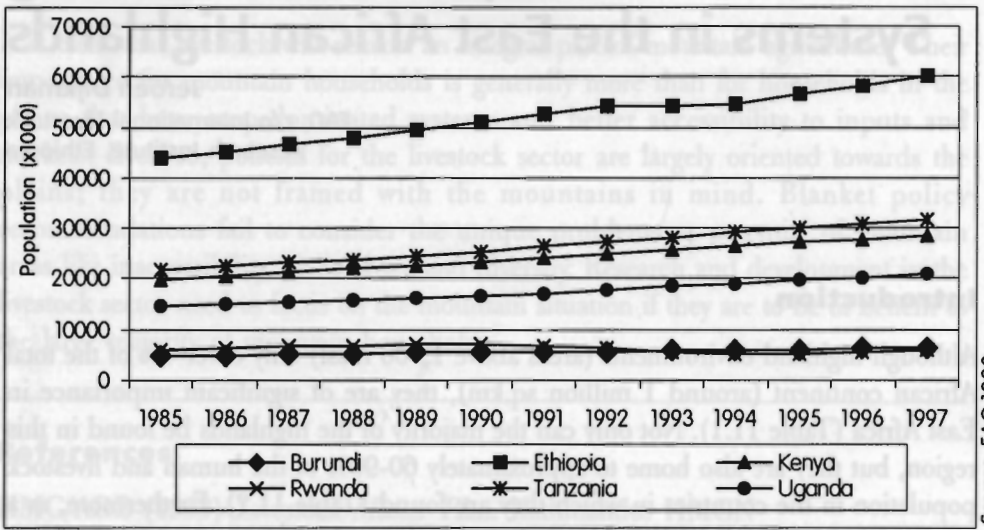

Figure 11.1: **Total population of some selected countries in the EAH**

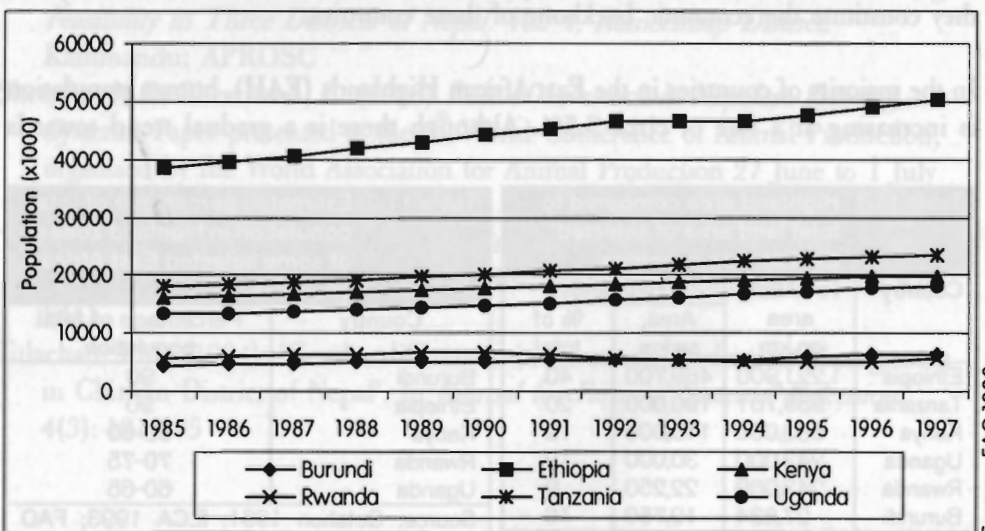

Figure 11.1: **Total population of some selected countries in the EAH**

Table 11.3: **Estimated total livestock numbers (x 1000) in six EAH countries**

	Cattle		Pigs		Sheep/goats		Chicken	
	1987	1997	1987	1997	1987	1997	1987	1997
Burundi	422	400	80	80	1075	1240	4000	4000
Ethiopia	27000	29900	18	23	42000	3870	57000	55000
Kenya	12645	13414	94	108	12540	13400	22000	29000
Rwanda	583	465	105	80	1384	1170	1000	1000
Tanzania	12777	13370	290	335	11260	13637	17000	26000
Uganda	3905	5363	470	940	3903	5544	16000	22000

Source: FAO 1996, 1998

The large increase in poultry numbers in some of the EAH countries is due largely to the expansion of commercial broiler and layer operations, which supply the growing urban markets. Pig production per se is of relatively low importance in the majority of countries under discussion as a result of religious and social taboos. The trends shown in Table 11.3 for Rwanda and Burundi are indicative of the continued process of population increase. In these countries the accompanying reductions in farm size and alterations in access to common pool resources have resulted in changes in livestock ownership patterns and herd and species' composition, leading to a significant reduction in total livestock units. As the links between livestock, vegetation, and soil are perceived to be indispensable to the survival of these systems, their breakdown or gradual disappearance would impede evolution towards continued intensification, higher productivity, higher investment, and sustainability. Most dramatically, this combination of high population growth, poverty, and resource degradation is widely indicated as one of the main causes of the atrocious 1993 civil war in Rwanda (see, for example, de Haan et al. 1997).

Whatever the specific country situation, however, even in the countries where total production in certain livestock sectors has increased (Table 11.4), these increases have, in general, not been able to keep pace with population increases, and only Uganda and Rwanda are showing marginal growth in per capita consumption of animal products. (Table 11.5). A lack of high quality protein in the diet of children and pregnant or lactating mothers can have severe consequences for the full development of human cognitive functions and productive potential.

Table 11.4: **Estimated total production of animal products (x 100 MT) in six EAH countries**

	Beef		Mutton		Pork		Poultry		Milk (cows)		Hen eggs	
	1987	1997	1987	1997	1987	1997	1987	1997	1987	1997	1987	1997
Burundi	11	11	1	1	5	5	5	6	32	32	3	3
Ethiopia	206	236	79	80	1	1	72	73	631	740	78	74
Kenya	219	270	21	23	5	5	44	55	2055	2300	40	48
Rwanda	12	10	1	1	2	2	1	2	84	80	1	2
Tanzania	171	201	10	11	8	9	19	35	475	600	33	52
Uganda	59	89	7	10	25	52	25	36	342	469	13	18

Source: FAO 1996, 1998

Table 11.5: Estimated food availability (KJ/capita/day) in six EAH countries

	Food total		Animal products		Meat		Milk	
	1987	1996	1987	1996	1987	1996	1987	1996
Burundi	8443	7150	230	197	105	92	59	50
Ethiopia	6714	7723	448	402	213	209	134	109
Kenya	8485	8251	1139	996	331	289	687	582
Rwanda	8560	8966	239	247	80	88	134	130
Tanzania	9573	8489	599	536	222	197	167	155
Uganda	8816	8832	532	607	218	272	163	159

Source: FAO 1996, 1998

Although indicative of the general trends, these rather gloomy statistics do not tell the complete story. In the past decade there have, for example, been several positive developments in market opportunities for smallholder livestock producers. These changes are best illustrated by looking at one such specific example.

Smallholder dairy

As a result of the increase of quotas in dairy production and a decrease in consumption in many western countries as a result of dietary concerns, world dairy production has been declining significantly (Staal and Shapiro' 1996). At the same time, however, there has been an increased demand in many developing nations and an upward trend in nominal prices, which is expected to continue (Delgado et al. 1999). As a result of this, opportunities for African dairy producers are favourable and increasing. Further encouragement and intensification of the dairy industry would be particularly suitable in the EAH for a number of reasons: the climatic conditions are highly favourable to the keeping of high grade or crossbred dairy cattle; smallholder dairy farming complements most of the production systems prevalent in the EAH; the input and technology requirements are generally within the means of existing producers and markets; production is compatible with the sustainable use of the available land resources; and smallholders already play the largest role in East African milk production (Laurent and Centres 1990; Staal and Shapiro 1996; Ade Freeman et al. 1998).

In spite of these rather favourable conditions, the response to this development opportunity has been very different in the different EAH countries. This is best illustrated by comparing the current situation in Ethiopia and Kenya. Although both countries have a similar comparative advantage for smallholder dairy development, the actual evolution in both has been very different (Figure 11.3).

The reasons for the differences in the development in the two countries are listed below (van Schaik et al. 1996; Staal and Shapiro 1996).

- In Kenya, dairy development has been based on the use of crossbred and high grade animals, whereas in Ethiopia their numbers are negligible.

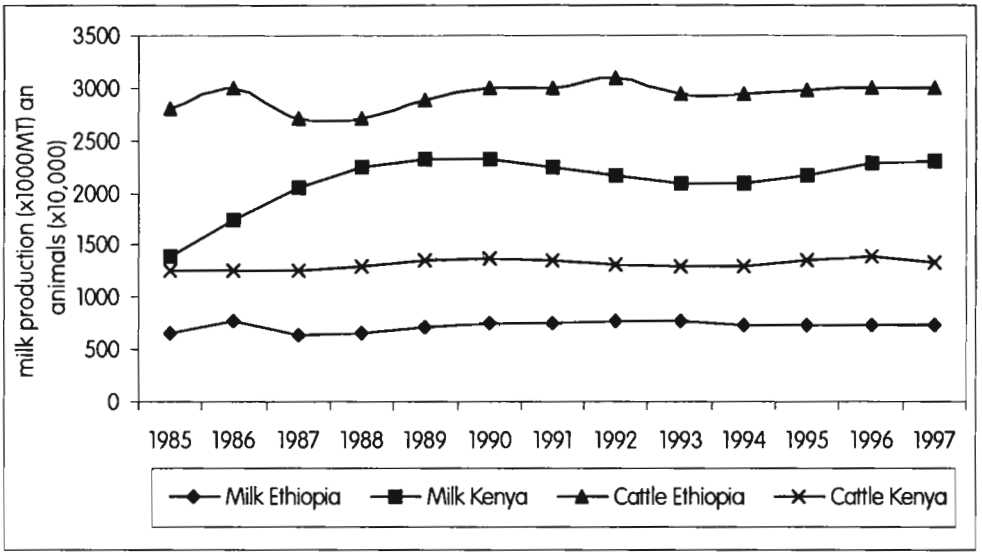

Figure 11.3: **Comparison of dairy production in Ethiopia and Kenya**

- The areas in Kenya where dairy farming is practised generally have a good infrastructure, which aids the marketing of perishable products such as milk (market access) and the access to information and inputs.
- In Ethiopia, most areas where dairy farming could be practised have a very limited infrastructure, and this has limited dairy operations to the peri-urban area of Addis Ababa.
- In Kenya the formal market is reasonably well developed (privatised) because export parity prices are paid and there is good development of collection and processing infrastructures and export of milk products.
- In Ethiopia, the formal milk market is hardly developed (less then 13% of all milk goes through the formal government controlled marketing channels) as prices are lower than export parity prices and government controlled, and there is no system for collection and processing.
- In Ethiopia, cooperatives have not been encouraged in any way. In Kenya, cooperatives have given farmers a voice in dairy policy, in addition to the other collective advantages.
- Services in Kenya are run by many private entrepreneurs, whereas in Ethiopia there are severe government restrictions that limit these developments.
- Changes in land tenure in Kenya have led to development of the use of land resources through shifts to rural production. In Ethiopia, however, all land is considered to be government property, which severely restricts inputs and development.

Although this is a rather specific example, it does illustrate some of the additional issues that can play a major part in the development or otherwise of particular

livestock industries in different countries or regions, even when at first glance these countries or regions seem to have the same comparative advantage (Tiffen et al. 1994).

The EAH: Diverse Environments, Similar Problems?

There is great diversity between the various regions of the EAH. Nevertheless, some useful general lessons can be drawn from looking at the situation in the two major environments found. The main features are summarised below.

- The equatorial (tropical) highlands, near the equator. Farming is largely based on horticulture with intensive hoe cultivation and shows a high level of sustainability.

Some indigenous farming systems, such as the Enset-based farming and the Konso mixed farming systems in Southern Ethiopia, the Chagga system in northern Tanzania, and the smallholder mixed farming of the Central and Eastern highlands in Kenya, are able to support population densities exceeding 400 people per sq.km.

Agricultural growth and sustainability has been achieved through:
- soil conservation measures (structural and biological);
- organic matter, accumulation of manure, mulch, green manure, and/or crop residues;
- reduced or altogether eliminated fallow;
- use of chemical fertilisers (cash crops);
- increased crop diversity;
- integration of trees and animals with crop farming; and
- improved markets and marketing.

(Getahun, 1978, 1991; Fernandes et al. 1985; Messerli and Hurni 1990; Fowlie 1996)

- The subtropical highlands away from the equator. Farming is largely based on extensive cereal/livestock-based agriculture and shows a high degree of unsustainability in the face of an increased population and a declining natural resource base.

Historically, the EAH lacked effective national and regional land-use policies.
Cereal-based systems have largely remained unchanged.
Agricultural growth in these areas has been based on an expansion of the agricultural area at the expense of forest and grazing lands as well as shortening or eliminating the fallow period, resulting in extensive degradation.
The sustainability of these systems breaks down at population densities higher than 50 people per sq.km.

Out-migration from these highland areas to less productive semi-arid lands or into urban centres is a common phenomenon. In some countries governments have been compelled to embark on costly and often less than successful resettlement programmes.

(Lamb and Milas 1983; Dejene 1990; Messerli and Hurni 1990; Emana and Storck 1992; Grepperud 1996)

There are estimations that half of the arable areas in the Ethiopian highlands are moderately to severely eroded and that half of the remainder will need careful management to check soil depletion. Loss of topsoil has become common. Estimates suggest that, annually, about 2 to 3.5 billion tonnes of soil are lost from the Ethiopian highlands and some 20,000 to 30,000 ha of land abandoned by farmers (Saleem 1995; Shiferaw and Holden 1996).

If we compare the farming systems in the two environments described above, we can identify some of the specific conditions that have led to them developing in the way they have, and the influence that enabling circumstances (infrastructure, markets, services etc.) have on the potential sustainability of a system (Table 11.6). Although, generally speaking, the climatic conditions in the equatorial highlands are far more conducive to farming than in sub-tropical highlands, this is thought to have played only a secondary role in the differences in development.

Although the equatorial highland systems are considered to be far more sustainable as a result of their integration, diversification, and intensification, the continuing growth of human population in these areas requires additional interventions if they are to sustain even higher population densities. Various scientists (Christoffersen et al. 1989; Singh 1991; Powell et al. 1995) have proposed the following interventions:

- increased application of agroforestry including home gardens;
- more biological soil conservation;
- further integration of trees and livestock with food crops; and
- overall watershed-based land-use planning.

Table 11. 6: **A comparison of the characteristics of equatorial and subtropical highland farming systems**

Characteristic	Equatorial highlands (e.g., Kenya)	Subtropical highlands (e.g., N. Ethiopia)
Cash crops	Important (tea, coffee)	No cash crops, only livestock used as source of cash
Food crops	Roots and tubers, grain	Cereals, pulses, oil crops
Cropping system	Mixed	Monocultures
Livestock	Dairy farming	All classes for meat
Animal traction	None or minimal	Significant
Hired farm labour	Important	Insignificant
Produce marketed	Important (>50%)	Insignificant
Forestry, game reserves	Highly developed	Insignificant
Non-farm income	Important	Insignificant
Infrastructure	Well developed	Poorly developed
Land improvement efforts	High	Insignificant
Total income per farm	High	Very low
Production efficiency	High	Low

(Getahun 1978; Jones and Egli 1984; Rodriguez and Anderson 1988; Storck et al. 1991; Storck et al. 1997)

The sub-tropical highlands are already known to have unsustainable production technologies. Several scientists (Christoffersen et al. 1989; Getahun 1991; Singh 1991; Powell et al. 1995) have proposed various interventions such as the following:

- environmental rehabilitation through afforestation and soil conservation;
- reducing livestock numbers by replacing local breeds with fewer head of improved breeds;
- use of irrigated agriculture, and rehabilitation and use of land on the valley bottom;
- widespread introduction of agroforestry practices; and
- growing of trees on marginal lands.

Although it is comparatively easy to enumerate the steps required, the question that has to be asked is how likely it is that these measures will be implemented? In the light of the recent changes in the traditional methods of intervention in the agricultural sector (with use of price controls and state monopoly marketing boards, restraints on private sector involvement in processing and marketing, and an array of inhibitory measures such as export taxes, import tariffs, export and import licenses, and quotas and bans) towards increased market orientation of policies (with privatisation or dismantling of state-owned interests in production and distribution, liberalisation of trade and markets, land tenure protection and regeneration of natural forest resources, and increased attention to issues of poverty alleviation and social needs) that have occurred in the region at large, the prospects are probably relatively good (Assefa 1990; Anteneh 1991; Ehui and Lipner 1993; FAO 1998; LID 1999).

Integration of Livestock into Farming Systems

The implications of the recent changes for the integration of livestock into mixed farming systems and for specific livestock production related issues, as well as some of the new opportunities that are arising in this climate of change, are examined in further detail below.

Draught animals

In most EAH countries, the use of animal traction was introduced only in the late 19th or early 20th century. Generally, the use of work animals is on the increase in these areas, although their use is often restricted as a result of the size of holdings and the lack of feed resources. Use of dairy cows (multipurpose) and donkeys (which have specific advantages from a gender point of view) is increasing, however. Unfortunately, the implementation of programmes to stimulate their use is often hampered through the lack of appropriate complementary technologies and an enabling environment because most policy-makers still view the use of work animals as a retrograde step.

Ethiopia is very much the exception to the rule in the EAH. Pairs of oxen have been used for cultivation for thousands of years and currently an estimated 8 million oxen cultivate about 80 % of the soils. The use of oxen is said to be essential to cultivate the heavy soils. Ethiopia also has the largest population of donkeys on the continent (about 6 million) which are mainly used for pack transport and play a key role in marketing. Unfortunately, the use of oxen is generally rather inefficient. The animals are used for six to eight weeks per year only and require a large follower herd to ensure their continued availability, which causes severe pressure on land and the available feed resources. Programmes to promote the use of single ox traction or the use of dairy cows for traction have had little influence because of the lack of complementary technologies and infrastructure and the fact that livestock are still one of the most secure investments in the country (Gryseels et al. 1986; Gryseels 1988; Panin and Brocken 1992; Winrock 1992; Wilson 1995).

In other countries in the world, decreasing farm sizes, and reduced availability and access to common property resources have led to the development of alternative strategies. In parts of Bolivia, for example, farmers who do not have enough resources to maintain a pair of draught animals throughout the year buy a young pair of oxen at the start of the cultivation season. These animals are used for work for the duration of the cultivation period, during which time the farmers take advantage of the relative abundance of feed resources. At the end of the working period the animals are sold (Dijkman et al. 1999a, 1999b). In this way the farmers not only reduce their dependence on the hiring of tractor services or work animals from other farmers – methods that frequently reduce the timeliness of planting and are often prohibitively expensive – they also optimise the generation of income from their work animal and feed resource sub-systems. Although the quality of the work produced by these young animals may not be comparable to that of more experienced pairs of work animals, soil preparation techniques and cultivation systems are such that this reportedly has little effect on crop production. One potentially negative effect is that the practice often depends on importing animals from other parts of the country, which could potentially result in the establishment of exotic pathogens and vectors. As yet, no systems like this have been observed in the EAH.

Diversification of use

In many smallholder farming systems, the activities carried out by the different types of draught animals are often well-defined. Frequently, however, there are opportunities to increase the efficiency of use of the draught animals by diversifying the tasks that they are used for and thus reducing the idle time.

In various different cultivation systems across the developing world, all field operations apart from primary cultivation, which uses oxen, are carried out by hand.

However, there are many possibilities for employing equines (single or paired) in systems where they are available, for example in tasks like inter-row weeding (see, for example, Betker 1993; Emhardt 1994). Similarly, oxen (single or paired) could be used for secondary cultivation purposes, equines for primary cultivation on light soils, or combinations of different species, as necessity determines. Unfortunately, the implements needed for these types of operations are often not available. However, in many areas it would be possible to evaluate, adapt, and manufacture low-cost implements that have proved successful in other countries. One of the main stumbling blocks, often mentioned, to the spread of these types of technologies is the established cultural prejudice against the employment of animals for activities that deviate from the norm. However, recent evidence from southern Africa, where farmers started employing donkeys for primary cultivation purposes following the loss of their oxen in recent droughts, and Bolivia where the use of equines for activities other than pack transport is rapidly increasing, would suggest that this is dictated more by requirements than by cultural taboos (Sims et al. 1998, 1999).

Nutrition

As a result of the large variety in environments, the systems of animal nutrition are very diverse and often of different importance. Feeding systems range from the grazing of a large number of mixed herds on natural pasture, as in Ethiopia, through tethering of cattle and small ruminants in certain parts of the Tanzanian, Burundian, and Rwandan highlands, to zero-grazing dairy systems (mainly for high-grade dairy cattle but also for goats) in Kenya, Tanzania, and other EAH countries.

Apart from different systems of feeding, there is also a large diversity in the importance of the various feed resources. Nevertheless, in almost all crop-livestock systems, crop by-products continue to be of great importance. Grown forages are also still of major importance in many, particularly market-oriented, systems, although it is likely that with further increases in population their importance will decrease. In some areas in Kenya, for example, the application of maize food/feed systems and the use of concentrates and other bought feeds in market-oriented dairy systems is on the increase. Increased market orientation often provides farmers with the cash resources to buy additional feed resources, although this is dependent on a proper functioning of the markets and availability.

Nevertheless, natural grasses and grazing are still of major importance in many crop-livestock systems. The herding systems employed in Ethiopia were mentioned before, but even in zero-grazing systems, cut roadside grasses and other natural vegetation still constitute a major part of the animals' diets. Tethering is often practised in very densely cultivated and populated areas as animals cannot be allowed to roam around.

Bought fodder is becoming more and more important particularly in market-oriented crop-livestock systems (concentrates and forage). In some areas in Kenya, for example, some farmers have started growing Napier grass as a cash crop. The relative importance of the trade in feed and fodder, however, is very dependent on an enabling infrastructure and policy environment.

The various trends discussed are also having a significant impact on the feeding systems employed. Increases in cropped area and/or the intensification of cropping, can reduce access to grazing areas and the availability of feed and fodder. In general, however, it also leads to the production of more crop by-products and residues (provided the crops grown produce residues that can be used by animals). The change may, however, shift scarcity problems from the dry to the wet season.

(Tothill 1988; Shem 1994; Wilson 1995; Akyeampong and Dzowela 1996; Drechsel et al. 1996)

Integrating food and feed systems

When we discuss feed shortages for ruminant animals, the first 'solution' we tend to think of is to plant more and better. This may indeed be the appropriate solution in some cases. However, competition for land to grow crops for human consumption may restrict the possibilities available. Although many elegant systems have been designed for cultivating fodder in association with other crops, thus far their success has been limited. Nevertheless, opportunities may still exist within the current cropping systems to optimise the biomass available to animals without jeopardising crop production.

Weeding is a time-consuming chore in the majority of cropping systems. The weeds we're trying to remove, however, are often the forage used in natural pasture or on fallow land. What are the possibilities for using this production of biomass better? One route would be to investigate the influence of these weeds on total crop production during the different stages of crop growth. It may be possible to devise systems in which weeds are managed to optimise both feed and food production from the available land. Some farmers in Ethiopia and Bolivia, for example, have developed an integrated food/feed system in which they allow certain weed species to flourish alongside the cereal crop to increase biomass production, forage palatability, digestibility, and nutritional value, thus addressing several priority problems simultaneously. It would be useful to compare efficiency and total production in this type of integrated system with systems in which forage and human food crops are cultivated separately in monocultures. Clearly many different permutations of the strategies mentioned can be imagined, but these depend on the cropping systems currently in use.

Soil fertility

One of the most important aspects of the integration of animals into cropping systems is the production of manure. In many parts of the EAH, supply of chemical fertilisers is still difficult, especially where the infrastructure is poor or when chemical fertilisers are beyond the financial means of farmers. Equally, many soils in the EAH are poor in organic matter and the cropping results obtained on these soils with organic manure are often much better than those with chemical fertiliser. Improvement of the physical properties of soil through the application of organic manure is also said to reduce soil erosion. Even where chemical fertilisers are used, combination with organic manure can result in synergistic effects, making both more effective. Thus, in many systems, livestock are the 'tool' that allows intensification through the importation of nutrients and the acceleration of nutrient cycling. In some places, however, the lack of trees and other energy sources leads to the use of manure for fuel (for household use and sale). On some farms in Ethiopia as much as 1/3 of cash income is derived from the sale of fuel cakes. Biogas systems, are gaining popularity in some highland areas of Nepal. Although this system enables the manure to be used both as fuel and as fertiliser, it does not have the income-generating aspect.

Unfortunately, significant amounts of nutrients are often lost as a result of the collection and storage methods used for manure, and the lack of urine collection. In general, 40-60% of the N excreted by animals is contained in urine (Powell and Ikpe 1992). Urine must be conserved for nutrient collection to be optimised. In systems where animals graze, this may be impossible to achieve. Although the grazing land benefits from the deposited urine, an estimated 50% of the N in urine voided onto pasture is lost through ammonia volatilisation. Much of the N contained in faeces dropped on pasture is lost by a similar route (Watson and Lapins 1969). It is therefore important to minimise exposure of livestock excreta destined for fertiliser use to the effects of climate (Tanner et al. 1995). Minimising nutrient losses through the promotion of effective recycling is a key issue in maintaining the sustainability of smallholder mixed farming systems. There is much research underway in this area and several more efficient systems are currently being tested and implemented. One interesting point is that improvement of animal nutrition often has a direct effect on the nutrient composition of the manure, and thus benefits both the crop and the livestock systems.

The method used to collect manure obviously depends on the husbandry system employed. Under zero-grazing systems, collection of both manure and urine is relatively easy, although many systems are rather inefficient in both collection and subsequent storage. If animals are herded, considerable labour is needed to collect the manure. If animals graze fallow land, the deposition of manure and urine will still benefit the soil, although there are problems with the spatial allocation of the

nutrients. In most herding systems animals are penned at night, which facilitates the collection of manure, although most of the urine will be lost. In some tethering systems, e.g., in Rwanda, the droppings of small ruminants are carefully collected for composting or direct use as manure.

(Powell et al. 1995; Drechsel et al. 1996; Hawassi et al. 1998; Lekasi et al. 1998; Thorne and Cadish 1998; Thorne et al. 1998)

Changing systems

In the past, cropping has been sustained by the transfer of organic soil nutrients from forest and grazing land via the fodder/bedding–animal–manure/compost (FAM) pathway. This pathway not only obliges farmers to keep large numbers of animals, it also requires access to a significant acreage of grazing and/or forest land to maintain the arable land (e.g., Wyatt-Smith 1982; Pandey and Singh 1984). While access to, and quality of, grazing and forest resources have declined, alternative options such as the use of costly inorganic fertilisers have not been available to poorer farmers. Under these circumstances, the most promising option for targeting the needs of the poorest farmers would appear to lie in reducing the nutrient losses associated with inefficient organic matter management practices. Recent studies (e.g., Pilbeam et al. 2000) have indicated that these can be highly significant, with the FAM pathway potentially responsible for more than 70% of all N losses from the system. Thus, in many areas, the role of the livestock component in regulating nutrient flows via the FAM pathway is pivotal for the sustainability of the system as a whole.

Strategic studies conducted in Kenya on the impact of livestock and manure/compost management on nutrient flows suggest that, for highly integrated systems, these factors must be taken into account if efficient nutrient management is to be used to enhance soil fertility. Key findings of this research include observations that small changes in the type and quantity of feed supplements can result in large differences in the extent of net N mineralisation following incorporation of manure (Delve 1998; Lekasi et al. 1998; Thorne and Cadish 1998; Thorne et al. 1998). Further research is needed, however, to examine specifically the scope for managing livestock to create more effective linkages between off-farm nutrient resources and arable land, given the scenario of changing access to and availability of common property nutrient resources.

Income Generation

Apart from their integration in, and aid to the farming system, livestock also have many direct income-generating and capital accumulation functions. This can vary from livestock being the main cash crop, as in smallholder dairy systems, to the occasional

chicken or goat sold to cover sporadic or emergency expenses. Livestock are potentially the most dynamic part of the rural economy. They can provide a steady stream of food and revenues, help to raise whole farm productivity and are often the only secure means of asset accumulation and an effective strategy for risk aversion at smallholder level. The range and amount of products sold depend on the different systems; they can vary from meat to manure, eggs to fibre, and milk to work. Although these products are very important, in many systems the contribution of livestock to the maintenance of the system (in all its forms) often constitutes the main (indirect) cash generating influence.

Changes in Use, Type, Species and Management

The changes in demography and markets, and the intensification of land use, has had a major influence on the use, type, species, and management of animals in some areas of the EAH. Some of the main examples are listed below.

From cattle to small ruminants — Significant reductions in landholdings and increased land fragmentation (in countries such as Rwanda and Burundi) are leading to a significant reduction in the number of cattle kept, as households cannot feed the animals anymore. As a result, farmers are changing from large to small ruminants. This trend is actively encouraged by the extension services and government agencies in these countries.

From local to high-grade animals — In countries such as Kenya and Tanzania where market-oriented smallholder dairy production has really taken off, the more traditional systems and animals used for dairy production are being exchanged for stall-fed exotic breeds to take full advantage of the existing market opportunities. In some areas of countries like Ethiopia, Tanzania, and Kenya, the same is happening in dairy goat enterprises.

From grazing to pens — Changes are taking place in feeding and management systems as a result of many factors connected to the recent trends, for example increases in the area under crops, reduction of access to common resources, ease of collecting manure and urine, efficient use of the available feed resources, health considerations, and investment in animal resources.

From mix to specialisation — Increased market and income-generating opportunities, and the need to improve the efficiency of use of the available feed and labour resources, have led to significant changes from, for example, mixed species' holdings to specialised dairy or small-scale fattening enterprises.

From self-grown to bought — Rather than spending scarce resources on raising replacement animals, many farmers opt to buy animals if and when they need them.

A similar trend can be observed in the acquisition of feed, particularly, in zero-grazing systems where herd sizes are largely independent of farm size. High stocking rates can be sustained by buying in fodder and concentrates, and these imported nutrient resources also contribute to sustaining the nutrient extraction rates from the soil that result from the intensive cropping in these systems.

From animals to no animals — Although this scenario is currently based on some anecdotal evidence from the Enset systems in Southern Ethiopia, it is likely that as farm sizes decrease, a situation can be reached in which no animals can be maintained on the farm. The eventual consequences for household survival, considering the importance of the animal component for the maintenance of the system as a whole, can only be hypothesised at present.

(Wilson 1995; Wilson et al. 1995; de Haan et al. 1997; Smith et al. 1997; Steinfeld et al. 1997; Nell 1998)

Key Policy Issues

National and international policies can have a major impact on production systems, market opportunities such as in dairy farming, processing, and affiliated supply services. In general, the new policies in the EAH lean towards increased market orientation, privatisation or dismantling of state-owned interests in production and distribution, and liberalisation of markets and trade, and they have an increased emphasis on issues of poverty alleviation and social needs. Nevertheless, there are still major problems in the availability and accessibility of credit, and even where credit is available the amount is normally only just enough to buy animals but not for the additional inputs required. In addition, in many of the EAH countries, policies have been only partially implemented. This leads to market distortions and disincentives. In particular, when farmers are not paid export parity prices for products, subsidies may be required on inputs to stimulate production. There are also significant constraints still to services focusing on rural areas as a result of the continuing preoccupation with the needs of the urban elite. Extension services are in most cases still massively understaffed, and the staff poorly trained and without the appropriate information and technologies that farmers require. In some countries (Kenya and Tanzania) the provision of veterinary and reproductive services is increasingly being taken over by the private sector. However, many of these privatised services will require additional support until the systems are fully developed.

(Assefa and Agrawal 1990; Kebede 1992; Umali et al. 1992; Swallow 1994; Mudinu 1996; Ade Freeman et al. 1998).

Role of Gender

Although it is widely known that women and children carry the main responsibility for many livestock, still only marginal attention is being paid to their specific needs and requirements in research and development programmes and the provision of services. More attention should also be paid to the effects that increasing population pressure has within and between households on access to natural resources. Particularly since women often control livestock resources, differential access to resources could have serious negative effects on production. Moreover, radical changes to livestock production systems leading to cut-and-carry feeding and the collection of manure are likely to cause significant increases in workloads for women and children in these areas. Even though all poor people experience a lack of services and opportunities for human development, a lack of a voice in decision-making, and social subordination and exclusion, in all or nearly all cases women and girls suffer from them to a greater degree than men.

Although the donor community's concerns have had some effect, gender appreciation in the provision of and access to services like credit and extension, or gender representation in research and development work, often remains tokenism. This is probably best illustrated by an example. The recently published agriculture modernisation plan in Uganda calls for the expenditure of US$120 million on improved and decentralised research and extension services. However, even though most farmers are women, little emphasis is given to gender issues and the number of female extension workers remains minimal.

(Pankhurst 1992; Mekuria 1994; Peacock et al. 1994; FAO 1998; LID 1999)

From Key Constraints to Sustainable Solutions

It is clear from the preceding discussion that there are still major problems in the EAH with respect to infrastructure and marketing, and access to information, services, and inputs. However, the changes in policies towards increased market orientation and reduction of government control and subsidies are resulting in significant improvement in the situation. Although these changes are in many cases slow, it is encouraging to see the improvements in service provision and marketing and these trends should be actively encouraged.

There continue to be large problems in many areas related to the maintenance and sustainability of the natural resource base, but the shift of government institutions away from a solely urban focus holds promise for the future.

Although much research has been carried out in the past decades, a large part was performed in isolation and without paying due attention to the external driving

forces that have caused, and are causing, significant changes in the existing farming systems. Any new initiatives, therefore, will have to look beyond the conventional. Although the new possibilities and opportunities that may emerge might sometimes seem far-fetched, one has to realise that the changes driven by population increase and environmental modifications are inevitable. Luckily, many research organisations have shifted their research agenda to a more client and poverty-oriented focus, with due respect being paid to the forces of change. In some cases this has already led to the diffusion of appropriate technologies. A number of practical examples of sustainable technologies that can sustain large numbers of people, and which are already widely used, have been highlighted in this paper.

Notwithstanding the present positive developments, it is still imperative that the efficiency and production of the current systems be dramatically improved to fulfil the needs of the coming years. The potential needs are highlighted by what has been called 'The Livestock Revolution' in a study which predicts that by 2020 each person in the developing world is likely to demand some 29 kg of meat and 63 kg of milk on average per year, up from 21 kg and 41 kg, respectively, in 1993 (Delgado et al. 1999). Achieving this will not only require changes to be made in the training that future researchers and development workers around the world receive, but also that we can develop a clear understanding of the external forces of change to enable us to approach the problems in a dynamic, integrated, and systems-oriented manner. Exciting new opportunities are developing for sustainable livestock production from these changes in macro-economics and consumption patterns, some of which are already being exploited successfully. Dairy farming (both cattle and goats) has been discussed at length in this paper, but there are other opportunities too for smallholder livestock producers like small-scale fattening of small ruminants and cattle to supply the increasing urban meat market. Likewise, even though increases in poultry production have been confined primarily to large-scale commercial enterprises, there is a new market developing for local eggs and poultry, as many people don't like the 'improved' eggs and the soft meat from commercial poultry.

Many problems have been experienced in delivering the results of research to front-line extension staff in a comprehensible and useable form. Without the effective implementation of this link, it is difficult to see how extension services (public, cooperative, and private) can promote improved management and new strategies amongst their client farmers in a way that is flexible enough to meet the individual needs and that accounts for the dynamics of smallholder systems. Paper-based extension literature (in tabular or other formats) is not easily assimilated by extension staff, who are not generally experts in the particular subject matter. Although some new approaches are currently being tested (Thorne 1998), these new methods still rely heavily on frequent contact between extension systems, that are often poorly

functioning, and farmers. Deficiencies in this process may mean that these approaches will not always be sufficiently responsive to changing seasons, resource endowments, local markets, and production objectives, compromising the extent to which farmers can base their management decisions on these and other factors. There is, therefore, a need to generate information in a form that reduces the complexity of the interaction between extension services and farmers and that allows the farmer to take a more active part in the evaluation of alternative strategies.

Smallholder farmers in the EAH have clearly demonstrated that, given the right environment and support, they can respond positively to change.

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Chapter 12

Systems of Milk Production in the Andean Region of Colombia: A Comparative Study

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Introduction

In this paper, an attempt is made to analyse the systems of dairy production practised in two areas of the Andean region of Colombia: the north high plateau of Antioquia (NHP-Antioquia) and Quindio Department, both located in the central range of mountains. Specialised dairy is the common system in NHP-Antioquia, whereas both specialised and dual-purpose systems are practised in Quindio. Holstein is the major dairy breed and *Pennisetum clandestinum* the major grass species in the area.

Colombia is located in the northern corner of South America. The country has frontiers with Panama, Venezuela, Brazil, Peru, and Ecuador and a long coastline with both the Atlantic and the Pacific Oceans. Colombia has a total area of 1,141,784 sq.km, and by 1996 had a population of close to 39,500,000 (34 inhabitants per sq.km). The country is divided into five geographical regions: Andean, Atlantic (Caribe), Amazonian, Orinoquia, and Pacific. The Colombian Andean region is located in the centre of the country and covers an area of about 352,000 sq. km (31% of the total). The Andes spread from Chile in the south to Colombia and Venezuela in the north. In the south of Colombia the range divides into three branches – west, centre, and east– that cross the country from south to north. The two main rivers of Colombia, the Magdalena and Cauca, run along the two valleys set between the eastern and central and between the central and western ranges of mountains, respectively. Both rivers flow into the Atlantic Ocean.

About 80% of the Colombian population live in the Andean region, which is the centre of the agricultural, economic, social, cultural, and political life of the country. The Andes are the source of the continental waters of Colombia, the major source of hydroelectricity for the country, and home to the coffee plantations that have been the engine of the Colombian economy since the mid 19th century. The three major Colombian cities, Bogotá (the capital), Medellín, and Cali are all located in the Andes. The Andean region has a total population of nearly 32 million, with an average 90 inhabitants per sq.km, compared to the national average of 34.

The temperature range in the Andes is determined by the altitude: a warm 24-30°C at 200-1,000 masl; a medium18-24 °C at 1,000-1,800m.; a cold 14-18°C at 1800-3,000m; and a very cold <14°C above 3,000m. In the greater part of the region annual rainfall fluctuates between 1,000 and 2,000 mm with higher values of 3,000 to 5,000mm around the perimeter.

More than 60% of farms in departments like Boyacá, Cundinamarca, Nariño, Cauca, and Antioquia are smalholdings of less than 20 ha (Ministerio de Agricultura y Desarrollo Rural 1998). The soil has low fertility, which affects the incomes of farmers and encourages them to migrate to the cities in the search for better opportunities. The challenge for agricultural research has been to develop a sustainable farming system that improves the current state of the livelihoods of mountain people.

The Northern High Plateau of Antioquia Department (NHP-Antioquia)

Antioquia Department is situated in the north-west of Colombia. The north high plateau is located to the north of the capital city of Antioquia, Medellín, in the central range of the Andes. The region covers 258,100 ha and has a total population of 102,319 (39.6 per sq.km) (Tobón 1997). The altitude ranges from 2,200 to 2,600m and the temperature fluctuates between 13 and 16°C. The relative humidity is around 79% and the annual rainfall varies from 1,400 to 2,750 mm (Tobón 1997). The main economic activity is pasture-based dairy production. Pasturelands cover 189,382 ha, or 73.4% of the region. In 1997, there were around 203,000 head of cattle, with a total milk production of 810,250 kg per day. Pig farming is also important; the total pig population in the department in 1997 was 79,050 (Tobón 1997).

Soil fertility is generally low; soils have high levels of aluminium and low values of P, Ca, and Mg. The organic matter content fluctuates between medium and high, but the process of decomposition is slow because of the low temperatures. Less than 15% of the original forest remains. The importance of these forests and of the productive

systems of the area becomes even clearer when the fact that the Riogrande and Guadalupe dams, which supply hydropower to the national grid, are fed with the water of rivers that rise in the North Plateau.

Systems of milk production

Farms are generally small. Seventy per cent of the farms have less than 20 ha of land, with an average of 42 cattle per farm (Quiros et al. 1997). Quiros et al. (1997) carried out a descriptive study of the systems of production in the Antioquia northern high plateau. The two main systems identified were: 'pigs-pastures-cattle-milk with pastures fertilised by pig manure', cattle graze on the pasture but are also given concentrate feed; and 'pigs-pastures-cattle-milk with pastures fertilised with chemical fertilisers', similar to the previous one but with the addition of chemical fertilisation of the pasture. Some modified systems are found in sub-regions such as 'pasture-cattle-milk-chemical fertilisers without pigs' and 'pasture-cattle-milk', which is considered a backward subsistence system. *Pennisetum clandestinum* is the dominant grass cover in pastures. Other grasses found in pastures include *Holcus lanatus, Anthoxanthum odoratum, Paspalum sp, Lolium sp,* and *Trifolium sp.* Overall, 51.5% of the farmers use a system of dairy production that includes pigs. The number of pigs per farm is generally less than 100. Pigs are normally reared in buildings located at the highest point in the farm so that the manure-water mixture can be distributed to the pastures by gravity. The pigs are fed exclusively on commercial concentrates. The most popular cow breed is Holstein, although breeds such as Jersey, Ayrshire, Brown Swiss, and Blanco Orejinegro (blackears white, a creole breed) are also found.

Pasture is the main source of feed for cattle. Cows in milk are given concentrates as a supplement during milking (twice a day), normally 4-6 kg daily. Calves are fed 3-4 kg of milk daily, for 3-4 months. These calves are usually fed the same concentrates as given to cows. Dry cows are given concentrates for 20-30 days before calving. Natural service is the most common method of mating. Artificial insemination (AI) is used on 30% of farms, and 10% use both systems (Tobon 1997).

Productive parameters

The main productive parameters of dairy cattle in the area are shown in Table 12.1. Different authors report an average daily milk production per cow of between 10.5 and 12.1 kg. Aristizabal and Ramos (1995) reported a milk yield per lactation of 4,051 and 4,193 kg (305 days adjusted) for farms in the municipalities of Don Matias and Santa Rosa whereas Aguilar and García (1995) reported 2,668 kg per lactation (305 days adjusted) for farms in the municipalities of Belmira, Entrerrios, and San Pedro. The author considers that the first figures are probably representative of elite

Table 12.1: **Productive parameters reported for dairy cattle on farms in the northern high plateau of Antioquia Department**

	Don Matias municipality	Santa Rosa municipality	Belmira, Entrerrios and San Pedro municipalities
Daily milk per cow, kg	10.5[1]	12.1[1]	10.8[2]
Lactation, days	328[1]	370[1]	343[2]
Milk per ha per day, kg	7.05[1]	14.2[1]	20.8[2]
Calving interval, months	14.53[1]	14.65[1]	13.84[2]
Stocking rate, equivalent mature cattle/ha	-	1.67[1]	2.4[2]
First calving, months	32.9[3]		32.7[4]

Sources: [1] Aristizabal and Ramos 1995
[2] Aguilar and García 1995
[3] Calderon and Sierra 1990 (cited in Tobon 1997)
[4] Figures for San Pedro municipality Jaramillo and Tobón (1991) (cited in Tobon 1997)

herds, and that 2,668 kg per lactation (305 days adjusted) is likely to be closer to the real average for the seven municipalities of NHP-Antioquia.

Quindio Department

Quindio department is located in the centre of Colombia, on the west of the central range of mountains. Quindio covers approximately 1,930 sq.km. The region at an altitude of 1,200 to 1,700m is mostly dedicated to coffee production. Quindio, Caldas, and Risaralda form the 'coffee belt' of Colombia.

Dairy farming systems

The dairy production systems in Quindio were described in a joint study carried out by German Technical Cooperation (GTZ) and the Colombian Agriculture Institute (ICA) (Rodríguez et al. 1991). In most farms located below 1,700m, the cattle industry is associated with coffee growing (generally the major enterprise on those farms). There are two main systems of milk production: specialised dairy (SD) and dual-purpose dairy (DP). Specialised dairy systems are entirely focused on the production of milk; dual-purpose systems are focused on the production of both milk and calves. SD is practised in 38% of the farms and DP in 62%. Average farm sizes are 24 ha and 68 ha for SD and DP, respectively. About 66% of the farms have less than 30 head of cattle. *Cynodon nlemfuensis* and *Penissetum clandestinum* are the prevalent grasses. *Cynodon nlemfuensis* is found mainly on the farms below 1,700m; *Pennisetum clandestinum* is the major grass at higher altitudes. Holstein is the major breed in the SD systems with some herds of Brown Swiss. Norman (a French breed) and its crosses are the common breeds on DP farms. In the DP system, calves suckle the cows before and after milking and are weaned when they are seven to nine months old. Calves are usually sold between 7 and 18 months of age for

further rearing. In the SD system (both in Quindio and the high plateau of Antioquia), calves are separated from the dams three to five days after calving and male calves are sold for slaughter shortly afterward. Female calves are fed milk in buckets for 31 to 120 days, between 90 and 630 kg in total. Very often the high amount of milk supplied makes the rearing of female calves uneconomic.

Productive parameters

The average daily milk production per cow is 8.5 kg in the SD and 4.2 kg in the DP system (3.4 kg if cows are milked once daily and 5.7 kg if they are milked twice daily). The average daily milk production per hectare is 12 kg and 4.5 kg respectively. The average stocking rate per hectare is 3.6 in SD and 2.1 in DP.

Development Strategies

Both farmers and the institutions working in rural development aim to increase farm production. In the next paragraphs, two productive strategies for the regions described above are analysed.

The conventional approach

The conventional technical approach tries to obtain the maximum milk yield per cow and per unit area by increasing the use of concentrates; upgrading the Holstein herds, using artificial insemination, and applying large amounts of chemical fertiliser. This approach is heavily dependent on investment and capital. It is inappropriate in NHP-Antioquia where the milk producers are mostly poor and have relatively small farms. Although it might be suitable for wealthier farmers, it still has a number of drawbacks. Even for rich farmers, milk produced in a system based on the use of costly inputs will not be able to compete with the lower-priced milk available in the international market. Since Colombia has an open market policy, application of this conventional approach will lead to a higher dependency on imported inputs at both farm and national levels. Currently, all dairy genetic resources, whether in the form of semen or live animals, are imported, as are most of the raw materials used for concentrates. This means that self-reliance of farmers is not fostered. Another drawback is that a certain level of environmental degradation is unavoidable in a system based on grazing of monocultures of grass on slopes. Chemical fertilisers may help improve the concentration of elements like N, P, and K, but they contribute to the development of soil erosion and changes in soil texture.

A new approach

The new approach is not aimed at maximising the production per animal or per unit area, as this would be dependent on 'imported' inputs. Rather it aims at increasing

farm production as a whole, with fewer imported inputs and greater reliance on local resources; a move from 'monoculture' pastures with few grass species to development of pastures with a diversity of fodder plants ('polycultures'); and an integrated production system that includes production of milk, beef, pork, multipurpose trees, energy, organic fertilisers, and earthworms.

The key elements of this approach are as follow.

- Crossbred Holsteins with some zebu (*Bos indicus*) or creole blood (1/4-1/2 zebu or creole) instead of pure Holsteins (like Brown Swiss and Ayrshire). The cows in the specialised dairy systems of NHP-Antioquia and Quindio only yield around 3,000-4,000 kg of milk per lactation; they do not produce more not because of lack of genetic potential but as a result of poor feeding, management and ecological conditions. Keeping purebred Holsteins will only serve to reinforce the impact of these constraints, not to solve them.
- Dual-purpose system instead of specialised dairy. The use of restricted suckling (even with high-grade Holsteins) will provide a cheaper rearing method for calves and a better control of mastitis. In the Colombian specialised dairy systems, between 90 and 630 kg of milk is not sold anyway, but supplied to the female calf. By using crossbred cattle, it is also possible to produce male calves that are suitable for beef production (see Preston and Leng 1987).
- Establishment of polyculture plots for cutting close to the main facilities (house, barn, milking parlour, pigsties). These plots supply feed for cattle and pigs and food for people. Association of different plants in the same plot has been shown to have benefits in different areas of the Colombian Andes between 1,400 and 2,500m. Some of the plants used in this system are *Trichanthera gigantea, Tythonia diversifolia, Morus alba, Boehmeria nivea, Erythrina edulis, Phaseolus vulgaris*, and sugar cane (Table 12.2).

Table 12.2: **Plants associated in polycultures in farms in the Colombian Andes**

Latin name		Altitude range masl	Family	Eaten by
Trichanthera gigantea	Tree	0-2,300	*Acantaceae*	Ruminants, pigs, hens
Tythonia diversifolia	Shrub	0-2,500	*Asteraceae*	Ruminants
Morus alba	Shrub	0-2,500	*Moraceae*	Ruminants, pigs, hens
Boehmeria nivea	Herb	1,000-2,200	*Urticaceae*	Ruminants, pigs, hens
Erythrina edulis	Tree	1,800-2,500	*Papilonaceae*	Ruminants (leaves), pigs (seeds), people (seeds)
Alocasia macrorrhiza[1]	Herb	0-2,500	*Araceae*	Pigs
Phaseolus vulgaris	Herb	1,000-2,500		People
Saccharum officinarum	Grass	0-2,300		Ruminants (whole plant, stalk, tops, bagasse), pigs (stalk, juice), people (processed juice)

[1] A promising plant currently being evaluated by CIPAV

- Establishment of tree-grass associations in grazing areas. In Colombia, the association *Pennisetum clandestinum - Alnus acuminata* has been shown to be beneficial in areas above 2,000m. Recently, Giraldo and Bolivar (1999) reported interesting results in Antioquia with *Pennisetum clandestinum* and *Acacia decurrens*, with marked differences between acacia planted at low density or at high density, and with control *Pennisetum* monoculture plots (Table 12.3). In the areas covered by this study, *Pennisetum clandestinum* is intensively attacked by pests such as *Draeculacephala clypeata, Hortensia similis,* and *Collaria scenica.* It is common practice to spray pastures with chemicals two or three times between grazing episodes, which are approximately 50-60 days apart. The chemicals used are expensive and toxic to both humans and animals. By contrast, observations over a two-year period showed chemicals to be unnecessary in areas planted with *Acacia decurrens-Pennisetum clandestinum* because pests caused no important damage (Giraldo A, 1999 personal communication[1]).
- Closing off of marginal areas to allow the natural regeneration of trees. This is a good option that can save the cost of tree planting; in the long-term these areas can supply poles and firewood (Lotero and Tafur 1999).
- Multipurpose live fences as a source of poles, firewood, and fodder, and for wind control. Some species of trees that can be used for this are: *Eucalyptus sp, Trema micrantha, Delostoma integrifolium, Erythrina edulis, Montanoa quadrangularis,* and *Croton sp.*
- Biodigesters should be an essential component of all farming systems. They produce biogas while maintaining the fertiliser value of the manure. Biogas can be used for cooking, for heating for piglets, and to generate electrical power (Zapata

Table 12.3: **Biomass production of the association *Pennisetum clandestinum - Acacia decurrens* planted at two densities. Antioquia Department, Colombia[1]**

	Control[2]	Low density[3]	High density[4]
Pennisetum yield, kg dry mass per ha per cycle	2,130a	2,084a	1,397a
Edible biomass per tree, g dry mass	-	3,386a	884a
Total edible biomass[5], kg dry mass per ha	2,130a	3,462a	2,378a
Firewood per tree, kg fresh matter	-	8.5a	1.5a
% Pennisetum	88.95a	93.05a	79.82b
% other grasses	8.12a	3.74b	11.78a
% weeds	2.94a	3.03a	8.85a

Source: Giraldo and Bolivar 1999

[1]Values in the same row with the same letter are not significantly different, Duncan analysis ($P < 0.05$)

[2]Control is Pennisetum clandestinum without trees

[3]407 trees/ha

[4]1110 trees/ha

[5]grass yield plus edible fodder of 18 month-old Acacia decurrens trees

[1]Giraldo; A . Researcher Universidad Nacional - CONISILVO. Medellín. E-mail: conisilvo@epm.net.co

1999). In addition, biodigesters control odour, which is a growing problem in areas of pig production. CIPAV has been working with plastic biodigesters since 1986 and now have a great deal of knowledge and experience in this field. Two sizes are used: a small 'family-sized' digester 1.25m in diameter and 3-10 m long; and a large 'industrial' digester 2.5m in diameter and 20-25 m long. The family type is suitable for smallholders with 5-15 sows, while the industrial type is suitable for about 100-120 sows. The current cost of these biodigesters in Colombia is about US$ 250 and US$ 1,300 for the family and industrial types, respectively. This includes the cost of digging the trench, roofing, a fence, inlet and outlet boxes, and the plastic. The effluent from biodigesters can be used for the organic fertilisation of pastures and polyculture plots.

- Earthworms grown on cattle manure produce high quality fertiliser. In a commercial farm located in Antioquia the author observed excellent results in earthworm production on cattle manure following the addition of some pig manure (about 5-10%). The earthworm compost is a very valuable fertiliser for the polycultures, and can be an important source of income in some places where there is a high demand for compost, mostly for greenhouses.

Conclusions

In the Andean region of Colombia the negative effects of the conventional livestock production systems are becoming more evident day by day. A great deal of research still needs to be carried out to develop and formulate alternative strategies and approaches, but it is important that these options are based on the integration of cattle and pig raising, polycultures of herbs and multipurpose trees, and organic fertilisation. The initial research results obtained in different agroecological zones in the Andes have shown the long-term advantages of such an approach.

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Livelihoods and Sustainability

Part Four

Chapter 13

Livestock Based Livelihoods in Tibet, China, and Sustainability Concerns

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Introduction

The Tibetan plateau, known as the roof of the world, occupies more than a third of the Hindu-Kush Himalayan region and an eighth of the entire territory of China. Tibet Autonomous Region covers an area of 1.2 million sq.km and is a major part of the plateau. More than 2.3 million Tibetans are currently settled in this sub-region. The average altitude is about 4,000 masl. Cropping and forestry are limited to a few areas because of the short growing season and pastoral farming is common. For most of the highlanders of Tibet, livestock are the only means of sustaining their food security and livelihoods. This paper provides an analysis of the trends, issues, and options of livestock development and livestock-based food security in the Tibetan highlands.

Changing trends in livestock development in Tibetan highlands

Accepting livestock as the basis of food security and livelihoods

Livestock are the predominant economic sector in Tibet accounting for more than 50% of the total gross production value of agriculture (Table 13.1). Tibet has a total usable rangeland area of 55 million ha, about 45% of the total usable land area. Nearly one million Tibetan farmers live in 14 counties and over 200 townships that are in purely pastoral areas depend entirely on livestock farming for their livelihood. For the nomads of the Tibetan plateau, livestock are the only way of ensuring food and livelihood security. Even in the lower valleys where cropping and forestry

Table 13.1: **The production value of crop, livestock, forestry, and fishing as a percentage of the total value of agricultural production (%)**

Year	Livestock	Crops	Forestry	Fishing	Sideline industry
1959-1969	65	33	0.1	0.01	2.3
1970-1979	62	34	0.3	0.02	3.3
1980-1984	48	40	1.6	0.03	9.9
1985-1989	52	37	1.5	0.04	9.9
1990-1996	51	45	2.0	0.04	2.2

Source: Tibet Statistical Yearbook 1998

farming are possible, livestock farming is still the main activity and major means of sustaining livelihoods and food security. This means that nearly half of the population of Tibet is deriving some livelihood from farm animals and nearly 30% depend almost entirely on livestock. Animal products from rangeland areas meet more than 50% of the people's food and agricultural needs. The government of the Tibetan Autonomous Region considers livestock to be the predominant sector for economic development and is giving top priority to promoting fast but sustainable growth of the livestock economy in order to ensure sustainable food security in the sub-region.

Proportion of livestock in total agricultural production

Historically, livestock formed the predominant sector and backbone of economic development in Tibet. The contribution of livestock and other sectors to total agricultural production value over the last 40 years is shown in Table 13.1, and the values for crops and livestock are illustrated in Figure 13.1. Prior to the 1970s, livestock contributed more than 65% of the total agricultural production value and crops only 33%. Since then the proportional contribution of livestock has gone down

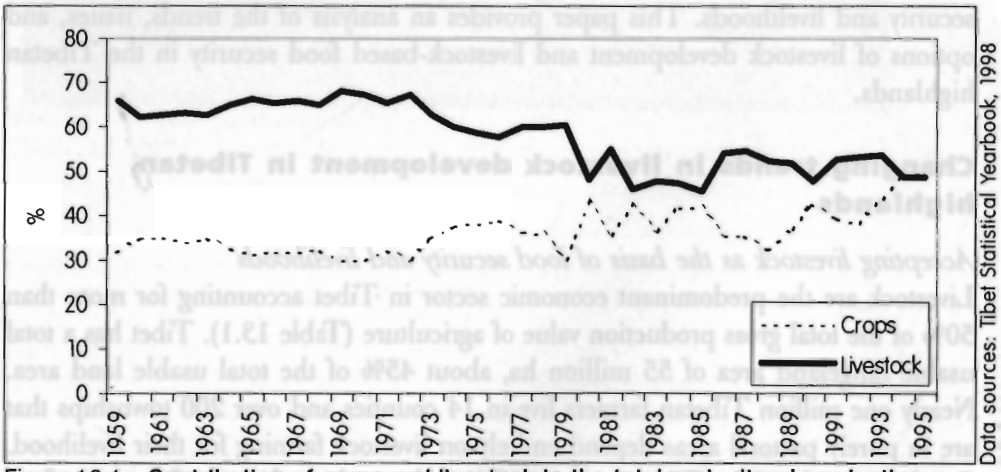


Figure 13.1: **Contribution of crops and livestock to the total agricultural production value**

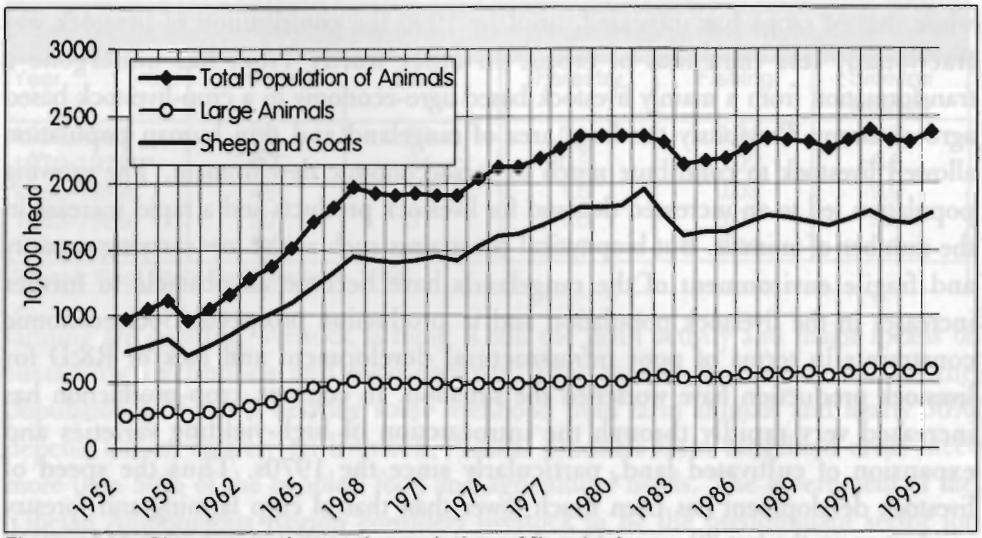
while that of crops has increased, until by 1996 the contribution of livestock was fractionally less than that of crops. In other words Tibet has undergone a transformation from a mainly livestock based agro-economy to a crop-livestock based agro-economy. Previously the large area of rangeland and thin human population allowed livestock to contribute much to socioeconomic development. The growing population led to an increased demand for livestock products and a rapid increase in the number of animals. But biophysical constraints such as the low carrying capacity and fragile environment of the rangelands have become an obstacle to further increases in the livestock population and to production prospects. Socioeconomic constraints in terms of poor infrastructural development and lack of R&D for livestock production have worsened the situation. In contrast, crop production has increased very rapidly through the introduction of high-yielding varieties and expansion of cultivated land, particularly since the 1970s. Thus the speed of livestock development has been much lower than that of crop farming and forestry production in the last 30 years. This does not mean that the contribution of livestock farming to ensuring food security in the Tibetan highlands is becoming less important. In contrast, boosting livestock development will help local Tibetans to improve their livelihoods through both food gains and income generation. However, in the past, development of livestock has been largely neglected in Tibet compared to crop farming.

Growth of the livestock population

The rangelands of the Tibetan highlands have a low carrying capacity. On average one sheep unit of animal needs two ha of rangeland, for example, five times more than in the USA. This is a limiting factor to growth in the livestock population. The changes since 1952 in the total population of livestock and in the populations of large animals and sheep and goats are shown in Figure 13.2, and the percentage changes over time summarised in Table 13.3.

The livestock population grew by nearly 10% annually in the 1960s, much more slowly in the 1970s, and barely at all between 1981 and 1996. The total population actually decreased in the early 80s and then recovered slowly. The changes in population are not distributed evenly across the region. Figure 13.3 shows the average annual growth rate from 1985-1987 in each county, in some counties in east and west Tibet the animal population is still decreasing.

The change in growth rates indicates that the total population of livestock has reached a threshold, particularly in northern Tibet. Any further increase in the livestock population could lead to overgrazing and degradation of the rangelands. In order to increase meat and milk production, it is necessary to increase the per unit productivity of both animals and rangelands. In recent years, many studies have



Source: Tibet Statistical Yearbook 1998

Figure 13. 2: **Changes in the total population of livestock**

Table 13. 2: **Average annual growth rates of the livestock population (%)**

Period	All animals	Large animals	Sheep and goats	Pigs
1960-1967	9.5	9.7	9.4	13.0
1968-1980	1.4	-0.1	1.8	5.2
1981-1996	0.1	1.1	-0.1	0.2

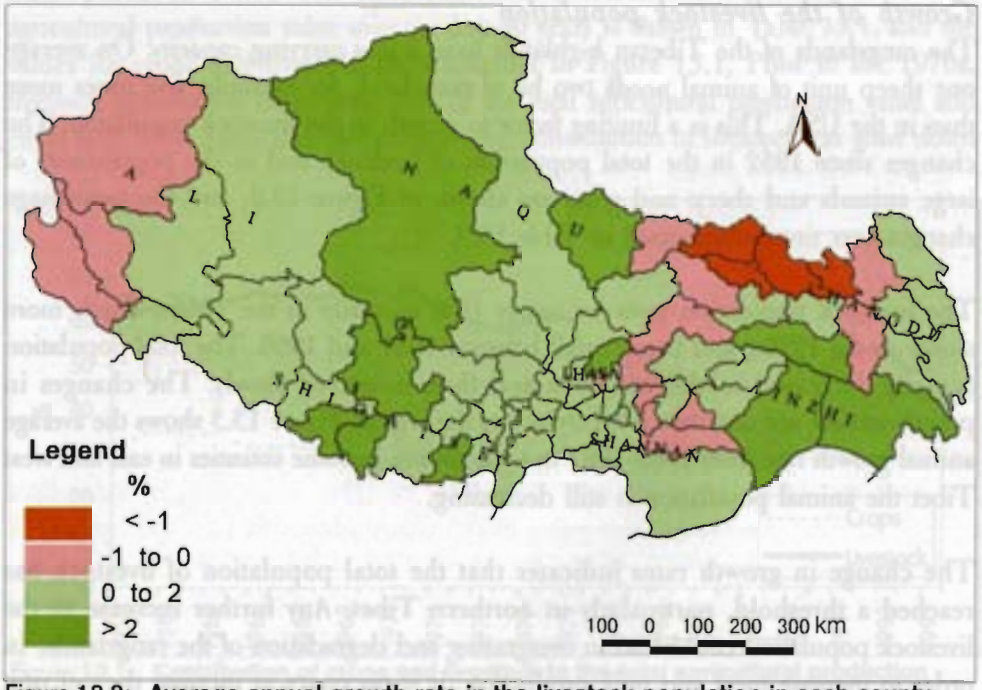


Figure 13.3: **Average annual growth rate in the livestock population in each county between 1985 and 1997**

shown that livestock production can be increased by integrating livestock in crop-animal farming systems. Crops such as barley, wheat, and peas provide a range of fibrous residues and by-products that can be used by both ruminants and non-ruminants. In some crop-dominated areas, over 70% of the feed for animals in winter is derived from crop residues. Currently only 30% of the crop residues in Tibet are used as feed for livestock, so there is a great potential for increasing the number of livestock and improving productivity through better promotion of crop-livestock interactions. Various initiatives have been started in this direction. They include processing feed from crop residues, fodder and forage production through multiple cropping, and introduction of improved grasslands. Through these kinds of initiatives, the total population of livestock, especially the number of cattle in crop-dominated areas in central Tibet, has increased in recent years. The promotion of crop-livestock farming systems will be a key driving force in the further development of livestock, and thus meat and milk production, in the region.

Meat and milk production

Although the population of livestock in Tibet has currently stabilised at around 24 million, the total production of meat, if not milk, is still increasing. The trends are shown in Figure 13.4, and the average annual growth rates as a percentage of total production in Table 13.3. There has been a steady increase in meat production since 1978, although the percentage growth rate has slowed down as the total amount has increased. In contrast, the total production of milk has remained more or less stable since 1988. At the rates current in 1996, the prediction was that in 1999 total meat production would be around 125,000 tonnes and milk production around 140,000 tonnes (Figure 13.4). This is equivalent to a projected per capita mount of 52 kg meat and 58 kg milk per year.

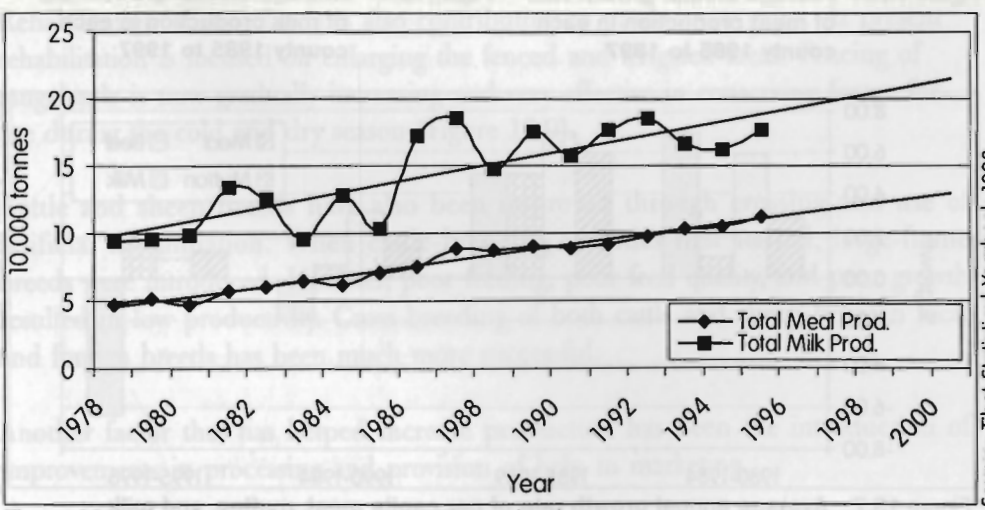


Figure 13.4: **Trends in total meat and milk production**

Table 13.3: **Trends in meat and milk production**							
Year	**Average annual growth rate of population**	Average annual growth rate of meat				**Average annual growth rate of milk**	
		Total	Pork	Beef	Mutton	Total	Yak & Cow
1980-1984	1.51	4.4	6.5	7.5	2.5	8.5	12.7
1985-1989	2.00	8.0	11.8	9.0	6.9	7.3	6.5
1990-1994	1.56	3.6	8.6	4.7	1.9	-0.3	-0.2
1995-1996	1.57	2.9	17.9	1.8	2.7	-5.6	-4.2

These changes in production growth rates have not been distributed evenly, however. The average annual growth rate of meat and milk production between 1985 and 1997 in the different counties is shown in Figures 13.5 and 13.6. Total meat production actually decreased in a few counties, and the total milk production decreased in most of the northern and central counties. Moreover milk production has not kept pace with the population increase, and meat production only just (Figure 13.7); after 1990 the growth rate of meat available per capita slowed down considerably and the amount of milk available per capita went down.

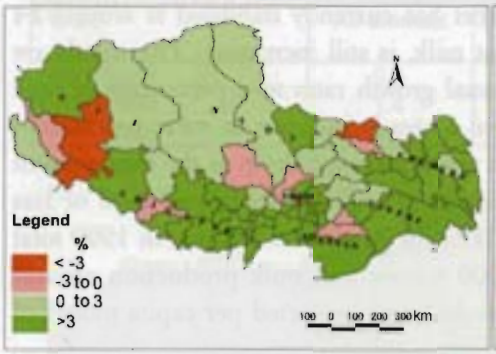


Figure 13.5: **Average annual growth rate of meat production in each county 1985 to 1997**

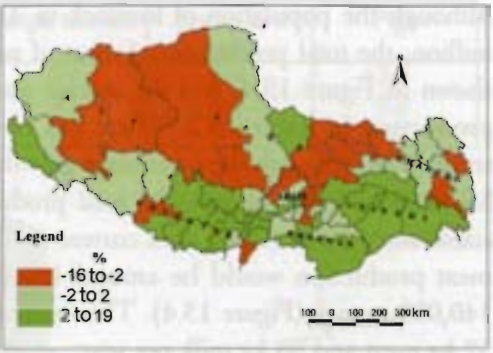
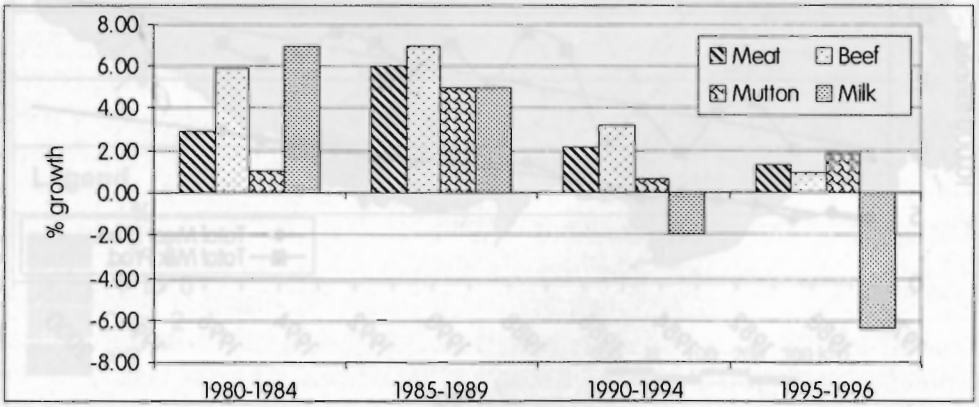


Figure13.6: **Average annual growth rate of milk production in each county 1985 to 1997**



Data source: Tibet Statistical Yearbook 1998

Figure 13.7: **Average annual growth rate of per capita meat, mutton, and milk production from 1980 to 1996 (%)**

Several factors have contributed to the increase in production that has taken place. In the past several decades, the number of non-meat and milk producing animals, such as horses and donkeys, has decreased significantly, so that the actual number of meat producing animals has increased. Stable growth and the development of a household-based poultry industry in urban and crop-dominated areas have helped to increase the total meat production and meet the poultry demands of city dwellers. Beef and cattle industries have gradually developed near to cities and along the lower river valleys. There has been a gradual increase in the culling rate for different livestock to about 20% for sheep and goats, 12% for cattle and yak, and 56% for pigs — much higher than in the 1970s (Figure13.8).

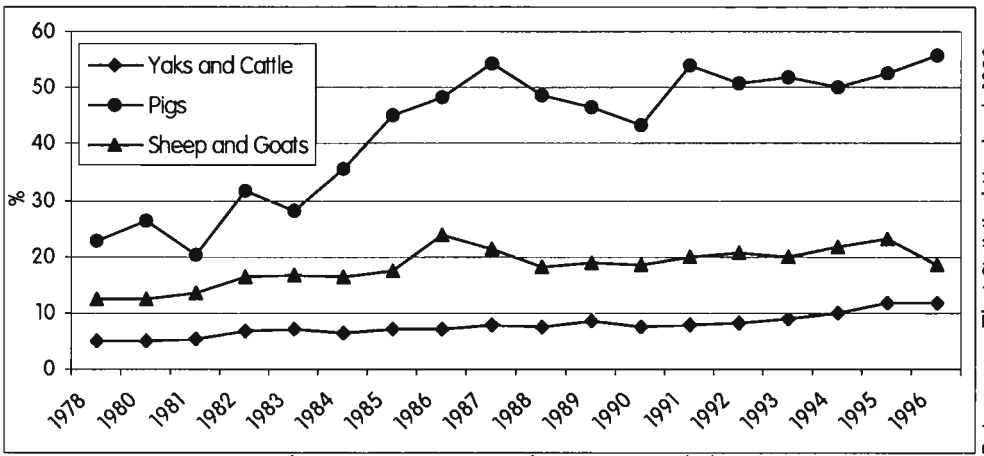
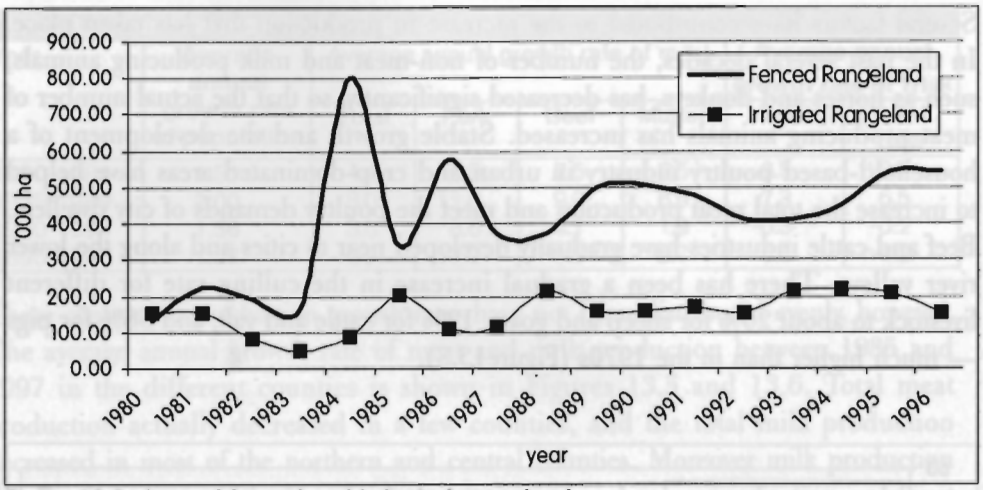


Figure 13.8: **Off-take rate (slaughtered and sold) of livestock (%)**

Rehabilitation of rangelands is also contributing to productivity gains. At present rehabilitation is focused on enlarging the fenced and irrigated areas. Fencing of rangelands is now gradually increasing and very effective in conserving forage for use during the cold and dry season (Figure 13.9).

Cattle and sheep breeds have also been improved through crossing and use of artificial insemination. When cattle-breeding activities first started, large-frame breeds were introduced. However, poor feeding, poor feed quality, and poor growth resulted in low productivity. Cross breeding of both cattle and sheep between local and foreign breeds has been much more successful.

Another factor that has helped increase production has been the introduction of improvements in processing and provision of help in marketing.



Data source: Tibet Statistical Yearbook 1998

Figure 13.9: **Area of fenced and irrigated rangeland**

Lessons for Developing Livestock Based Food Security in Tibet

Food security, and in a narrow sense food self-sufficiency, has been one of the crucial concerns of agricultural development policy in Tibet throughout its history. No matter at what stage and what kind of measures were taken for the development of agriculture, the main focus was always to achieve food security, especially self-sufficiency in meat and milk. In 1994, the Government of the Tibetan Autonomous Region adopted a food self-sufficiency policy. This set the goals for achieving self-sufficiency in grain, meat, and milk ('three dimensional self-sufficiency'). The goal was to produce an annual per capita amount of 400 kg of grain, 50 kg of meat, and 100 kg milk. It is only recently that Tibet has recorded a surplus in food-grain production. Food from livestock such as meat, milk, and butter is still in short supply. The situation is worsening as a result of population growth and the increased expectations and living standards of people. In 1996 there was a big shortfall in locally produced milk in central Tibet, where the majority of the population is concentrated, and in some counties a shortfall of meat (Figures 13.10 and 13.11).Large amounts of meat and milk are imported from other parts of China to meet the demand.

Thus, at present, Tibet has an insufficient supply of livestock-based food products. The supply-demand gap in livestock products is increasing year by year, especially in regions where population is concentrated. The transportation costs for meat, milk, and butter imported from other parts of China are high, thus there is considerable financial pressure to increase local production. Large parts of the rangelands have already been overgrazed, and it is difficult to increase livestock production further. The situation is being aggravated by the increased frequency of natural disasters like snowstorms.

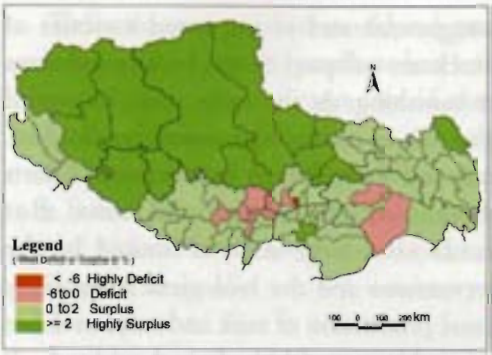


Figure 13.10: **Surplus or deficit of meat in each county (1996)**

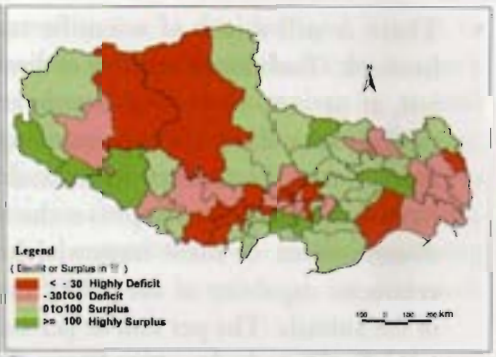


Figure 13.11: **Surplus or deficit of milk in each county (1996)**

The following lessons have been learned from the development of pastoral-based livestock production over the last few decades.

- Conservation and rehabilitation of rangelands have been largely ignored. At the same time improvement and development of artificial grassland have made little progress. Currently the total area of rehabilitated rangelands – re-seeded, irrigated, fenced, or artificial grassland – is only 0.02% of the total rangeland area in Tibet.
- Degradation of the rangelands, and the resultant decline in the ability of farmers to withstand the shocks of natural disasters, remains an important problem in pastoral areas. Over 20% of the rangelands in Naqu and 19% in Shannan are seriously degraded. Few efforts are being made to develop fencing and irrigation systems, to control diseases or damage from mice, to eradicate poisonous plants, or to replant and fertilise the grasslands. The area of pasture available for grass cutting and winter grazing is decreasing year by year. The production of grass from the rangelands has decreased by 60% since 1960, while the proportion of poisonous plants has increased from 15 to 45%.
- There is no tradition of setting up reserves of forage such as stored hay, and there is still no move to develop such a system. Thus management strategies are needed to reduce livestock loss during storms and to maintain the body weight of animals during winter. In the pastoral system, flocks usually have a high proportion of young and old animals and low proportion of productive animals. In Tibet, the average proportion of productive animals in the livestock population is about 23%. One reason for this is the high death rate of animals during winter, which compels herders to keep more livestock as security for the next year and means that the culling rate cannot be increased. The whole livestock production system thus displays a vicious cycle of 'high death rate→practice of keeping more livestock over the winter→less culling→ less economic benefit→poor livelihood gains of the herders'.

- There is still a lack of scientific management and of improved varieties of livestock. Traditional varieties of livestock are adapted to the local conditions but, at present, these local breeds are vanishing. At the same time, improved varieties are still not playing a meaningful role in increasing livestock production. Furthermore, the productivity of local yak and sheep breeds has declined. Efforts have been made to improve the breeds of yak, sheep, and cows. But dissemination of these improved breeds on a large scale is limited by the economic capability of the public interventions and the biological adaptability of the animals. The per unit or per animal production of milk and meat in Tibet are still among the lowest in China. This is because of lack of good quality feed, particularly during the winter, lack of proper veterinary services, and poor feeding strategies. To cater for the growth in the human population and ensure the livelihood of nomads, the production of livestock products needs to be increased considerably. But if the productivity of animals declines this can only be achieved by increasing the number of livestock – which leads to overgrazing.
- The contradictions between ownership of livestock and ownership of rangelands remain unresolved. In 1980-1981, the commune system ended in rural Tibet and the responsibility system for agricultural and livestock management began. Each person was allocated a fixed number of animals so that everyone had equal assets. But the rangelands were not allocated to individual herders and still belong to the government. When livestock are private property and the rangelands public property, herders have no incentive to use the rangelands sustainably. This is also leading to overgrazing and degradation of the rangelands.
- The concept of marketing livestock products has not yet been promoted and thus the commodity rate for livestock production is still very low. In a nomadic society wealth is measured in terms of the number of livestock one has, and this attitude has not yet changed. The average culling rate for sheep and goats in Tibet is still only around 20%, for yak and cattle it is even lower. More than 50% of culled animals are consumed by the herders themselves; few livestock products are sold outside the nomadic community.
- In the present situation of overstocking combined with a fragile rangeland ecosystem, parts of the pastoral area of Tibet are trapped in a vicious cycle of "weight increase in summer→fattening in autumn→loss of weight in winter→ death in the spring". Because of the lack of supplementary feed for animals during the winter and spring, most herders suffer a huge loss of animals when there are natural disasters. In the snow disaster in late 1997 and early 1998, for example, herders in northern Tibet lost 50-80% of their animals. Many nomads are plunged into severe poverty (Xiao 1999). It is very difficult now for these nomads to ensure their food security without external support, particularly government support, to help them raise their livestock herds.

- Today the major concerns of local governments are 1) that the rapid increase in demand for livestock products has to be met through a less productive livestock population; 2) the capacity of the infrastructure for developing animal husbandry is insufficient to meet the challenge from frequent natural disasters; 3) the rapid growth of demand for wool, cashmere wool, and leather may lead to a further increase in the animal population in the marginal rangeland ecosystem; and 4) local farmers with a weakly developed competitive spirit are facing a strong impact from the market economy and external investment for livestock development.
- In order to deal with these problems, the provincial government adopted the so-called 'new revolution' in 1992. This approach focuses on capacity building in the whole system with the objective of leading Tibet towards self-sufficiency in meat and dairy products. All three of the traditional livestock farming systems: 'pastoralism', 'transhumance', and 'mixed crop-livestock farming', are facing the change towards commercialised livestock production that is emerging through both state and private investment. More attention is being given to the development of crop-based livestock production systems in lower regions of Tibet; the focus in pure pastoral production systems will be more on rangeland rehabilitation. Thus overall livestock farming is in transition from a rangelands based or pure animal husbandry system to a crop-livestock based mixed farming system, i.e., from the extensive traditional system to an intensified system.

The following development approach is suggested for the promotion of crop-livestock production systems.

- Sustainable increase in food grain production through extension of improved crop varieties, particularly in agro-pastoral areas; improving marginal croplands; and improving water use and irrigation systems – including promotion of water-harvesting and efficient-use technologies in rain-fed areas. The croplands should also provide more opportunities for livestock development through processing of feed from agricultural by-products and production of more forage and hay. The crop-livestock farming system cannot progress unless a productive crop farming system is established. Ensuring sufficient food grain means developing a potential supply of concentrated feed with a high quality grain base. Increasing the productivity of major cropland also means that more marginal areas can be devoted to developing artificial grassland and cultivating perennial forage integrated with crops.
- Sustainable development of livestock farming in crop dominated areas, made possible by giving priority to the production of animal feed and the development of markets for livestock products, and reinforced by the introduction of new technologies. In order to increase the production of feed, it is very important to

improve the forage production technologies associated with cropland. It is also necessary to expand the use of forage crops such as oats, peas, alfalfa, and other local and introduced plant species. Developing multiple cropping systems for forage production and using barley and wheat straw for livestock feed are the most promising options.

- The focus should be on optimising the agricultural production structure, achieving sustainable increases in productivity, improving the quality of agro-products, promoting the income-generating capability of agricultural production, and conserving the environment.

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Chapter 14

Sustainability Concerns of Livestock-Based Livelihoods in the Andes

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Introduction

Mountains account for 20% of the world's landscape and are home to at least 15% of the earth's people. Mountains are also home to the poorest of the poor. Some of the poorest mountain people live in Latin America in the Andes of Ecuador, Peru, and Bolivia; a sizeable number live in remote mountain areas of the Hindu Kush-Himalayas. In these areas, there are grave social, economic, and biological concerns for humankind.

The Andean region in South America is a wide mountainous area covering approximately 1.4 million sq.km. Most of the estimated population of more than 113 million depend on agriculture for their livelihood. The majority of the farming systems in the high Andes are mixed crop-livestock systems. Livestock production plays an important role in the sustainability of these heterogeneous farming systems and is less susceptible to widespread climatic risks than crops. Animals take on a number of different and important roles within the mixed system: food supply, feed bank, work, source of energy in the system, source of fertiliser, and link to local markets. Livestock production is intrinsically associated with environmental quality. Production of crops and pasture on hillsides is directly associated with soil erosion and affects the supply and quality of the water used downstream; when the soil is covered by grass soil erosion is less than with crops alone.

This paper describes how the challenge of the constraints faced in the Andes can be met by adopting a holistic approach. The region includes several countries and

ecosystems so that participation by a group or consortium of institutions is seen as necessary for an integral approach. Horizontal characterisation of agro-ecosystems (across the region) rather than a localised analysis is necessary in order to work towards sustainable use of the natural resources across the Andean region. In the consortium approach of CONDESAN (Consortium for Sustainable Development of the Andean Ecoregion), different institutions across the Andean region from both the government and private sectors are linked together to promote sustainable food production.

South America and the Andean Region

The area in South America denominated in a broad sense as the Andes covers around two million square kilometres and includes territory in seven countries. It extends from the northern coast of Venezuela and Colombia (latitude 11°N) to Argentina (55°S). It can be divided into two main areas: the Andean region and the Southern Cone. The latter comprises mainly Argentina, Uruguay, and Chile. The major part of the Andes lies in Ecuador, Peru, Bolivia, Colombia, and to a minor extent, Venezuela.

The Andean region is a mountainous area whose altitude ranges from 2,000 to more than 4,500 masl with variations in form and width. About 71% of the area lies between 2,000 and 4,000 masl, about 16% between 4,000 and 4,500m, and 13% above 4,500m In Colombia, the Andean region is 100 to 300 km wide and includes three mountain chains separated by the Cauca Valley and the Magdalena river. These chains are united in Ecuador to form the Loja node at the start of a higher and homogeneous mountainous chain, 150 to 200 km wide, which runs through the country. This mountain chain continues in Peru forming the Pasco node, and linked by the Vilcanota node, before it reaches the large and wide area of the Altiplano that spans part of Peru and Bolivia.

The population of South America is around 370 million (FAO 1994) and is expected to reach 490 million by 2025. It is expected that the increase will be in urban areas only, and that the rural population will remain at the current level. The average population density in the main Andean countries (Colombia, Ecuador, Peru, and Bolivia) is estimated to be 39.3 per sq.km, with higher densities at the lower altitudes, and is expected to increase to 56.7 per sq.km by the year 2010. Population growth means that the pressure on rural areas to produce more food will increase. Food demands will not be satisfied unless there is a drastic change in the use of natural resources through application of more appropriate policies and technologies. Changes are also needed to improve parameters such as infant and adult nutrition, health and sanitary conditions, and education. Urban dwellers cannot expect that a

mass of ill-nourished, powerless, and illiterate peasants and farmers, historically disenfranchised and currently disadvantaged by inappropriate policies, will be able to produce enough food in a sustainable way. Current trends indicate that, although total food production in the region has increased in the past twenty years, food per capita has remained constant. It is essential that food per capita at least remains at the present level of calories and protein intake, which for the vast majority of people is already well below the recommended levels.

Poverty is increasing in the region, and if this continues it can be expected to lead to a greater degree of malnutrition, which will have an irreversible affect on the human capital of the region. In the 1980s, about 55 million people were already suffering from malnutrition (Janssen 1991). This critical situation is aggravated by the ongoing degradation of the natural resources used for agriculture, which will lead to decreased yields. For example, soil erosion in the Peruvian Andes is proceeding at a rate well above the five tonnes per ha threshold value (Quiroz et al. 1995). This indicates that current management practices are not sustainable. Table 14.1 shows some selected socioeconomic indicators for the Andean region and the Southern Cone.

Eco-geographic areas

In the Andes the concept of region overlaps well with the concepts of ecoregion, biome, area of life, bioregion, and biotic province, among other classifications. The Andean region has diverse sub-ecoregional zones each with specific characteristics of climate and cultural and socioeconomic conditions. Such zones include the Bolivian Altiplano and the savannas of Bogota. At each ecological level, the altitude, rain, and temperature define the predominance of forage species and agricultural crops. The temperature range is restricted by the longitude and modified by the altitude. Precipitation and moisture vary greatly and define a mosaic of soils in relatively small areas. The combined characteristics of rainfall and altitude define three main eco-

Table 14.1: **Selected economic and other human welfare indicators in the main regions of the Andes and the Southern Cone**

Indicator	Andean region	Southern cone
National Gross Product (US$10[6])	123,855	479,204
Income per capita (US$/year)	1,158	2,132
Urban population[1] (%) 1990	65.5	74.4
Proj. 2030	78.6	81.0
Poverty incidence (%)	53.6	37.4
Human development index (HDI)[1]	0.66	0.81
Agricultural land distribution[2]	0.74	0.86
Calories consumption per capita (cal/day)[3]	2,369	2,784
Protein consumption per capita (g/day)	57.9	79.8

[1]HDI includes life expectancy, education, and health; [2]Gini coefficient; [3]1 calorie = 4.1868 joules

geographic areas known as the Green Andes, the Central area, and the Altiplano or Yellow Andes (Tapia 1996).

- *Green Andes* — This area covers the parts of the mountains of Colombia, Ecuador, and northern Peru that lie between 3,800 and 4,400 masl. Annual precipitation is more than 1,000 mm and the area is characterised by intense mists and the absence of arboreal species. There is an abundance of grass, which is used as a feed resource.
- *Central Andes* — This is the most extensive area. It includes almost the entire Andes. In the tropical area it rises to 4,200 m; to the north and to the south to 3,000 m. The climate is cold and crops are mainly frost tolerant species such as the bitter potato and the kañiwa. Livestock raising is based on native grasses.
- *Yellow Andes* — This area lies between 15° and 27° S. It is a highland area ranging from 2,800 to 4,800m, containing a plateau known as the Altiplano and bordered by the western and eastern mountain ranges. It includes the lakes Titicaca and Poopo (Peru and Bolivia, respectively). The low parts of this area are favourable for agriculture. The high areas are characterised by extensive livestock production.

In addition to these is the Pre-Puñena province. This area is part of north Argentina and Chile. It is characterised by slopes and dry areas between 1,000 and 3,400m with a limited area devoted to agriculture.

Several characteristics differentiate the Andean region from other mountainous parts of the world (Gastó 1993), in particular the very steep slopes and extreme climatic variations associated with considerable regional diversity. The region faces severe problems of poverty and resource degradation which have no simple solutions. Traditional small farmers within communities have developed specific and traditional agricultural systems appropriate for the local conditions. However, high population density and urban development are producing imbalances in sustainable agricultural production and the well-being of farmers in the region. Marginal conditions and limited access to resources are the main reasons for the failure of previous development efforts.

Biological, Economic, and Social Indicators

Table 14.2 shows some major macroeconomic indicators for the main countries of the Andean region.

The annual growth rate of the population in the countries of the Andean region ranges between 2.2 and 2.7%. The projected population for the year 2010 is about 43% higher than at present. The trend of rural to urban migration is in the order of 15%. This means that measures are required to ensure sustained food production

Table 14.2: Major macroeconomic indicators in the countries of the Andean region[1]				
Macro economic indicators	Andean region			
	Ecuador	Peru	Bolivia	Colombia
Population				
Total (millions) 1990	10.3	21.6	7.3	33.0
Projected in 2010 (millions)	15.5	31.0	11.1	42.9
Average annual growth rate % (1970-90)	2.7	2.4	2.6	2.2
Density (inhabitants/km2)				
- 1970	21.0	10.3	3.9	18.8
- 1990	36.1	16.8	6.7	29.0
Distribution (%)				
- Urban				
1970	39.5	58.1	38.2	57.5
1990	54.7	69.3	51.5	73.1
- Rural				
1970	60.5	41.9	61.8	42.5
1990	45.3	30.7	48.5	26.9
Economy				
EAP[1] (%)	32.7	35.2	31.1	30.8
Agricultural exports ($million)				
- 1970	175	177	121	598
- 1990	778	287	205	2,385
Agricultural GNP (% of total)	17.4	14.1	21.2	22.3
Debt increase (%)	4.5	4.5	6.4	3.6
Social				
Life expectancy (years)				
- 1970	61	56	51	64
- 1990	66	64	61	69
Illiterate (%)	14.2	14.9	22.5	13.3
Consumption				
- Protein (g)				
1970	51	62	50	51
1990	53	60	56	55
- Energy (Mcal)				
1970	1.9	2.3	1.8	2.2
1990	2.5	2.3	2.1	2.5
Agriculture				
Deforestation, average annual				
- 1970	1.2	0.3	0.4	0.5
- 1990	2.6	0.4	0.1	0.6

Source: IICA 1994
[1]Economically active population

and to increase labour occupation. Agricultural exports are expected to grow by 2%, which is less than the recommended level of 4% (McCalla 1994). Adding value to products by processing could increase the value of exports and benefit farmers, but a large proportion of the rural and urban poor might not be able to buy value-added products. This tradeoff requires further analysis.

Various studies indicate that the governments and the international community need to maintain or renew their commitment to agricultural growth (Winograd 1995).

This means that an effort must be made to develop adequate policies and cost-effective investments in agricultural research, extension, and the management of soil and water to alleviate the pressure on food production. Similarly, investments should be made in human capital and rural infrastructure.

The dramatic changes in socioeconomic and environmental issues around the world, and especially in the Andean region, have created new challenges and opportunities for research and economic development in the region. One key constraint to the sustainable development of the Andean region at the specific eco-regional level is the lack of local capacity to analyse and understand the complexity of the world agricultural situation, and to develop with the local population a productive and sustainable approach to using their resources in a market-oriented fashion.

Development of the Andean region has become necessary and important at national and international level because it is the core area that provides the basis for livelihoods and the natural resources, in particular water, for a large region. Almost 80% of the water supplied to the Amazon basin comes from the Andes. Problems within the Andes, particularly in the Altiplano, such as salinisation, soil erosion, and destruction of waterways can have major impacts downstream.

The Development of Livestock Production Systems in the Andean Region

Mountain specificities

Research towards the development of sustainable production systems in the Andes, must take into account the specific features that characterise the region. These are summarised in the box in terms of the special characteristics of all mountain areas, the 'mountain specificities', described by Jodha (1990), as they apply to the Andean region.

Grassland resources

It is important to have some knowledge of the existing types of grassland and their present state when considering the development of livestock systems. Table 14.3 shows the main grasslands' associations found in the Andean region, together with an indication of their present stocking rate (sheep per ha per year). The stocking rate is given in sheep units because some areas ('bofedales' and 'tolar') are not commonly grazed by cattle. Restoring grasses and shrubs in degraded pastures is a necessary prerequisite for restoring the balance of the biodiversity of plants (Paladines 1995).

MOUNTAIN SPECIFICITY	THE ANDEAN SITUATION
Fragility	The Andean region is a naturally fragile environment. There is intensive use of the natural resources.
Marginality	In general, decision-makers pay little attention to the living conditions and expectations of Andean producers.
Inaccessibility	Access to goods and services and opportunities for marketing are limited, which poses difficulties that restrict the sustainable development of the region.
Diversity	As a result of the wide diversity in climate and topography, the region contains a broad diversity of environments and resources, many of which have been used in forms of multiple production.
Adaptation Mechanisms	The extreme conditions in the mountains have generated traditional practices and management forms for the agricultural systems.
Niche	The combination of biodiversity and specific environments provides mountain areas with a potential comparative advantage for certain activities and the production of certain products.

Table 14.3: **Andean grassland associations - current carrying capacity and ecological situation**

Main grassland areas	Stocking rate, sheep units[1]	Ecological situation
Chillliguar rangelands (*Festuca dolichophylla*)	2 – 6	Partially overgrazed, palatable species disappearing
Bofedales: spring-fed, year-round-irrigated rangelands in the Puna	3 – 4	Seasonal use
Pajonal: middle and short bunch grasses of the Puna	0.5 -1.5	Mostly overgrazed
Tolar, shrubs (*Parastrephia, Bacharis*)	0.5 - 1.2	Process of deforestation
Paramo rangelands	0.5 -1.0	Partially overgrazed

[1]Sheep units: 35 kg head per ha per year.
Sources: Tapia 1996; Paladines 1995

Crop-livestock production systems

Considerable differences are found both among and within different agroecological zones in the crop-livestock production systems that are employed, as a result of differences in water availability, risk of frost, slope, and access to markets and market

demands. The main features of these different systems are summarised in Table 14.4, and discussed in more detail below.

Table 14.4: **The major mixed crop-livestock production systems in the Andes**

Agro-ecological zone	a. Altitude (m) b. Rainfall (mm) c. Slope (%)	Crops grown, livestock kept	Livestock products	Feeding system
Inter-Andean Valleys	a. 200 - 2700 b. 250 - 700 c. 5 - 40	Maize, faba beans, rye grass, white clover, alfalfa Cows	Milk, cheese	Grazing, protected forage, agricultural by-products, commercial feed concentrates
Hillsides	a. 2700 - 3500 b. 500 - 800 c. 20 - 90	Maize, wheat, barley, potatoes, other root and tuber crops Triple-purpose cattle, sheep, goats	Milk, cheese, weaned and mature animals, wool, dung	Grazing, crop residues, protected forage
Suni	a. 3400 - 4000 b. 500 - 600 c. 0 - 80	Potatoes, oats, barley, wheat, quinoa, faba beans Sheep, camelids, triple-purpose cattle	Milk, cheese, wool, fibre, weaned and mature animals, dung	Grazing, crop residues, protected forage
Jalca	a. 3400 - 4000 b. 700 - 1300 c. 30 - 90	Potatoes, barley, oats Sheep, triple-purpose cattle	Milk, cheese, wool, weaned and mature animals, dung	Grazing, crop residues, protected forage
Puna	a. 3800 - 4500 b. 600 - 1200 c. 20 - 60	Bitter potatoes, quinoa, kañihua, cereals Sheep, camelids, triple-purpose cattle	Wool, fibre, weaned and mature animals, milk, cheese, dung	Grazing, crop residues, protected forage

Source: Tapia 1996 (modified from Quiroz et al. 1991)

Livestock production in the Andes is based on grazing of pasture, supplemented with crop residues, particularly stovers, or agricultural by-products and, in certain cases, with improved feed resources. Thus rangelands constitute the main feed resource for mixed systems with ruminant species. Native species dominate the grasslands across the region (Leon-Velarde and Izquierdo-Cadena 1993). The species found in both native and introduced pasture vary greatly according to agro-ecological zone. There is considerable scope for improved pasture management and forage conservation techniques, combined with better use of agricultural by-products, to contribute to livestock development.

Weather conditions in the inter-Andean valleys are similar to those in temperate areas. Although they are favourable for milk production, the available feed resources are not used optimally at present. The availability and quality of feed resources in

the four other zones – hillsides, suni, jalca, and puna – are quite different to those in the inter-Andean valleys. Seasonality is more evident in both the quantity and quality of forage. Crop residues are a buffer during the dry season, which may last from four to six months (Quiroz et al. 1991). In general, animals not only constitute the main source of income, they are also the 'savings account' of most rural households (PISA 1993). This highlights the importance of using crop residues to reduce mortality rates. Crop residues and by-products are fed mainly to large ruminants, but, after a good harvest, they are also given to small ones. With the introduction of new types of pasture such as rye grass, alfalfa, and white clover, practices are changing. Cattle and sheep are now favoured, with lower-quality feedstuffs being left to camelids, which are more able to digest them (San Martin and Bryant 1987).

Although local National Agricultural Research Stations and universities have a history of research on feed resources, most investigations have been conducted at specific sites (research stations, peasant communities, and farming systems). The impact of research on feed resources has been limited and localised. The main constraints to the adoption of research results are the heterogeneity of the region, as determined by factors such as altitude, climate, soils, quality and quantity of feed resources, and ethnic background; lack of any methodology for integrating research results into technological alternatives to solve the different problems encountered; and inappropriate incorporation of socioeconomic aspects into the technology development and transfer process. There is still considerable potential for increasing sustainable crop-livestock productivity and household income if these constraints are taken into account during the design phase of research and development programmes. What is needed is an integrated research and development approach oriented to meet market demands.

Nearly all of the existing technologies have been generated with the single objective of increasing crop-livestock productivity. They should now be tested to see whether they can be used both to increase production efficiency and to enhance the natural resource base. This requires careful analysis of the farming systems and the natural resource base, and an in-depth understanding of the crop-livestock systems in mountain areas and the interaction of farmers with the environment. This interaction must be looked at not only at the farm level – the scale often used to generate and validate technology for crop-livestock production – but on larger scales, so that the impact on the environment can be adequately assessed. Production systems and ecosystems need to be documented with an emphasis on both determining vulnerable areas and on the potential contribution of crop-livestock production systems to solving the problem of feeding an increasing population without causing deterioration of the natural resources.

Agro-pastoral production systems

The pastoral production systems in the Andean region have developed as a result of environmental factors, type of forage, size of holdings, and land tenure, as well as existing policies. Livestock, especially ruminants, play an important role in most highland areas (Li Pun and Paladines 1993). The principal feed source is natural grass, especially at high altitude where there are severe restrictions to growing agricultural crops. The most important species are camelids, cattle, and sheep. They play several roles: as assets; animal traction; source of meat, fibre, and wool; and a source of cash income. Livestock production and the management of grasses are important factors in the economy of Andean farmers, but they have received little interest or support for research and the use of new technologies (Li Pun and Sere 1993).

Livestock Productivity

The main types of animals kept in the Andean region, and their average productivity, are summarised in Table 14.5.

In general, the production of milk, meat, and wool are declining as a result of poor management and inputs. The productivity is also affected by low nutrition, parasite

Table 14.5: **The main animal production systems in the Andean region: species, feeding practices, and productivity**

Species	Type	Feeding practice	Livestock	Production
Cattle[1]				
Milk	I	Forage/concentrate	Holstein-Brown Swiss	1,880-3,600 kg
	SI	Forage/residues	Crossbreeds	800-2,100 kg (210-310 days, milking 2x per day)
	Ex	Grazing (dual purpose)	Creole	600-1,200 kg
Meat				
Calf-cow	Ex	Grazing/residues	Creole	220-320 kg per head
Fattening	SI	Concentrate/forage	Creole, crossbreeds	280-370 kg per head
Sheep[2]	Ex	Grazing/forages	Corridale, others	3.8-5.2 kg wool 10.2-21.8 kg meat/head
	Ex	Grazing/residues	Creole, crossbreeds	1.8-3.6 kg wool 13-15 kg meat/head
Alpacas[2]	Ex	Grazing/residues	Huacaya, Suri	1.1-3.6 kg fleece 26.4-31.4 kg meat/head
Swine	I	Concentrate/residues	Duroc, Landrace, Yorkshire	65-92 kg per head
	Ex	Grazing/residues	Creole, crossbreeds	45-70 kg per head
Goats	Ex	Grazing/residues	Anglo-Nubian, crossbreeds	11-15 kg per head
Poultry[3]	I	Concentrates	Hybrid	150-190 eggs 0.8-1.2 kg meat/head
	Ex	Household	Creole, crossbreeds	20-130 eggs 0.8-1.4 kg meat/head

Source: PRODASA/CIP 1996
I = Intensive; SI = Semi-intensive; Ex = Extensive;
[1]milk is total per lactation; [2]wool/fleece is per head per year; [3]eggs are total per year

infestation and infectious diseases, and the lack of adequate breeding and selection. Research results indicate that there are considerable possibilities for improving the levels of animal production in the Andean region.

The main production and productivity parameters for the four countries in the Andean region separately are shown in Table 14.6. Cattle play an important role. Colombia has the largest population of cattle and the greatest total production of meat and milk. Peru has more sheep than the other countries, although still many less than in Argentina and Uruguay. Peru and Bolivia have similar-sized populations and similar production levels of goats. Pigs and poultry are considered to be 'short-term' food production, but these animals compete for food grains with people and more research is needed on alternative feed resources for them.

Alpacas have a unique comparative advantage in the production of fibre. Although only three per cent of the total volume of fibre is marketed at an international level, the demand is high and the fleece commands a competitive price. Moreover, alpaca and llama meat constitute the main source of protein for the inhabitants of the Altiplano. Improvement in the traditional processing practices for alpaca meat, and selection and breeding of alpacas for good fibre, are key challenges for future research (Leon-Velarde and Guerrero 1999).

Table 14.6: **Production and productivity parameters of the main animal species found in crop-livestock production systems in the Andean region**

Species	Ecuador		Peru		Bolivia		Colombia	
	1971-89	1992	1971-89	1992	1971-89	1992	1971-89	1992
Cattle (m)	3.0	4.8	4.3	3.9	4.5	5.8	24.1	25.3
Meat total (1000t)	79	143	87	105	100	132	607	651
kg/head	167	184	123	152	171	163	183	210
Milk total (1000 t)	924	1550	796	795	71	120	2,187	4,476
kg/head	1,446	2,084	1,298	1,407	1,396	1,412	965	994
Sheep (m)	1.5	1.6	13.8	11.9	8.9	7.5	6.0	4.6
Meat total (1000 t)	3	3	21	19	20	12	9	10
kg/head	14	14	14	14	11	9	15	14
Wool (1000 t)	1.2	1.1	5.5	4.6	4.8	3.9	1.0	1.0
Alpacas (m)	----		2.8	3.1	0.2	0.2	----	
Llamas (m)	-----		0.7	0.8	1.5	1.7	----	
Goats (m)	0.3	3.4	1.7	1.8	1.4	1.5	0.6	1.0
Meat total (1000t)	1	2	9	9	5	5	4	4
kg/head	15	15	12	12	11	11	16 –	16
Milk (1000 t)	2	3	19	19	14	11	10 -	12
Pigs (m)	3.4	2.5	2.2	2.4	1.6	2.3	2.0	2.6
Meat total (1000t)	58	87	72	91	47	68	98	134
kg/head	45	45	60	61	50	50	62	69
Poultry (m)	33	57	40	60	17	33	30	62

Source: Data from FAO 1996; IICA 1994
m = millions; t= tonnes

Figure 14.1 shows the average levels of livestock production in the Altiplano– separately for lead farmers and for communities as a whole. Most Altiplano farmers are producing at levels below their potential. With existing technologies, lead farmers have shown that it is possible to increase milk, wool, and fibre production, increase animal birth rates and average weight, and reduce mortality rates, which are seen as an indicator of inadequate management. In order to increase production overall, it will first be necessary to analyse the sociocultural factors involved, as well as the impact of existing policies, access to credit, and land tenure, and consider ways to improve these.

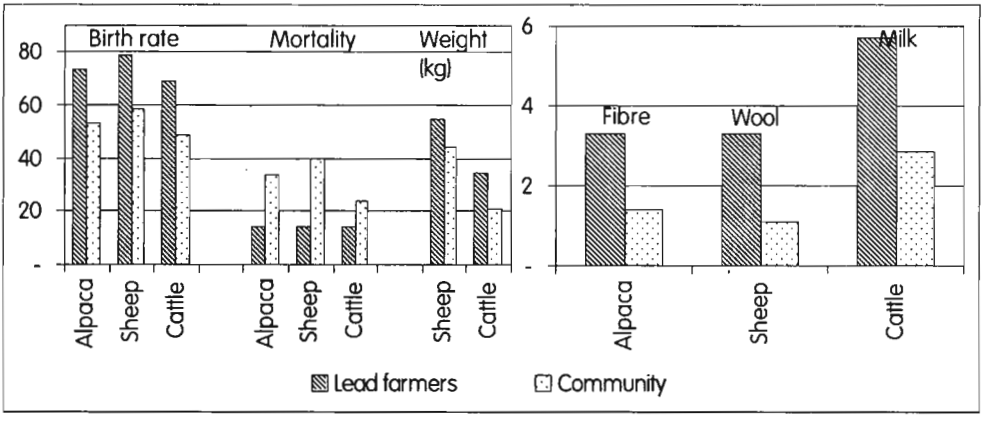


Figure 14.1: **Current potential of livestock production in the Altiplano**

The sources of income and expenses for a typical small farmer family in Puno, Peru, are shown in Table 14.7. At the level of the household economy, livestock are a source of protein, energy, shelter, fertiliser, draught power, and savings. The gross margin at the level of the producers is very low, however. In general, the animal production contributes around 73% of income and crops 27%. However, 20% of the animal production and 80% of crop production are used for family consumption (PISA 1993).

Most Andean producers are grouped into communities. They have access to both private and communal land. Usually the community has rules for the management of crops and animals: there is an established crop rotation and grazing management system. The crop cycle is 'potato→quinoa→barley (for forage)→fallow for three to four years'. Animals graze the native grass on fallow plots, facilitating nutrient recycling through animal excreta. Use of better quality cover plants at this time could contribute to improving the soil fertility and animal production. Recent studies (PRODASA/CIP 1996) indicate that livestock systems have an average income of US $ 1,130 per year with a capital of US$ 8,150, and US $ 876 per year with a capital of US$ 4,000. For cropping systems, the average income is about US$678 per

Table 14.7: **Sources** of income and expenses for a small farmer family in the **community** of Santa Maria, Ilave, Puno, Peru (1992)[1]		
Subsystem	US$ per year	per cent
Income		
Crops (potatoes, quinoa, oca, barley, others)	214	21.4
Livestock production	458	45.8
Processing (handicrafts, animal products, jerk meat)	107	10.7
Migration and trading	60	6.0
External support (food aid, others)	162	16.1
Total gross income	*1001*	
Expenses		
Own consumption of products	393	44.4
Food and supplies	110	12.4
External support (food aid and others)	162	18.3
Other cash expenses	220	24.9
Total gross expenses	*885*	
Gross margin	**116**	

[1] Adapted from PISA 1993; PRODASA 1993

year with a capital of US$ 3,800. Farming families in the Andes participate in a range of activities, including growing crops and raising livestock, handicrafts, and work outside the farm, which help them diversify their sources of income and manage the risk. Livestock help reduce the climatic and economic risks from frosts and drought.

Communities in the Andean Altiplano include a large number of families. Studies show that communities have an average gross margin of some US$ 67,000 per year, which represents an annual gross margin of US $ 1,015 per year per family. Adequate land-tenure policies that facilitate growth of production need to be developed and introduced.

Modelling the Sustainability of Crop-livestock Production Systems

Agricultural scientists appear to agree about the importance of sustainability as an objective for research. However, in order to make the concept operational it is first necessary to have a method for quantifying sustainability. 'Sustainability' has been defined or characterised in a surprising number of different ways (IFPRI 1990), and no agreement has yet been reached on appropriate methods for measuring it. The common denominator is measurement of a trend over time. Table 14.8 shows some indicators of sustainability used in the analysis of crop-livestock production systems in the Andes.

Model simulations can be used to integrate mainly biophysical, biological, and economic components, including the social component, as an integral part of management. Simulation is an important method for developing possible scenarios

Table 14.8: Main parameters and indicators considered in the analysis of a crop-livestock production systems[1]

Parameter/ components	Sub-System components		
	Crops	Rangelands	Forest
Soil properties	- Organic carbon content - Nutrient content - Cation exchange capacity - Erosion rate	- Salinity - Organic carbon content - Nutrient content	- Nutrient content
Water quality and quantity	- Salinity - Seasonality - Pollutant concentrations	- Precipitation patterns - Pollutant concentrations	- Seasonality - Evapo-transpiration fluxes - Pollutant concentrations - Base flow
Biological diversity	- Species' richness and diversity of indicator groups - Population size of base species - Crop diversity - Diversity of pests and soil organisms	- Species' richness and diversity of indicator groups - Population size of base species - Forage diversity	- Species' richness and diversity of indicator groups - Population size of keystone species - Forage diversity
Production of goods and services	- Crop productivity (output/input) - Crop genetic reserves	- Stocking density - Forage productivity	- Yield of wood and non-timber products
Energy and nutrient flows	- Parent rock - Nutrient mobilisation - Nutrient (fertiliser) input fluxes - Energy efficiency and quality	- Nutrient mobilisation	- Primary productivity - Nutrient mobilisation
Landscape: composition and patterns	- Field size - Land-use conversion rate	- Grazing gradients - Land-use conversion rate	- Spatial variation of vegetation types - Land-use conversion rate
Atmospheric composition	- Acid precipitation - UV-B irradiation - Troposphere ozone concentration - Carbon dioxide concentration	- Acid precipitation - UV-B irradiation - Troposphere ozone concentration	- Acid precipitation - UV-B irradiation - Troposphere ozone concentration - Carbon dioxide concentration
Climate	- Mean temperature and variability - Mean precipitation and variability	- Mean temperature and variability - Mean precipitation and variability	- Mean temperature and variability - Mean precipitation and variability

[1]Does not include wildlife/unexploited land, freshwater fisheries, wetlands/groundwater, coastal resources, or marine fisheries

Such scenarios can help improve the basis for taking political decisions on the use of land resources and introduce the concept of bio-economic sustainability.

Figure 14.2 shows different schematic representations of sustainability calculated using a linear and a non-linear model. In both cases only a single variable (biological response) was considered, and at present it is only possible to try to plot changes in each variable separately over time. Nevertheless, to have a real measure of sustainability it is necessary to develop a combination of variables in a composite index. This is a challenge for the future. When looking at sustainability against time, it is necessary to consider the trend at a particular hierarchical level, for example related to a farm or a region, and look at the inputs and outputs at that level. At farm level the classical variable is the production expressed either as kg per ha or as income per ha. A recommended indicator at regional level is the continuity of supply of a given product. The main concern in the simulation models is the availability of information in relation to the technical point of intervention. Model d (in Figure 15.2 (B)) does not have a biological explanation; but with a technical intervention becomes model b.

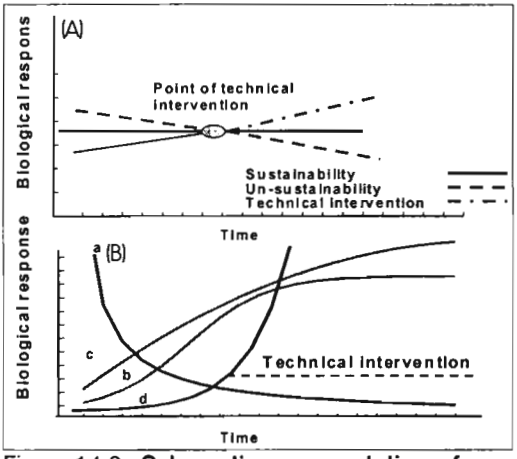


Figure 14.2: **Schematic representation of sustainability calculated using linear (A) and non-linear (B) models**

The possible effect of technical intervention can be analysed using models and simulation. Figure 14.3 shows the change in production (gross income) with time following a technical intervention in an alpaca production system using a simulation model. (This is line 'b' in Figure 14.2A) Three phases can be discerned – Phase I, technical intervention; Phase II, response to technical intervention; and Phase III, asymptotic of maximum potential –

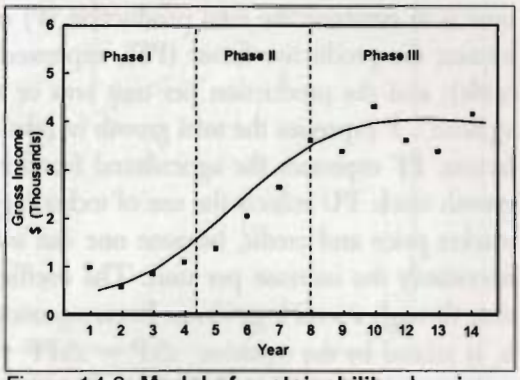


Figure 14.3: **Model of sustainability showing the change in gross income of an alpaca production system over time**

before sustainable production over time is reached (Leon-Velarde and Quiroz 1994, 1999). Note that time is a constraint in relation to technology, as well as an exogenous factor that farmers cannot control. Consequently, many of these systems remain in the 'status quo'.

The total factor productivity (Harrington 1992) indicates a measure of sustainability in relation to output over inputs. Likewise, it is related to the production trend per capita (C), expressed as kg.ha per inhabitant. This implies the use of the production per unit area (Y) as kg per ha, the cropping area (ha) and the population density (inhabitants per ha). In this form the equation is $C = Y (A/P)$. This equation differentiated with respect to time and expressed in percentage change becomes:

$$(dC/dt)/C = (dY/dt)/Y + (dA/dt)/A - (dp/dt)/P;$$

where
$(dC/dt)/C$ is the per cent change of the per capita production in a short space of time.

For example, if the production growth is 3.5% per year, the crop area is being reduced at 0.4% and the population growth is 2.5%; the production per capita will increase by $3.5 + (-0.4) - 2.5 = 0.6$ % per year. This does not reflect any technical intervention because time is not considered in the equation, but any reduction can be interpreted as an unsustainable system.

Phase I, technical intervention; Phase II, response to technical intervention; Phase III, asymptotic of maximum potential

One way to integrate bioeconomic information to show sustainability and impact over time is to combine the total production (P) of a particular area expressed in kg, l, or tonnes; the productive factor (PF), expressed in number (ha, milking cows, head of cattle); and the production per unit area or animal (PU) expressed in $t.ha^{-1}$, $kg.ha^{-1}$, $kg.head^{-1}$. P expresses the total growth in relation to technology and credit among other factors. PF expresses the agricultural frontier including expansion of area or animal growth stock. PU reflects the use of technology. In some cases it is difficult to separate market price and credit, because one can influence the agricultural frontier but not necessarily the increase per unit. The coefficients of each variable are obtained over time through a semi logarithmic linear equation ($\ln Y = b_0 + b_1X$), thus the coefficient b_1 is related by the equation $\triangle P = \triangle PF + \triangle PU$. The results of a typical analysis are shown in Figure 14.4, which displays the annual growth rates of four commodities (potato, wheat, alpaca fibre and milk) in the Altiplano of Peru between 1970 and 1988. For wheat, both the area planted (PF) and the production per unit area (PU) showed growth rates, and the total production increased accordingly. There was a reduction in

the area planted with potatoes (PF) and even though the production per unit area increased (PU) the overall effect was a reduction in total production. With both milk and alpaca the production factor (number of animals) increased, but the production per head went down, resulting in overall negative growth rates and indicating a lack of technology (Ccama 1990).

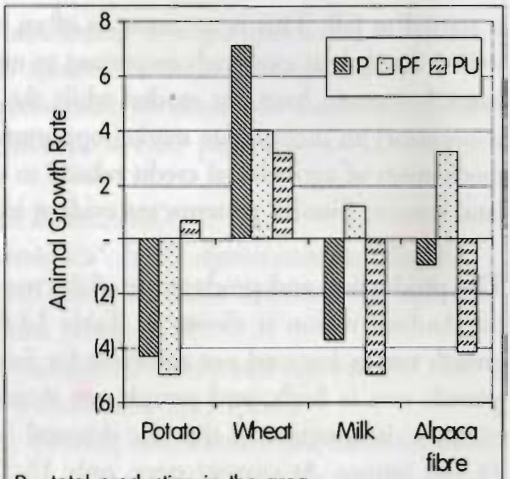
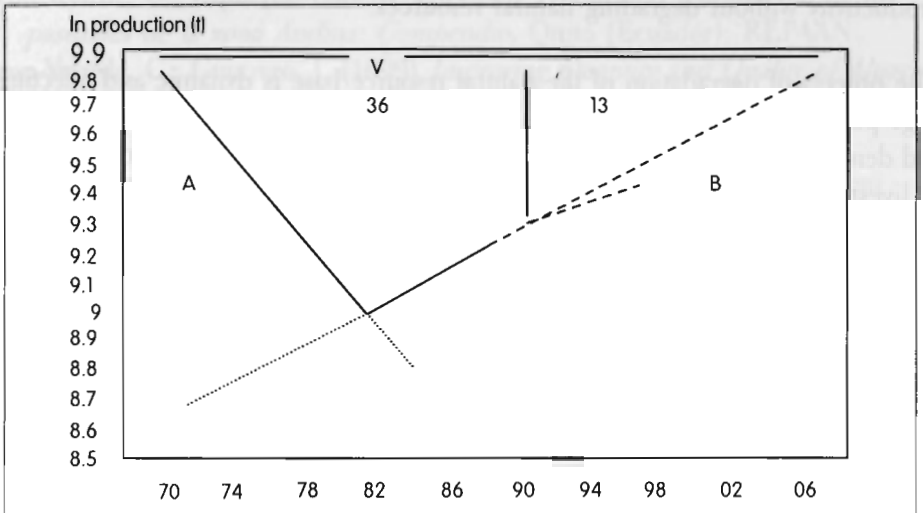


Figure 14. 4: **Growth rates for potato, wheat, milk, and alpaca fibre in the Altiplano, Peru (1970-1988)**

Analysis of total production in relation to the production factors and productivity also enables the influence of exogenous factors to be seen. This is illustrated in Figure 14.5, which shows the evolution of milk production from 1970 to 1988 (Ccama 1990). The first part (1970-1980) shows a negative trend, whereas after 1980 the trend is reversed. Assuming that this positive trend is maintained, it is possible to extrapolate the line and identify the point at which milk production will reach the level it was at before 1970 (the Agrarian reform). At the given rate of growth the level would be reached by 2006, 36 years after



Note: Line A shows constant decrease in production, while line B shows recuperation at an assumed constant rate. Data after 1990 indicate a slowing in growth rates, however, shown by the second dotted line.

Figure 14.5: **Graphical representation of the influence of exogenous decisions on milk production in the Altiplano of Peru**

it started to fall. This is an example of an impact produced by policies that are not well defined. It is extremely important to note, however, that during the 36 years the natural resource base was eroded while the human population increased. Further, it is necessary to incorporate market opportunities based on demand and, as well as a mechanism of agricultural credit related to operational size, technical assistance, and land tenure. Similar patterns are evident in other countries of the Andean region.

The production and productivity of the main animal species in the four countries of the Andean region is shown in Table 14.6. Some indicators are positive, but the growth rate is low and not sufficient for future demands to be met. The population growth rate is high, and people are demanding more food at lower prices. For example, it is estimated that the demand for meat in Lima (Peru) in 2005 will be 74,840 tonnes. At current rates, only 15,350 tonnes will be available, a deficit of 59,490 tonnes. Other animal products show a similar trend. Thus it seems likely that any increase in production of animal products can be absorbed by the regional market, indicating good opportunities for crop-livestock systems in the region.

Conclusions

It is difficult to offer clear solutions to the issues raised in this document because the biophysical and socioeconomic conditions are changing rapidly. However, technical intervention and accumulated knowledge about crop-livestock systems can be used at specific sites. A wide range of appropriate methods and procedures will need to be used as tools to support decision-making in order to improve production and productivity without degrading natural resources.

The process of degradation of the natural resource base is dynamic and affecting a large part of the Andean region. The population in large urban cities is increasing and demanding more services and food. Although both the number and productivity of livestock are growing, the actual rates are not enough to cover the additional demand for meat and milk. Thus it seems likely that more products will have be imported, unless the necessary adjustments are made in land tenure, size of operational holdings, use of appropriate technology, and other factors. Partial or complete processing in situ of products with a clear market demand is highly recommended. Research will play an essential role in all these processes.

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Chapter 15

Animal Agriculture and Watershed Management: Reconciling Public and Private Good

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Introduction

Approximately 10% of the world's population, 600 million people, live in highland and mountainous regions (Messerli and Ives 1997). They are the managers of the forests and watersheds that are the source of much of the world's water, biological diversity, minerals, timber, and fuelwood. Their actions have far-reaching consequences. The felling of mountain forests can, for example, make remote downstream countries more prone to flooding. It also increases the amount of carbon in the atmosphere. Thus the welfare of mountain people and the sustainability of their food production systems should concern people everywhere, but this is not well recognised. As a result, highland people are marginalised and mountain areas are depleted and the whole world is being impoverished and made less safe.

Belatedly, there is growing awareness amongst enlightened agencies of the consequences to the global environment of neglecting the problems of mountain agriculture (UNCED 1992). UNCED Agenda 21, Chapter 13, and the follow-up regional and global activities, have culminated in the UN General Assembly declaring 2002 'The International Year of the Mountains' with activities planned to highlight the urgency for remedial action. The general stresses and problems that have to be addressed in establishing sustainable mountain agriculture include:

- rapid population growth;
- farming on slopes and the associated erosion;
- remoteness and poor infrastructure resulting in poor access to markets and services;

- limited job opportunities; and
- political isolation and non-participatory development planning.

This paper argues that something not only should but can and must be done to make research more relevant to individual mountain smallholders for the good of all. This will have to be carried out holistically at the watershed scale with livestock as a principle component. This report borrows heavily from collaborative research in Ethiopia (involving the Ethiopian Agricultural Research Organisation (EARO), ICRISAT, ILRI and other colleagues) that seeks to determine the conflicting (positive and negative) attributes of livestock in highland agriculture and thus develop technologies and policy options to ameliorate the negative and accentuate the positive social and environmental effects.

The smallholder's perspective

Mountains are typically densely populated by smallholders whose landholdings are made up of small fragmented pieces of land spread across narrow biomes and also segregated topographically (Rhoades 1997). Even though the landholdings are not physically contiguous, the smallholders regard them as single farming entities because they depend on being able to access resources from the different biomes to meet their needs sustainably. Growing populations force further subdivision of already small plots thereby forcing the adoption of more continuous cropping and impeding the traditional soil and water husbandry practices (Mohamed Saleem 1998).

These circumstances, occurring in Nepal for example, have led to a litany of problems that aggravate each other. Resource-poor farmers are forced to cultivate increasingly steep slopes, seek fuelwood and forage from forest areas, and move their grazing livestock seasonally to very high altitudes (Rhoades 1997). This leads to overgrazing of hill pasture, which impedes regeneration and results in a progressive decline in livestock productivity. The intensified use of marginal lands has accelerated erosion and reduced soil water-holding capacity causing falling crop yields with bleak prospects for the mountain farmers. The same can be said about most mountain systems of the developing world – in Asia, Africa, and the Andes.

Private and public consequences of neglecting mountain agriculture

In densely populated mountains, the problems inherent in situations with unstable soils, high intensity rains, and torrential river flows are exacerbated resulting in damage to hill irrigation structures, silting up of reservoirs and irrigation canals, and degeneration of riverbeds in the hills and lowlands. This causes floods and loss of agricultural production in the lowlands as a result of siltation. Wells in the hills dry up in the dry season, forcing people to spend more time collecting water or to migrate

to the lowlands. This situation illustrates the connection between the private good of the mountain farmer and the public good of the wider public, which depends on mountain resources.

The population-induced stresses on smallholder mountain farming systems are being aggravated by the consequences of climate change in more severe and threatening ways than is evident in lowland agriculture. Areas above 4,000 masl have, in the past, been protected from cultivation by the cooler mountain temperatures, which set limits to cropping in the upper reaches. Seasonal gathering of tree products and livestock grazing were the main land uses at these altitudes. However, it is predicted that global warming will force large areas of tropical lowlands out of production, while at the same time making the very high altitudes thermally suitable for agricultural use. This will move farming systems into higher altitudes where low temperatures have limited weathering and, therefore, the soil depth thus increasing the risk of land degradation. Furthermore, melting snow caps and changes in the hydrological cycles will increase the incidence of damaging flash floods and droughts.

The effects of warmer climate over the past ten years in the Ethiopian highlands are indicated by incidences of malaria in places above 1,800m. This is threatening people who have no acquired immunity. Similar changes in the epidemiology of livestock diseases are also attributed to increases in temperature.

Such changes demand the development of new sustainable land-use systems for the mountains that will provide for the local inhabitants yet protect the interests of lowland people. These will not develop spontaneously because of the conflict between the immediate demands of smallholders and good environmental practice. Research is required to find answers to this conundrum.

Research needs

In the past, research and development strategies developed in the lowlands were extended to the mountains without due consideration of the different requirements of vertical and fragmented terrain. This was not successful; new farming systems need to be developed to suit the interlinked requirements and functions of small plots of land of varying quality distributed in different locations and altitudes, especially with respect to soil and water management.

It will only be possible to improve the welfare of smallholders if land-use systems are developed that meet their needs for cropping and for access to woodland and grazing resources while at the same time protecting wider interests in soil and water management. Proper management of mountain watersheds is dependent on

reconciling individual and collective demands and responsibilities in managing natural resources. Crop cultivation and animal agriculture are vital integrated components of sustainable mountain-watershed management.

Livestock, with their capacity to cause degradation through overgrazing and demand for forage, can be extremely damaging to steep slopes. On the other hand, livestock can be very valuable in supporting the sustainable use of land resources if their ability to utilise grasses, browse, and crop residues, and to supply manure and farm power is wisely integrated into the farming system. They also generate revenue and form capital assets that enable smallholders to withstand the pressures put on them to practice unsustainable cropping and woodcutting for their day-to-day survival.

The role of livestock in production systems

Livestock have many functions, but producing food, or the money to buy food, are the most important (Mohamed Saleem 1998). Foods from animal sources provide calories, high quality bio-available protein, and micronutrients such as vitamin B_{12} that are not available in plant foods and which are critical to human health and especially childhood development. Food supplements from animal sources also enable humans to extract more micronutrients from cereals.

Studies in Mexico, Kenya, and Egypt have shown that children with access to foods from animal sources had better health, growth, and cognitive development than their counterparts who were restricted to diets wholly from plant sources (Neumann 1998). This is of critical importance because it is the key to enabling children to achieve their full individual and collective potential to contribute to national development.

Livestock also make important contributions to cropping systems through the role of manure and urine in soil nutrient cycling. Animal power is in many areas critical to smallholders for tillage and transportation. Animals also provide social and financial security for smallholders who have few alternatives for building assets that can sustain them through droughts and other calamities. However, although livestock are individual property, they typically draw on common land and water resources in different parts of the landscape at different times of the year, and they can cause adverse effects by grazing, trampling, harvesting of forage, and the disposition of animal wastes that impinge on all the people that share the resources, regardless of their personal livestock holdings.

Reconciling private and public goods

In earlier times, agricultural research focused on improving animal and crop productivity independently of each other. However, in the seventies and eighties it was recognised that crops and livestock interact and must be considered jointly when

optimising whole-farm performance. More recently it was recognised that research had to go well beyond farm boundaries to ensure positive impacts on poverty alleviation, natural resource management, and protecting the environment. This recognises that activities on private farms have to be reconciled with societal aspirations, especially with regard to watershed management.

Watersheds are segregated by steepness of slope and soil type because different combinations of these characteristics create different production potentials and limits and require different technologies for sustainable use. The farmers are aware of this, but land pressures and the lack of alternative technologies and policy disincentives for change have led to unsustainable land use. How to help highland smallholder farmers find new solutions to these problems is the main focus of the participatory research by a consortium of institutions working in Ethiopia, involving EARO, ICRISAT, and ILRI. The results of a pilot project in the Ginchi watershed are described here as an example.

Livestock as a Means of Improving Watershed Management: the Ginchi Case Study

The situation

A 350 ha sub-watershed was demarcated for detailed study of the problems and potentials for sustainable land use within the larger Ginchi watershed that drains into the Awash River which flows eastward down the Ethiopian highlands. The changes in this watershed are representative of the major general trends observed in highlands with increasing population pressures (Figure 15.1). In the 1950s, 70% of this watershed was grazed pastureland and there were no more than 9,000 metres of drainage channels. Over time, the number of people and livestock depending on the watershed has increased and most of the pastureland, even on steeper slopes, has been converted into cropland, which today covers 70% of the area. The soil has been eroded, new gullies have formed, and the old ones have widened and deepened to a total length of over 18,000m (Alemayehu Mamo and Mohamed Saleem, unpublished). The watershed no longer provides sufficient food for the resident families, nor sufficient grass for livestock feed and thatching, especially in the dry and early wet seasons.

The smallholders depend on oxen for tilling the soil and threshing crops. Cows provide milk for home consumption and for sale to generate a daily income. Cattle and sheep provide meat for domestic use and sale. Horses and donkeys are kept for transport. After the crops are harvested, these livestock are free to move anywhere in the watershed. During the crop-growing season, however, they are confined to the steeper slopes and banks of the watercourses – and the stocking rate on the common lands is very high. The biomass available is neither sufficient to feed the animals nor

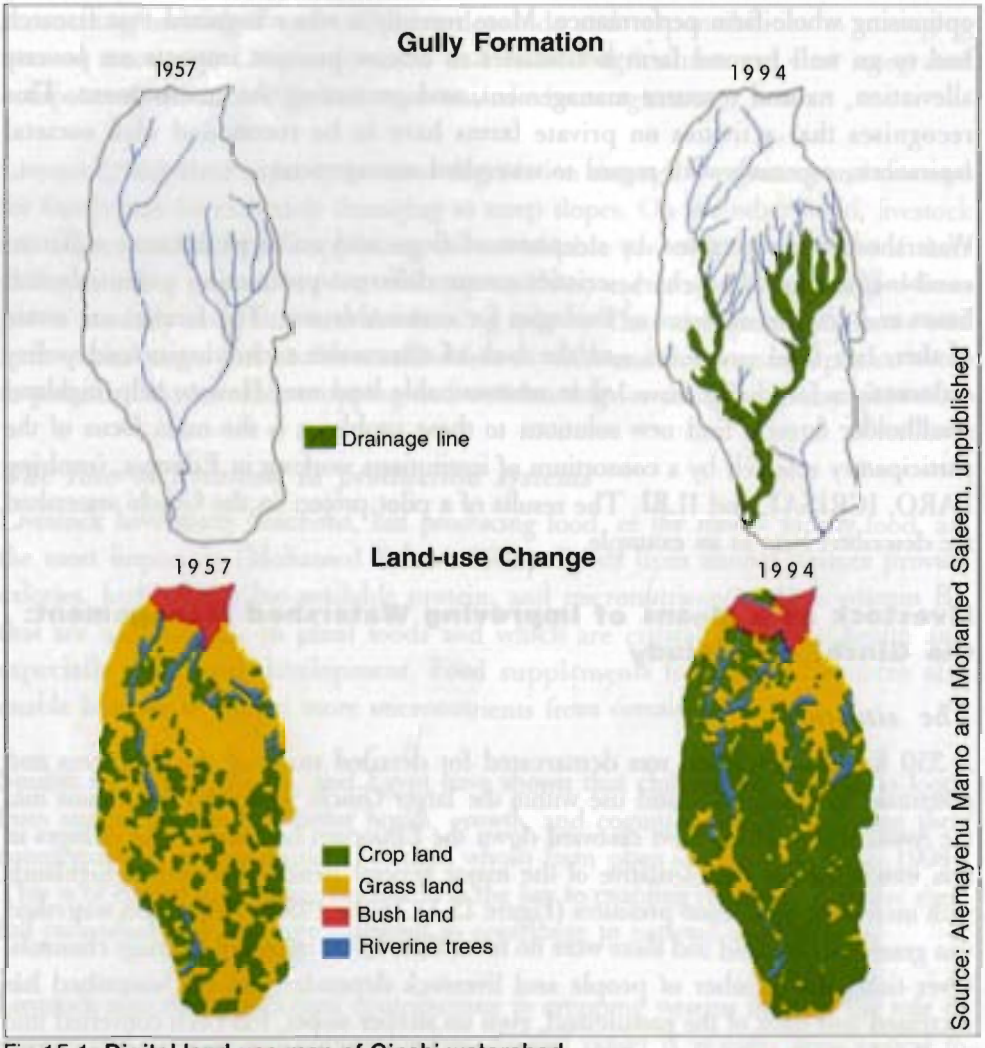

Fig 15.1: **Digital land use map of Ginchi watershed**

to provide an effective cover to protect against erosion or impede water flow down the slopes (Mwendera et al. 1997a). Until crops are planted, ploughed slopes without vegetative cover rapidly lose their shallow soils. The Ethiopian highland area is estimated to lose over 2 billion tonnes of soil annually (EFAP 1992).

Water stagnates in the high clay content Vertisols (black cotton soils) of the shallow valleys making cultivation difficult, and crops are not sown on these soils until the latter part of the season when the surface water has receded. Improving the drainage is complicated by the fact that separate pieces of small landholdings of individual households are scattered across different parts of the watershed. These pieces have to be spatially and socially integrated with the landscape and the community needs.

Table 15.1: **Framework for animal agricultural research in the Ginchi watershed**

Problem	Reason	Consequence	Solutions	Constraint
Prime lands Productivity in the prime lands is low. There is a need to maximise production of food for people as well as feed for livestock from the same land unit.	- Declining soil fertility and little or no application of fertiliser. Dung used as fuel and not recycled back to the fields	- Opening up of more land from grazing areas to grow food crops	- Apply appropriate level of fertiliser to replenish and maintain nutrients - Recycle dung - Introduction of forage types that fix N biologically into the farming system	- A costly operation for the average farmer, recommended levels cannot be used - Dung is needed for fuel and there are not many alternative fuel sources - There is no technology to integrate forage in the farming systems
	Actors: The solutions require individual actions, but the benefits of maintaining soil nutrient status will impact others using the watershed.			
	- Some of the prime agricultural lands not fully utilised because of waterlogging (e.g., the Vertisols' area) for part of the year	- Only part of the growing season can be used and there are only limited types of land use	- Develop beds and furrows to improve drainage and suitable cropping packages for the changing opportunities	- Traditional animal drawn implements inadequate for shaping land, manual land shaping very laborious and involves women and children - Draining water from a farmer's plot accentuates the waterlogging problems of the neighbouring farmer below
	Actors: Individual decisions to improve drainage and intensify land use will have to be supported by the community, collective action is required to produce a common drainage system (public good) which will also maximise the benefits of individual farmers (private good)			
Livestock population far exceeds the carrying capacity of the watershed	Different livestock are kept for different purposes (e.g., oxen for draught power, cows for milk).	More livestock per unit area, particularly under demographic pressure to increase crop area; therefore feed shortage and land degradation	Use of the same animal for different purposes (e.g., using cows as draught animals).	Social prejudice against using cows for draught as they are considered too weak to perform 'hard work' such as pulling a plough
	Actors: Individual decisions can be encouraged by collective support			

Table 15.1: **Framework for animal agricultural research in the Ginchi watershed (Cont'd)**

Problem	Reason	Consequence	Solutions	Constraint
Common land Low animal productivity due to feed deficiency, grazing animals without supplementary feed suffer most	- Animals are spatially confined to common river-banks, rugged terrain, and steep slopes that are marginal for cropping, particularly during the wet season. - Although animals have open access to any part of the watershed after the crop harvest, the feed available during the dry season is inadequate in quality and quantity.	Overstocking and grazing, inadequate regrowth of vegetation accentuated by soil erosion and nutrient deficiency (made worse when dung is collected for fuel), lower water infiltration and compaction	- Reduce the number of animals - Release more common land for grazing by intensifying land-use and increasing productivity of grain and fodder in other parts of the watershed (more gently sloping areas)	- Different livestock have separate functions and therefore all animals are needed. Suggestion of reducing animal numbers not welcomed by farmers, and they have no incentive to do it - Lack of alternative technologies for intensification of land-use
	Actors: Although the ultimate benefit from both solutions is of a public nature, solution 1 requires collective action, while solution 2 requires action to intensify production by individual farmers for collective benefit from freeing up grazing lands.			

A general framework of the situation was developed to determine what animal and agricultural research would be required to generate appropriate technologies and to assess their potential private and public impact at the watershed level. This framework – the research model – is shown in Table 15.1.

Intensifying land use

The size of landholdings and number of livestock kept are shown in Table 15.2. Typical of the region, the Ginchi farmers are poor, with family landholdings ranging from 0.25 to 4.75 ha. Each family has on average 1.34 draught oxen and 0.86 cows. The more fortunate families that own more oxen also have larger landholdings and cultivate more land. The principal grain crop is teff (*Eragrostis tef*), which is grown on the Vertisols found in the lower shallow valleys (slope 0-4%) of the watershed.

Although the rainy season starts in May, teff is not sown until late in August or early September because the Vertisols are waterlogged. This leaves the soil exposed for two or three months after being ploughed at the onset of the rains.

A commitment to long-term research was required to develop ways of draining the Vertisols that would allow earlier planting to diversify cropping and provide better soil protection. This was ultimately achieved by modifying the traditional oxen-drawn plough 'maresha' by joining two of them together with a 1.2m space bar and attaching wings to the inner sides of the ploughs that lift the soil into beds separated by drainage furrows. With constant consultation with and participation of the farmers, the 2,000 year-old 'maresha' was adapted into a broad bed maker (BBM) that can be drawn by the traditional pair of oxen (Figure 15.2). The farmers can now sow cereals as early as June and the long growing period to January/February opens up opportunities for multiple cropping in sequences or relays and in mixtures of

Table 15.2: **Mean landholding, number of plots, and number of livestock kept in the Ginchi watershed area**

	Mean holding per household	Range
1. Landholding (ha)	3.35	0.25-4.75
2. Plots (no.)	6	1-14
3. Livestock holding		
Draught oxen	1.34	0-4
Cows	0.86	0-3
Heifers	0.47	0-3
Young bulls	0.40	0-2
Calves	0.67	0-4
Goats	0.47	0-11
Sheep	0.70	0-6
Donkeys	0.49	0-3

Source: Ginchi watershed survey data 1996 (unpublished)

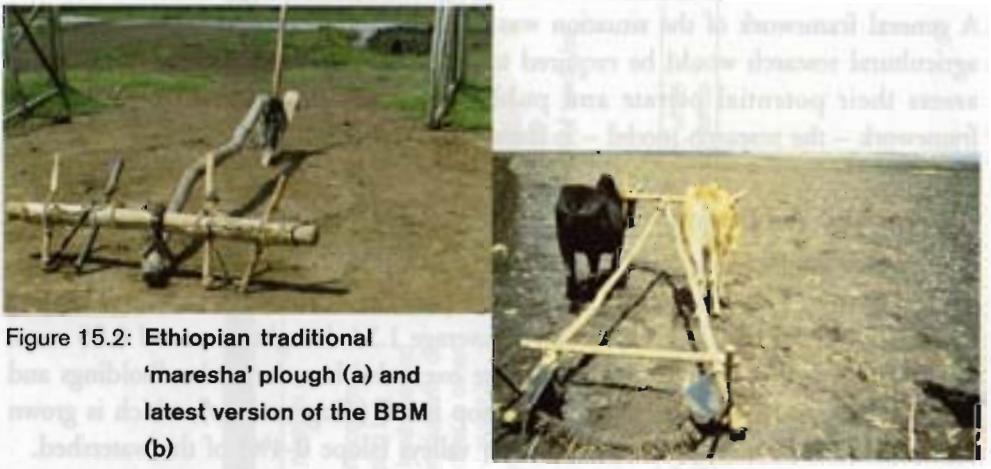

Figure 15.2: **Ethiopian traditional 'maresha' plough (a) and latest version of the BBM (b)**

food and forage crops (Table 15.3); at the same time the early establishment of plant cover reduces soil erosion.

The research was carried out on-station and on-farm, but always with farmer participation which included:

- designing implements and testing the animal power required to pull them through soils of different consistencies;
- testing the arrangements of broad beds on slopes of varying steepness to minimise erosion and determine the slope-limits of the technology;
- screening suitable types of crops and forage and developing strategies for attaining compatible associations;
- developing strategies for optimising food and feed quantity and quality per land unit; and

Table 15.3: **Grain and fodder yields from different use intensities of Vertisols**

Land-use types (LUTs)	Mean yield kg dry matter per year				Total fodder kg dry matter per year
	Grain	Crop residues	Sown forage	Weeds	
Only local wheat	0.70b	1.54d		0.52 bcd	2.1 d
Only improved wheat	1.57a	4.06b		0.38 cde	4.4 d
Only lablab forage			13.34 a	0.34 de	13.7 a
Only sesbania			0.73 c	0.95 a	8.2 c
Sesbania-lablab mixture			10.86 ab	0.57 bcd	11.4 ab
Improved wheat/clover mixture between sesbania alleys	0.87b	2.46c	3.13 cd	0.74 b	8.8 c
Improved wheat followed by grass pea between sesbania alleys	1.76a	4.85a	4.06 d	0.61 bc	10.2 bc

Source: Mohamed Saleem and Abiye Astatke 1996

[1]Total fodder = crop residues + sown herbaceous and tree forage + weeds as appropriate to LUTs

Means followed by the same letter within a column are not significantly different ($P<0.05$)

- developing strategies to optimise the use of the extra feed produced by the improved land-use systems.

Use of the BBM has significantly and sustainably increased food and fodder production for those who have adopted the system. Protection against soil erosion not only makes the private cropping systems more sustainable but also reduces sedimentation of communal watercourses. At the same time, improved drainage from the upstream lands can lead to increased water reaching downstream plots, where it causes increased problems. Thus for the benefits to be realised on a wide scale, communal planning is required to avoid water shed from one farm merely adding to the problems of the downstream neighbours.

Intensifying livestock production

There are fewer livestock diseases prevalent in highland areas than in tropical lowlands. Thus high potential breeds can be introduced from temperate countries even though they are susceptible to tropical diseases. Through a government-promoted scheme, smallholders in Ethiopia have adopted Friesian crossbred cows that produce much more milk than the indigenous breeds. However, these cows require more feed than the local cows, and they have to be supplemented with purchased feed. This absorbs much of the extra income from increased milk sales.

The farmers also have to care for and find year-round grazing for the oxen they need for ploughing, even though the ploughing season only lasts six to eight weeks (Gryseels and Anderson 1983). In the search for more home-produced feed for the more-profitable dairy cows, research was undertaken to determine if the crossbred cows could provide the draught power and replace the oxen. Exploratory on-station research proved that dairy cows can produce milk and provide sufficient draught power without any adverse physiological effects, provided that they are adequately fed (Table 15.4). The farmers who observed the dairy-draught experiments expressed interest in the technology and volunteered to participate in on-farm trials. Replacing ox-power with dairy-draught technology has proven to be feasible so long

Table 15.4: **Milk yield of working and non-working F1 crossbred dairy cows at smallholder farm level**

Work Status	Daily milk yield (kg)	305 days milk yield (kg)	Lactation yield (kg)	Lactation length (days)
Working	5.1	1501	1725	381
Non-working	5.6	1682	2104	426
Lactation				
First lactation	5.8	1740	2071	410
Second lactation	4.9	1443	1758	398

Source: Mengistu Alemayehu et al. 1998

as the farmers have good access to milk markets, animal health care, and breeding services. The quality of the roads and distances from urban markets are major factors in determining the costs of sales and, therefore, the feasibility of the technology.

In a situation where farmers collectively recognise the limits to the stock carrying capacity of the watersheds, the dairy-draught technology represents an attractive mix of private and public good because it enables the reduction of animal numbers and the restriction of animal movements in fragile areas while increasing smallholder incomes. The feed released by the displaced oxen leads to more profitable milk production, and the manure and urine can be more readily collected for use as organic fertiliser. In Nepal, manure is used for generating 'biogas' with the slurry still providing a good fertiliser. This reduces the pressure on wood as a fuel for cooking and heating and has had a significant impact on forest regeneration and protecting tree cover. It might be possible to introduce this type of technology in other areas, for example, the Ginchi watershed, to solve the problems caused by using manure for heating purposes. An unexpected benefit of the dairy-draught technology observed in Ethiopia is that by eliminating the need to herd oxen more children have been able to attend school. However, the benefits of the private and public good from dairy-draught technology cannot be realised unless it is supported by enabling policies that encourage farmers to invest in innovations and use the common land rationally.

Managing Common Resources

In mountain areas in developing countries, livestock have open access to land that is unsuitable for cropping. The livestock belong to individuals, but uncontrolled grazing causes damage that is shared by all,and better practices are required to protect the communal interests.

Terraces and other methods of physically retaining the soil on slopes may be applicable for high-value crops but are generally too expensive. Alternatively, sod forming with creeping forage can provide an effective alternative soil protective cover, depending on the biomass threshold required for soil protection on different slopes (Figure 15.3). But grazing has to be regulated to maintain the threshold levels of biomass (Mwendera et al. 1997b). At moderate grazing pressures, regrowth of pastures is stimulated and deposition of manure helps to keep the botanical composition in a dynamic equilibrium. The threshold grazing intensity and frequency and acceptable nutrient loss and replenishment strategies can be established scientifically. But the grazing regulations have to be enforced by collective agreement and action. There must also be alternative sources of feed to make up the deficiencies when grazing pressures have to be reduced at crucial points in the growing season.

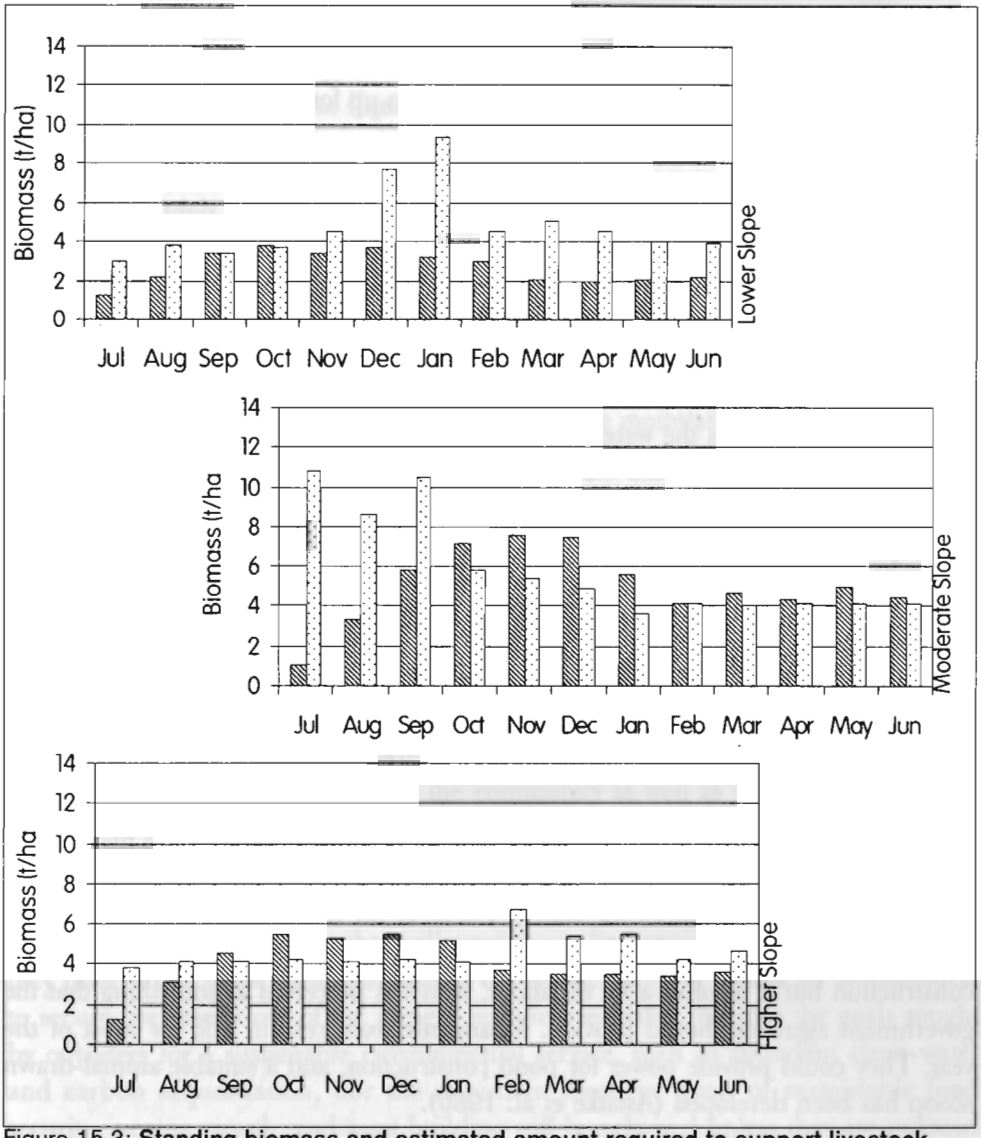

Figure 15.3: **Standing biomass and estimated amount required to support livestock and protect soil on different slopes in the Ginchi watershed**

Almost by definition, people living in watersheds have to be concerned with the movement of water down the watershed. Where there is intensive farming drainage channels are needed that pass between privately-owned fields and through common lands. Without care, as seen at Ginchi, erosion can spread rapidly to damage the channels, taking good land out of production. Ways have to be found to motivate individuals to cooperate with others to design and manage the waterways. This requires finding linkages between public and private interests in watershed management. In the example of the Ginchi watershed, it was shown that by improving drainage using the broad bed maker,

farmers can actually create negative consequences downstream. Smallholders with contiguous plots need to lay out their drainage systems jointly and link these to a common drainage channel. This requires some land to be given up for construction of the channel, which gives rise to complex communal problems that require skilful handling.

At Ginchi, research was required to determine how to access the right of way across private lands and how to recruit the labour required to construct the common channel. The landowners and their families had to be persuaded that their investment would be justified by sufficiently increased farm productivity. The planning and negotiations were complicated. It was not possible to form more manageable sub groups of farmers because the landholdings of each family were widely dispersed across the watershed; construction of the channel had to be agreed upon by most residents of the watershed. Ultimately, it was found that leadership in the drainage project conveyed status in the society and this motivated individuals to participate. The participatory process, encouraged by the researchers, facilitated negotiations that proved to be sophisticated and subtle. It was found that the residents did not invest their labour equally. Those who had more land in the watershed and owned plots with at least one border along the channel contributed most labour. In other words, individuals who had the greatest private stake in the collective endeavour contributed more to the construction and success of the public good (Mohammad Jabbar and Mohamed Saleem 1999; Gaspart et al. 1998).

The average annual rainfall in Ginchi exceeds 1,200 mm, but for four to five months of the year women fetching water for their households and children herding livestock have to walk long distances for water. There is no tradition of sinking wells or constructing ponds to conserve water. Extension staff have encouraged pond construction but it involves a lot of labour, which is perceived as something that the government agencies should provide. Meanwhile oxen remain idle for most of the year. They could provide power for pond construction, and a suitable animal-drawn scoop has been developed (Astatke et al. 1986).

Under the former communist regime, farmers, at the instruction of peasant associations, committed oxen and labour to dig ponds in some parts of the Ethiopian highlands. The people for whom the ponds were meant could not opt out of contributing. Nevertheless arrangements were made to accommodate differences in private resources and interests. Animal owners contributed in accordance with the number and condition of their animals. People who did not own work animals were expected to contribute in other forms.

These peasant associations have now been dismantled, but people with access to the ponds are grateful to the associations even though it was they themselves who

constructed the ponds. However, despite the appreciated benefits of reliable sources of drinking water in the neighbourhood, there are no ponds in the Ginchi area and research is needed along the lines of that undertaken for constructing the common drainage channel to find a means of motivating and organising the voluntary individual inputs required for the common good.

Conclusions

The scientific community has produced many technologies that are irrelevant to the most urgent needs of smallholders. While this is less prevalent with participatory research, there is still more to be done to make research appropriate to watershed-scale circumstances. This is needed urgently because mountains have not been at the forefront of development policies and the effects of changes in mountain systems are less well understood than in other systems.

The conventional systems' approach to research for development focuses primarily on policy interventions and technology components and their interactions at the household level. To have an impact on human welfare in mountain systems in terms of poverty alleviation, food security, better nutrition and human health, and environmental heath, it is necessary to go beyond household profitability, resource productivity, and resource requirements. Technologies and policies, and their interaction, have to be integrated at the community as well as the household level.

Unless common and private interests are reconciled the conflict between them will be detrimental to both. Livestock are perceived by many outsiders to be bad for mountain environments. But they will continue to be kept in the mountains because they present one of the best, and indeed one of the very few, means for smallholders to secure livelihoods out of the meagre resources available. Neither the goals sought by outsiders for a sustainable environmental service, such as abundant clean water and carbon sequestration, nor the mountain dwellers' goals of sustainable food security, income growth, and asset building will be achieved unless they are pursued through common reinforcing objectives.

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Chapter 16

Draught Animal Power in Mountain Highland Agriculture: Issues and Options

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Introduction

Draught animal power (DAP) is an important input in mountain highland agriculture, and in some places it has no viable alternative. The attributes of draught animals – energy for agricultural operations, physical products, income/employment gains, and sociocultural and ecological services – are vital for the sustainable development of mountain highland agriculture. The various agricultural transformation processes taking place in the Hindu Kush-Himalayan (HKH) region demand more use of DAP. This demand is likely to increase many times relative to the current supply. Thus the supply of DAP should be managed in parallel with the development of cash cropping in hill and mountain areas. Institutional policies and programmes dealing with animal husbandry, particularly animal breeding, are not conducive to the DAP system. They need to be reviewed and reformed from a regional perspective taking into account the present status and future prospects of mountain agriculture. This paper discusses several important issues currently faced by DAP and highlights some options crucial for its improvement.

DAP and Mountain Farming Systems

Draught animal power (DAP) is an outstanding example of the application of appropriate technology by marginal and small farmers, particularly in the developing world. In the diverse ecosystems of the mountains of the HKH region, DAP is the only feasible source of energy for agricultural work. Large-scale substitution by fossil

fuel-operated energy systems is not only difficult but also inappropriate. There is unlikely to be any acceptable alternative to DAP within the foreseeable future.

In subsistence farming regions, productivity and yields will only be improved if mixed farming involving DAP is developed (Bodet 1987). However, despite its potential contribution to agriculture, DAP has not been addressed adequately in the context of mountain farming systems. Several studies have been made that describe the close link between DAP and productivity and sustainability (Singh 1985, 1998; Singh and Naik 1987; Singh et al. 1995; Singh and Partap 1999; Partap and Singh 1999). The average yield and intensity of cropping have been found to be influenced more by availability of power per unit area than by irrigation, fertiliser consumption, or the use of high-yielding varieties (Srivastva and Yadav 1987).

Mountain agriculture is in a transitional phase and is currently witnessing transformation in selected pockets. However, most agriculture in the HKH region is still traditional. Whether traditional or transformed, the predominant feature of mountain agriculture is that the cropped area uses draught animal power and human muscle power (i.e., animate energy) for virtually all agricultural operations. This renewable energy is, as it should be, part of the strategy for sustainable agriculture. Machines using fossil fuel power cannot be used to any appreciable extent, thus animals and humans remain the most suitable source of agricultural power. The debate on the sustainability of mountain agriculture generally overlooks this vital factor. In the predominantly agrarian society of the HKH region, animals are omnipresent. In fact, they are an integral, inseparable, and indispensable part of mountain and highland farming systems.

The current livestock development policies of the Hindu Kush and Himalayan countries focus on conventional animal husbandry involving cross breeding, health care, and fodder cultivation for specialised milch cattle, coupled with market-oriented production. The cattle population in many highland areas is stagnating or declining (Singh 1999, Tulachan 1998) and this, together with continued institutional neglect of the DAP system, could result in a decline in the supply of DAP.

Improving the sustainable use of DAP is vital for the development of regenerative agriculture in the mountains. Potential options, technological advances, and the institutional support necessary for augmenting and promoting the DAP system need to be given their due priority in the sustainable development of mountain agriculture. DAP should receive the support it deserves.

No Alternative to DAP

In order to meet the increased demand resulting from population growth and rising standards of living and overcome the present state of under-nutrition, malnutrition, and poverty, agricultural production in the mountains needs to increase substantially, and the increase should be sustainable. Among other things, this will require adequate and sustainable power resources. Draught animals are the most economical and readily available source of energy in rural mountain areas. Thus DAP, complemented with manual work, should be part of an ecologically sound, environmentally friendly, and mountain-specific approach to increasing agricultural productivity in the region.

There is a direct relationship between the level of energy use, human, animal, or fossil, and the level of production per unit of land. In fossil energy driven systems, the relatively high use of energy explains the relatively high productivity. But the source of energy is not important for the level of production. There are organic integrated systems in which virtually no fossil energy is used that are at least as productive as modern systems in terms of overall production, but have less negative impact on the environment and are possibly socially more acceptable (Durno et al. 1992). Studies in the Philippines showed that the same yield of rice could be obtained on mechanical, transitional, and traditional farms (Kuether and Duff 1981). Thus using comparative energy balances as a basis for formulating policies can be misleading unless the data are combined with information on such factors as production, availability, and cost, and the impact on the environment, gender, and the community as a whole (Reijntjes 1992).

Transformation of agriculture and cropping practices often goes hand in hand with mechanisation. But mountains are the exception. Almost complete transformation has been seen in some favourable pockets of the mountains, without any appreciable degree of mechanisation. A very limited use of fossil fuel energy is visible in some transitional areas like the wide valley areas of the foothill ranges in the Indian central Himalayas, where a handful of farmers occasionally use hired tractors for land preparation because the land is flat, easily accessible, and well-linked to the plains, but this is atypical of the mountains proper.

DAP and farm mechanisation

There are many reasons why DAP is preferable to fossil fuel power in mountain agriculture (Gill 1981, Bhalla and Chadha 1982, Nair 1982, Ramaswamy 1983, Bodet 1987, Singh and Naik 1987, Reijntjes 1992, Singh and Partap 1999).

- The source of energy already exists in the region. DAP does not have to be manufactured or bought at a high cost.

- The use of animals considerably increases a farmer's 'work force'. It enables the farmer to diversify agriculture, to increase the cultivated area, and to carry out agricultural work in time.
- Machine-based energy systems cause the production activity to concentrate on a limited number of crops, thus reducing the diversity of the production system.
- Animal-drawn implements are cheaper than mechanised equipment. Animal-drawn implements can be made locally and are more suitable for the small, often fragmented and scattered farms found in the highland areas.
- Draught power does not need expensive and non-renewable fuels. Draught animals can be fed residues and by-products available on a farm, producing in return not only energy but also food (milk from female cattle), methane (biogas), and manure, as well as many other products obtainable after death.
- The use of draught animals enables farmers to integrate livestock and crop production and permits the exploitation of the potential of cattle on settled, subsistence farms.
- Mechanisation causes direct labour displacement in land preparation. If it does not also contribute directly to increasing cropping intensities and yields, or to facilitating a switch to more labour-intensive crops, there will be a net loss of employment opportunity in areas where alternative sources of income are scarce.
- The fossil energy used in machines is a finite resource and its use has a considerable negative impact on the environment.
- Most farmers in the HKH region cannot afford technologies based on fossil fuels.

These points all highlight the advantages of DAP over mechanisation in mountain areas, where the characteristics of the resource base are altogether different from those in the plains.

The Primary and Secondary Roles of Draught Animals

In addition to providing draught power for agriculture as their primary role, draught animals play many other roles in mountain farming systems that may be referred to as their secondary roles. Primary roles include ploughing or tillage, levelling, puddling, earthing-up, weeding, and threshing. The secondary functions range from direct, visible contributions, such as supplying dung and milk, to less visible gains such as contributions to employment, income generation, farmers' security and companionship, sustaining livelihoods, and sustainability of the farming systems. The secondary roles of draught animals are inseparable from those of most other classes of livestock (Table 16.1).

Draught power is one of the basic requirements for cropping in an agricultural system. Notwithstanding the availability of good seed, fertile soils, irrigation facilities,

Table 16.1: **Contributions of draught animals and other livestock species to mountain agriculture**

Contributions	Draught Cattle		Buffaloes	Goats	Sheep	Pack Animals
	Male	Female				
Agricultural Operations						
Ploughing	X					
Levelling	X					
Puddling	X					
Weeding, earthing-up	X					
Threshing	X	X				
Loading, pack-carrying	X[a]					X
Physical Products						
Dung, manure	X	X	X	X	X	X
Milk		X	X			
Meat				X	X	
Wool					X	
Income/Employment Gains						
Direct productivity improvement	X					
Smaller gains through sales	X			X	X	
Larger gains through sales	X	X	X			X
Off-farm activities	X					X
Income through hiring out	X					
Social, Cultural, Ecological Gains						
Cropping diversification	X					
In situ manuring of fields	X	X		X	X	
Renewable energy supply	X					
Religious, ethical values	X	X				
Festivities, fairs, rituals	X	X				
Social status, prestige	X	X				
Encouragement of social cohesion	X	X				
Enhancement of sustainability of the farming system	X					

[a] Used only by transhumant societies

and a favourable climate, crops cannot be sown and harvested without draught power. Untimely or inadequate supplies of draught energy lead to a decrease in crop production.

In the mountains, as in many parts of the world, the productivity of the farming systems depends largely on animals' ability to convert fodder into manure. In mountain areas, especially at high altitudes, crop residues decompose very slowly. The ruminant digestive system helps speed up nutrient recycling in cropland. Ruminants also help transfer the soil nutrients from forest vegetation to croplands, improving the fertility of the agro-ecosystems.

The dung produced in stalls must be transferred to cultivated land, which requires considerable time and effort and also results in a loss in quality. Manuring in situ, by

tethering the animals directly in the fields, is an important strategy developed by mountain farmers over the ages in which draught animals play a crucial role.

Draught animals provide employment for a great number of people, for whom they are a crucial source of family income. In the fast changing scenario of the present day, the DAP system is emerging as a big income-generating enterprise for a large number of marginal and small landholders, landless families, and some middlemen.

In times of emergency, draught animals can be sold for cash. They are often sold to meet substantial expenses such as weddings, building houses, and higher education of children. They are an asset and give farmers status, companionship, prestige, and security. They also occupy a prominent position in the sociocultural setting in many highland areas and thus cement the social cohesion of mountain people (Table 16.1).

DAP and the Agricultural Transformation Process

Traditional subsistence agriculture is still the most common practice across vast areas of the HKH region. The majority of the mountain population overwhelmingly subsists on and engages in traditional agriculture. This is the result of the high degree of inaccessibility and isolation: the greater the inaccessibility the greater the chances of traditional management. In isolated areas, farmers tend to be self-sufficient, but wherever the possibility exists, farmers try to extract benefits by adopting cash cropping. Natural diversity has been and is being utilised by traditional farmers both for sustenance and for developing diverse food production and livelihood systems.

Commercialisation of mountain agriculture

Commercialisation of mountain agriculture represents the efforts of mountain farmers to use their scarce land resources more efficiently to generate income. In terms of growing crops this means growing cash crops; diversifying; using inputs from science and technology; and building sound upland-lowland linkages (Partap 1995).

Mountain environments provide niche areas that are especially suitable for particular activities and products. Such niche areas can provide a comparative advantage for the mountains over the plains for activities related to such things as horticulture[1], floriculture, spice cultivation, and growing or collection of medicinal and aromatic

[1] In South Asia used broadly to mean cash crop farming, such as fruit farming, vegetable farming, floriculture, and mushroom production.

plants. In general it is horticulture, in particular fruit farming, that receives the most focus during the process of transformation. In the lower fertile valleys, with irrigation facilities and linked with markets, transformation is based on growing vegetables. In some high altitude areas, particularly between 1,800 and 2,500m, orchards are at the core of the process. In certain areas, especially in the central and western parts of the Indian Himalayas, apple farming has brought about a significant change in mountain agriculture. These areas are moist and thus provide a niche for off-season vegetable farming as well. Generally, apple cultivation and off-season vegetable cultivation are found together. In some lower areas transformation is based on the introduction of high-yielding varieties of cereals.

Impact on DAP

One thing is common to the transformed systems mentioned above: they are all energy intensive. In addition to requiring small to large amounts of external inputs, the systems require a large amount of animate energy (see below). As mentioned above, machines powered by fossil fuel are both rare and inappropriate in most mountain areas, in contrast to the plains. DAP and human energy are thus the only sources of energy available for managing the process of transformation.

Families with marginal landholdings in the central Himalayas often don't own draught animals; they generally depend on hired (or shared) bullocks for land preparation as do families with insufficient labour – as a consequence of male migration or otherwise. Small landholders generally keep bullocks throughout the year, or sometimes only during the ploughing season. Medium and large landholders usually keep a pair of bullocks throughout the year if they have sufficient labour, or hire them if labour is insufficient. Purchase, sale, and exchange of draught animals is very liberal among all the groups. Exchange of labour and sharing of bullocks and/or ploughs within a community is more common in transformed areas than the traditional or high hill areas.

In recent years, DAP has emerged as a good source of profit and employment for some families in transformed areas, especially those with small and marginal landholdings. In addition to preparing their own land, these families hire out their bullocks with or without a ploughman at prescribed rates. This practice, further strengthened by the transformation process, has emerged as an income-generating enterprise for a number of households.

Transformation and livestock fodder

Transformation in mountain agriculture is likely to severely affect the supply of livestock fodder from cultivated land. At present, in the central Himalayas an

estimated 35% of livestock fodder comes from cultivated land. With the continuous pressure on common property resources (CPRs), the dependence on cultivated land for fodder is likely to increase. But the changing trends in cropping patterns and the move towards high-value commercial crops means that supplies of fodder are likely to decrease. The major type of transformed agriculture is horticulture, and in areas where horticulture dominates the land has almost ceased to provide fodder for livestock. Similarly, the trend in cereal cropping is away from millet towards wheat and rice, and from all of these to crops like white seeded soybeans. But millet crops provide more dry fodder than wheat and rice because they have a higher straw to grain ratio, while soybeans provide no fodder at all.

Adoption of high-yielding varieties (HYVs) and use of external agro-inputs have helped to increase the productivity of major crops. However, dwarf HYVs have low straw to grain ratios and thus produce less fodder, and animals also don't like the fodder from HYVs as much as that from the long-stalked native varieties. Mountain farmers therefore value the high fodder yielding native varieties of crops. The poor straw yield inherently associated with the dwarf high-yielding varieties is one of the factors that has worked against large-scale adoption of new varieties of food crops.

Use of DAP in Different Farming Systems

There are many variables in mountain agriculture that determine the use of DAP. An intensive study was made of the use of DAP in different farming systems found in the central Himalayas in India (Singh 1998). The farming systems were divided into four categories, that found in the low hills (the Siwaliks), that in the mid hills in areas farmed according to traditional practices, that found in areas of the mid hills where transformation had taken place, and that in the high hills or mountains. The distribution and density of draught animals found in different areas and on different sizes of farm are shown in Table 16.2. The number of cattle per household was greatest in the mid hills zone in areas still using the traditional system of agriculture, and lowest in the high hills. The distribution and density of draught animals suggest that most of the draught animal population is concentrated in the villages using a traditional system of agriculture.

Only traditional villages had two or more draught animals per household; less than two bullocks per household indicates some degree of hiring and/or sharing. The average number of draught animals per household and per ha cropland is determined to some extent by the degree of inaccessibility or isolation, in terms of both distance from the main road in the region and from the plains and traditional influence. Where there is out-migration or working away of adult males, farms have fewer bullocks and there are fewer per ha cropland.

Table 16.2: Distribution and density of draught animals in the villages sampled in different farming systems

Type of Farm	Marginal	Small	Medium	Large	Overall
Low hills					
Population, no. per village	77	84	23	16	200
(%)	(39)	(42)	(12)	(8)	(100)
No. per household	0.7	0.8	1.6	0.5	0.7
Density, no. per ha cropland	2.0	1.4	1.1	0.2	0.9
Mid Hills: Traditional					
Population, no. per village	39	108	92	13	252
(%)	(16)	(43)	(37)	(5)	(100)
No. per household	1.5	2.2	3.0	2.2	2.2
Density, no. per ha cropland	4.0	2.6	1.8	0.8	2.1
Mid Hills: Transformed					
Population, no. per village	11	25	25	16	77
(%)	(14)	(33)	(33)	(21)	(100)
No. per household	0.4	1.1	1.4	1.8	1.0
Density, no. per ha cropland	1.8	1.5	1.0	0.9	1.1
High Hills					
Population, no. per village	5	7	39	7	58
(%)	(9)	(12)	(67)	(12)	(100)
No. per household	0.1	1.4	1.9	2.3	0.5
Density, no. per ha cropland	0.5	2.8	1.7	1.0	1.3

Source: adapted from Singh (1998)
Note: marginal <0.5 ha; small 0.5-1.0 ha; medium 1.0-2.5 ha; large >2.5ha

The extent to which animals were shared or hired is shown in Table 16.3. Some hiring in and out took place in all zones except the high hill zone. Except in the traditional mid hill villages, large landholders did not hire out bullocks. When not all households can afford to own a pair of bullocks, sharing is clearly a positive indicator for DAP use since it tends to keep the population of draught animals in balance, promotes efficient and economic use of the existing population, and also stimulates social cohesion. Hiring in of DAP saves expenditure on bullock rearing throughout the year, whereas hiring out creates opportunities for employment and income generation for small and marginalised farmers.

Tractive performance and use of power

Most draught power is used for ploughing operations. The tractive effort of bullocks ranges from 9% of body weight during weeding and earthing up operations, through 16% during ploughing at 2.4 km per hour, to 19% during puddling operations at 1.6 km per hour (Table 16.4). These high values indicate the special ability of the lightweight and hardy native draught animals to generate a high percentage of body weight as tractive effort. On average a pair of bullocks tills and levels 1,100 sq.m of land per day during seven hours of continuous work. The average draught power output per animal (average weight 250 kg) during ploughing is 0.26 kWh (0.35 hp).

Table 16.3: **Percentage of different landholding groups in the villages sampled in different farming systems participating in sharing and hiring of DAP**

Type of Farm	Marginal	Small	Medium	Large	Overall
Low hills					
Sharing	32	27	7	6	25
Hiring in	34	36	14	70	38
Hiring out, all households	12	12	7	0	10
(households owning bullocks)	(37)	(31)	(9)	(0)	(28)
Mid hills: Traditional					
Sharing	23	0	7	0	7
Hiring in	0	2	23	17	8
Hiring out, all households	35	24	19	17	25
(households owning bullocks)	(47)	(24)	(19)	(17)	(25)
Mid hills: Transformed					
Sharing	24	9	0	0	11
Hiring in	52	39	39	11	40
Hiring out, all households	20	26	11	0	17
(households owning bullocks)	(100)	(50)	(17)	(0)	(34)
High hills					
Sharing	11	20	10	0	9
Hiring in	51	0	0	0	30
Hiring out, all households	0	0	0	0	0
(households owning bullocks)					

Source: adapted from Singh 1998
Note: marginal <0.5 ha; small 0.5-1.0 ha; medium 1.0-2.5 ha; large >2.5ha

Table 16.4: **Power output of draught animals during different agricultural operations (total effort of pair of bullocks)**

	Average speed km per hour	Tractive effort [1]kg	Power [2]kW
Ploughing	2.4	78	0.52
Levelling	2.7	48	0.36
Puddling[3]	1.6	95	0.42
Weeding and earthing up[3]	2.6	47	0.34

Source: Singh 1998
Figures are based on eight hours' operation (seven hours ploughing and one hour levelling) by a pair of bullocks. Each bullock weighed 250 kg
[1]actually kilogram force or kgf, equivalent to 9.806 Newtons
[2]1kW = 1.34 hp
[3]Estimates based on Singh and Naik 1987

In practice one pair of bullocks is sufficient to complete all the operations over an area of 1.5 ha. At the rates described above, ploughing and levelling of this area would take a pair of bullocks working every day for eight hours approximately two weeks. The area of cropland in the villages studied and the number of pairs of bullocks available to work it are shown in Table 16.5. In the high mountains and the traditionally farmed area in the mid hills the number of bullock pairs available was sufficient or considerably more than sufficient to work the area of cropland. In the transformed area of the mid hills the number of bullock pairs was somewhat less than needed to easily work the area, and in the low hills there were far less

Table 16.5: **Cropland area and DAP available in the sampled villages in four zones of the central Indian Himalayas**

	Low hills	Mid hills – traditional	Mid hills – transformed	High hills
Total cropland area, ha	228	118	68	43
No. of available bullock pairs,	100	126	38	29
Average area operated per bullock pair, ha	28	0.9	1.7	1.5
Balance in area operated per bullock pair, ha[1]	(+) 0.8	(-) 0.6	(+) 0.2	0

Source: Singh 1998
[1]Based on 1.5 ha as a standard area to be operated by a pair of bullocks

pairs than needed if all the work was to be performed by DAP instead of with tractors.

All agricultural operations carried out by draught animals, i.e., ploughing, levelling, puddling, weeding, and threshing, also require a certain amount of human energy. There are many other operations that require human energy alone – hand-weeding, irrigation, transport and application of manure, breaking of clods, sowing and transplantation, application of fertiliser and pesticides, harvesting, and hand-threshing. The average working hours and energy invested by people and animals per hectare for the cultivation of crops in the four different zones is shown in Figures 16.1 and 16.2. Agricultural transformation is an energy-intensive process. The working hours per hectare and the energy per hectare from humans, bullocks, and overall were highest in the mid hill areas where agricultural diversification had taken place, followed closely by the low hills. More energy per hectare was required for

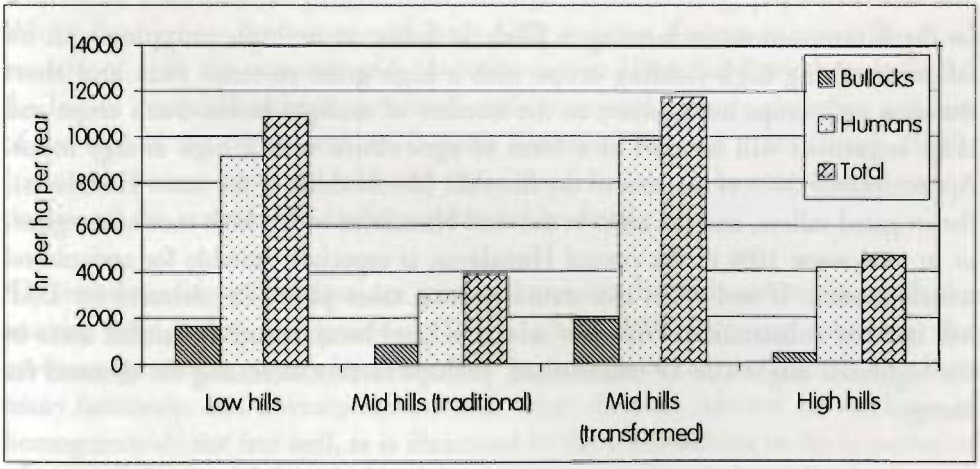

Figure 16.1: **Average working hours invested per ha per year in different farming systems by humans and bullocks**

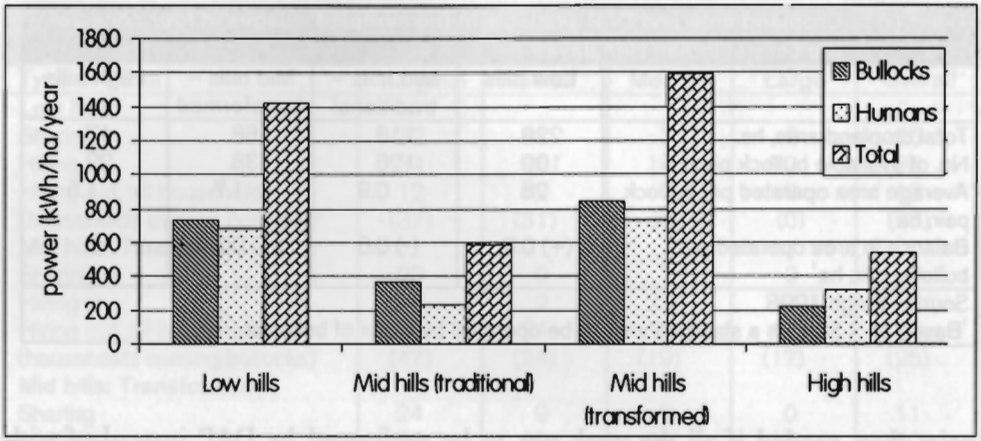

Figure 17.2: **Average energy invested per ha per year in different farming systems by humans and bullocks**

traditional mid hills agriculture than in the high hills, but the actual working hours for people were less as a greater proportion of the energy was supplied by DAP. The average number of days worked by bullocks varied enormously, from only 59 days a year in the high hills to as many as 236 days a year in the transformed mid hill area. In high hill agriculture only 41% of the total animate energy used in crop cultivation was supplied by DAP, in the low hills about 52%, in transformed mid hill agriculture about 54%, and in traditional mid hill agriculture as much as 62%. The transformed agricultural system made the most efficient use of the available DAP and human resources, and this was reflected in a higher degree of crop diversification and higher crop yields in the area.

Cash Cropping and the Prospects for DAP

In the future, mountain farming is likely to focus on multiple cropping with no fallow involving high-yielding crops with a high grain to straw ratio and short duration cash crops not sensitive to the number of sunlight hours. Such crops and crop sequences will be part of a form of agriculture with a high energy input. Approximately 30% of the area of the Siwaliks (the foothills of the outer Himalayas), the irrigated valleys, and the areas in the mid Himalayas with a high moisture regime, or in total some 10% of the central Himalayas, is especially suitable for agricultural transformation. If and when this transformation takes place, the demand for DAP will increase substantially. With new advances (and breakthroughs), rainfed areas in the highlands might also be transformed, perhaps further increasing the demand for energy.

Commercialisation of agriculture in the mountains basically relies on cropping systems based on horticulture. Singh (1998) found that vegetable cultivation

required the maximum input per hectare of both DAP and human energy. Although fruit farming itself requires no DAP input (e.g., apple orchards), the area under fruit trees is extensively used for vegetable cultivation. As a result the orchard-vegetable cropping system actually demands more DAP than a cereal-based system.

Horticulture is emerging as a dominant activity with fairly extensive development potential in mountain areas (Banskota and Jodha 1992; Partap 1995) so that the prospects for DAP appear to be bright. However, in transformed areas buffaloes are preferred to cattle (Singh 1998) so that the DAP supply in such areas is likely to depend increasingly on a hiring system. Inter-village hiring might dominate, with animals coming from villages adhering to more traditional farming practices, because the transformed village communities would have less time for cattle rearing. In the more distant future, villages engaged in cash crop farming might also come to depend on hired human labour.

Commercialisation based on increased cultivation of nuts, timber species, or medicinal and aromatic plants would lead to a reduced demand for DAP.

Conventional Animal Husbandry and DAP

Crossbreeding of indigenous cattle with European bulls has, for decades, been the standard institutional approach for improving the production and productivity of cattle in the Indian Himalayas, as in the rest of the HKH region and all developing countries.

The cattle improvement programmes through crossbreeding, popularised as the White Revolution, have met with only little success despite massive financial investment, with the exception of a few areas such as Himachal Pradesh in India. In the Indian central Himalayas, crossbred cattle accounted for only about five per cent of the total in the region with no increase between 1988 and 1993 (Singh 1998). Livestock owners have not adopted these programmes to any significant extent despite all the institutional facilities extended to them.

The crossbreeding policy does not take into account the environment in which the animals have to live and produce (Singh 1994). In developing countries, the environment cannot usually be controlled. In these countries the animals also have many functions, and diversity has survival value. Animals selected on the basis of homogeneity do not fare well, as is illustrated by the many failures in the importation of 'upgraded animals' from industrialised countries to less industrialised countries (Orskov 1995).

Female crosses of European (*Bos taurus*) and zebu (*Bos indicus*) breeds of cattle have been accepted by farmers in warm climates, however, thanks to the increased lactation length, higher milk production, and earlier age of calving of the crossbred animals. Crossbred females have also been fairly well received in the Himalayan Terai owing to their production traits. But the White Revolution technology has only been really successful in areas where a large amount of fertile land could be devoted to the production of animal feed, where good veterinary services could be provided, and where there was a mechanical alternative to DAP. Where these conditions are generally lacking, it is still possible that such animals could be accepted by individual families. But in mountain areas with a community-based setting, programmes are only likely to be successful if they are acceptable at the community level, not only by individual families.

The animals bred by mountain farmers are multipurpose. They provide both manure and power for agriculture and milk for the household. Improving one trait, like milk production, at the expense of another, like draught power, would upset the balance needed for integrated production.

There has been little acceptance of crossbred males for draught purposes in the plains because of the general opinion that their working performance is inferior to that of the indigenous cattle, since they do not have a large distinctive hump and are unable to tolerate high temperatures (Goe 1983; Singh and Naik 1987). Farmers all over India consider crossbred bullocks to be inferior to local bullocks in stamina, strength, and vigour (Mali et al. 1983). Research scientists have also concluded that, whereas crossbred females can be good milk producers if fed adequately, the field performance of their male counterparts is very low and the animals are not suitable as work animals (Annaji Rao 1983). At the same time a crossbred bullock requires at least 50% more feed than a bullock of indigenous breed; so even if it had the same unit of work output its economic efficiency would be only two-thirds that of a local animal (Rajpurohit 1975).

Main Constraints to the Use of DAP

In order to improve the prospects for DAP it is first necessary to identify the major constraints, the reasons for the reduction in the draught power of animals, and inefficient and uneconomic patterns of use. Research and development to overcome these problems will help the development of DAP as one of the options for enhancing the productivity and sustainability of mountain farming systems. The major constraints identified so far are summarised in Table 16.6 and discussed further below.

Table 16.6: The major constraints to DAP in mountain agriculture	
Major constraints	Major effects and consequences
RESOURCE RELATED	
Topographic Variation Difficult, undulating terrain, reduced accessibility, altitudinal variation, weather extremes	Difficult to make full use of DAP, loss of time and energy of humans and animals, difficult to transport inputs and outputs, increased vulnerability.
Fragmented and Scattered Holdings Small terraced fields, long distances between parcels of land	Difficult to use DAP efficiently, enormous loss of human and animal energy and time, less than potential yields, difficult to transport inputs and outputs.
Problem Soils Low water holding capacity, high proportion of gravel, nutrient deficient, low pH, shallow depth, vulnerability to erosion	DAP supported cultivation abandoned in some places, reducing the use of DAP
Climatic Extremes Rain, snow, hail storms, strong winds, seasonal hazards	Breakdowns in the continuous use of, and loss of benefits from, DAP, decreased potential of draught animals, risks to animal health
Imbalanced Land Use Low ratio of CPR to cultivated land, changing cropping patterns, increased intensity of resource use	Reductions in grazing area and fodder supply leading to poor nutrition of draught animals, decreased draught capacity of animals, and higher cost of bullock maintenance.
Changing Floristic Composition Endangered climax species, emphasis on monocultures of non-fodder trees and annual crops	Decreased amount of fodder for draught animals, decreased draught capacity of animals, reduced use of animals
Changing Livestock Composition Lower proportion of draught animals in herd	Shortage of draught power for agriculture, overuse of existing animals leading to reduced draught capacity, excessive burden on human beings for agricultural operations
MANAGEMENT RELATED	
Lack of Improved Harnesses and Implements Often inefficient and primitive implements	Draught capability not fully harnessed, increased cases of injuries, loss of animal days, slow rate of work
Improper/Inadequate Health Care Neglect of ethno-veterinary services, inadequate health care infrastructure	Decrease in draught capacity of animals, slow growth rate, high infertility incidence in females, reduced lifespan and working life, high mortality rate, loss of animal days
Mishandling of Animals Yoking to defective implements, overwork, inhuman/merciless treatment	Continuous overstress on animals, reduced draught output, reduced working life
Conventional Animal Husbandry Policies and Programmes Changing husbandry priorities, crossbreeding, neglect of DAP	Reduced proportion of draught animals, increased number of often unusable crossbred bullocks, reduced supply of draught power to agriculture, increased burden on human resources to fill the power deficit
Source: Singh 1998	

Resource-related constraints

Topographic variation creates some difficulties in the full use of DAP. Undulating terrain, variation in altitude, and steepness of slopes reduce the accessibility to

many areas and severely affect resource management, including management of DAP.

The fragmented and scattered landholdings are the result of the overall terrain conditions, the need for farmers to maximise the diversity of their holdings to ensure food security, and the law of inheritance which encourages the division of already small plots among all heirs and has led to fragmentation of property over many generations. The distance between and small size of plots leads to enormous losses in terms of human labour and DAP and much waste of time in going from one tiny field to another.

In the mountains, common property resource (CPR) areas are being converted to cropland. This reduction in grazing area and depletion of forage mean a loss of good nutrition for draught animals and thus a reduction in their draught capabilities. These also lead to manifold problems for agriculture (e.g., insufficient nutrient flow from forests and pastures to cropland) and in the social system (including paucity of fuel, fodder, forest-based foods, wood for agricultural tools and implements, and timber for house construction). It is difficult to maintain unproductive animals without the support of CPRs. Moreover, the high cost of increased stall feeding favours keeping buffaloes rather than cows, since milk prices are based on the amount of fat in the milk (Jodha 1992). Overall the proportion of draught animals kept in cattle herds is gradually being reduced in many parts of the Himalayas, and this imposes another constraint on the DAP system.

Management-related constraints

The agricultural implements being used for draught are still inefficient and often primitive as is the harness system. Some institutes and research organisations have produced improved designs, but they are generally not suitable for increasing the capabilities of draught animals – they cost too much and the extension facilities are inadequate. The harnesses and implements used today are almost the same as those seen in ancient works of art. "India has put satellites in space and harnessed the atom," says Ramaswamy, a leading DAP expert, "but our carts are 5,000 years old, because professors are scared they may not get promotion if they work on designing better carts." An estimated million or more animal hours of work are lost annually in India as a result of the traditional defective yoke that inflicts injuries on the necks of animals.

Health services for draught animals are far from adequate. There is little emphasis on a humane approach, draught animals tend to receive less care and are ill treated and overworked. This further reduces their efficiency.

Finally, as discussed above, conventional livestock husbandry policies and programmes have had several long-term negative effects on the DAP system, mainly as the result of creating an environment for developing specialised milch breeds at the cost of the multipurpose (strictly speaking, dual purpose) draught breeds that are suitable for mountain agro-ecosystems.

Improving the DAP System

In order to use DAP to enhance agricultural production and sustainability, it has to be combined with other agricultural techniques, policies, and programmes. Some of the potential technological and institutional options are discussed below. Enhancement of DAP is an essential component in ensuring the sustainability of agricultural development in mountain areas.

Potential options

Some of the options available for improving the use of the existing potential of DAP resources, and thus contributing to increased agricultural productivity, are as follow.

- Increasing the number of days of bullock use per year and number of work hours per day through diversification in crop production, e.g., multiple cropping, mixed cropping, cash cropping, annual-perennial links
- Using more animal species as DAP resources; for example yaks, dry cows (as used extensively in Bangladesh), donkeys, mules, and horses. Yaks, for example, found in high Himalayan areas, are regular breeders, may live up to 40 years of age, and may give birth to 20 or even more offspring (Negi 1990).
- Involving work animals in more activities – for example, some transhumant societies also use bullocks as pack animals
- Increasing power output per animal – this can be achieved through improved (and matching) designs of yokes, harnesses, and animal-drawn implements; providing balanced nutrition and better health care to mothers, calves, and work animals; and proper training of animals
- Consolidation of scattered holdings – if possible this would contribute to more efficient DAP management and the avoidance of loss of time and energy
- Improving the condition of CPRs like common forests and grazing lands, through the type of techniques and strategies described in Jodha (1992, 1995) and Miller (1995). This would ensure regular supplies of fodder and other biomass to the farming system and would be a key element in improving the sustainability of the system overall.

Technological advances

Research and technology must look at DAP as an integral part of the whole farming system. In order to be upgraded, the DAP system needs practical technological

innovations that can be used by farmers. Farmers' traditional technologies can be instrumental in guiding such innovations. Technological advances should not remain confined to laboratories, they must reach the farms and be within the financial means of farming communities. Furthermore, to be effective, technological advances in the DAP system must be combined with long-term strategies for sustainable mountain agriculture.

The best research and development efforts should be applied to the DAP system and related technologies in the search for ways in which farmers may make better use of a resource already at their command. Such techniques could lead to an enhancement of the status of DAP, so that its value as an effective contributor to food production and rural prosperity is more readily recognised and accepted (Kemp 1987).

Animal nutrition and optimum rates of work are two areas in need of further investigation. The criteria vary according to the geographical area in question. Research into animal nutrition must be based on a knowledge of the feed resources available in a particular mountain area. Rates of work depend largely on the interactions between the task, the implement, the harness, the animals, and the operator (Kemp 1987).

Nutrition of draught animals

The feeding practices commonly followed by farmers in the mountains are simple. They depend on naturally available feed resources and crop by-products and vary with the seasons. The performance of livestock in terms of growth, reproduction, and working capacity, is influenced by the availability of feed and the feeding schedule.

Ideally, animals should be fed a balanced diet that provides all the nutrients required. The actual quantity needed of the different ingredients depends on the body weight and working capacity of the animal. The energy and nutrients needed to maintain health and other physiological activities when the animal is in a resting state are called maintenance rations. The additional rations that provide the energy and nutrients necessary for work are called work production rations. Draught animals need to be fed sufficient to provide work energy, not just enough for survival.

Normally good quality green fodder (legume) is sufficient for maintenance. If the fodder quality is poor (non-legume), then it should be supplemented with adequate quantities of concentrate mixture. If the fodder is of very poor quality (such as dried grass and crop residues), it can be treated with urea to improve digestibility. For many years roughage has been treated with chemicals such as sodium hydroxide,

calcium hydroxide, and others to improve the nutritive value. But urea (essentially ammonia) treatment has a stronger appeal than calcium or sodium hydroxide treatment since it increases the nitrogen content of straw as well as the palatability, digestibility, and energy values. Urea treated straw, fed to livestock, results in increased intake and better growth rates than untreated straw. The straw is treated by adding 40 to 50g of urea per kg of straw at a moisture level of around 60% and covering tightly for about four weeks before using as feed. The urea is hydrolysed by the enzyme urease, releasing ammonia. This method is safer, cheaper, and more convenient than other methods for storage and handling. It can be used conveniently on small farms. However, roughly two-thirds of the urea-ammonia is wasted (Kumar 1986).

Certain physical treatments can also be used to increase fodder value. Chopping of roughage increases voluntary intake, grinding increases intake and digestibility and reduces wastage. Pelleting reduces dustiness and volume, and thus also leads to increased feed intake. Soaking is one of the oldest and cheapest methods used. One to two hours' soaking removes dust from straw and stovers and makes them moist, which improves their palatability and increases feed consumption. Soaking also removes the oxalates present in rice straw, these bind calcium and if left reduce the calcium availability for the animals (A. Kumar, unpublished report).

Under normal conditions, a working bullock derives energy first from the carbohydrates in the feed, and then from stored fat. Only if there is an excess demand for energy, will it be met from protein containing tissues such as muscles. If the diet contains sufficient carbohydrates, then mature draught animals need no extra protein over and above that in the maintenance diet.

Feed should be given to work bullocks according to their nutrient requirements, and these depend upon their work potential and body weight. The heavier the work, the greater the requirements. Some green fodder should be given to meet the calcium and Vitamin A requirements. Cereals such as maize, wheat, and barley should be given to working animals as they are responsible for the production of propionic acid in the rumen, which is a good source of glucose and energy. Crop residues should be provided to draught animals as per availability. The quality of crop residues can be improved through proper chemical and physical treatment. Jaggery, molasses, and mustard oil, all of which are rich in energy, can also be fed to the animals.

Designing new harnesses and implements

It should be possible to develop improved designs for yokes, harnesses, and other implements by considering the engineering principles involved in transferring power

from an animal to an implement. If draught animals could be equipped with more efficient and more comfortable harnesses, their pulling capacity could be tripled and their working lives increased by a factor of two or three (BRT 1990). Apart from providing increased pull, the newly designed yokes and harnesses should be helped to eliminate suffering.

As a result of various inherent local factors and environmental considerations, it is possible that the population of draught animals will go down. It would be useful to design a new harness system for a single animal, rather than a pair. A pair of animals is thought to be 14-20% less efficient than a single animal in terms of power conversion efficiency (Kumar 1991). Such a harness would help maintain the actual amount of draught power available despite a decrease in the animal population.

The draught of a plough (and any other agricultural implement) is dependent on weight, shape, and scouring properties; the size and number of furrows; presence of different attachments; soil characteristics; slope of the land; speed of travel; and skill of the operator (Goe 1983). Therefore efficient agricultural implements need to be developed for specific site characteristics.

Widespread use of any newly designed yokes, harnesses, and implements will largely rely upon the vocational training of local craftsmen. Care must be taken to ensure that the local craftsmen are suitably trained in the maintenance and repair of harnesses, yokes, and implements. The hand tools used in mountain agriculture should also be given new shapes and designs suitable to local site-specific conditions, and acceptable to local farmers.

Such technological improvements in tools, implements, yokes, and harnesses would increase the efficiency of the DAP system and help farmers increase their productivity by integrating DAP technology into their present system.

Institutional intervention

The conventional type of institutional intervention can have a negative impact and actually contribute to lack of sustainability in the animal husbandry sector through the effect on DAP (Singh 1998). An appropriate, long-term cattle breeding policy could be instrumental in increasing the use of DAP in mountain areas. The conventional policy needs to be reviewed thoroughly so that a more appropriate new breeding policy can be developed.

The lack of adequate policy measures for strengthening DAP as a part of the development of sustainable mountain agriculture is a basic problem that needs to be

addressed. DAP should be treated as an important component in the integrated energy system and as an input qualifying for institutional and infrastructural support.

Adequate infrastructural facilities are needed, these include R&D and extension services for the design and introduction of more efficient, matching harnesses and animal-drawn implements and for the improvement of the DAP system. Such facilities would greatly encourage efforts towards the sustainable development of mountain agriculture. Statistics should be published from time to time on draught animals, their usage patterns, and other points of interest, to help researchers and scholars in this field.

In the mountains and highlands, there is a good chance of developing a policy framework with a long-term perspective for promoting and upgrading the DAP system and ultimately developing sustainable agriculture.

Conclusions

The contribution of DAP is vital for the sustainable development of mountain agriculture. The nature and intensity of the problems related to DAP are different for different mountain areas, and for different ecological zones or farming systems in the same area. In the HKH region, agriculture is in a phase of transition towards market-oriented cash crop farming. Commercialisation of agriculture is advocated by institutional policies and fuelled by the policies of economic liberalisation adopted by governments in the HKH countries. The aim is to increase farm employment and income and to take full advantage of ecological niches in the Himalayan mountains. Three principal types of transformation dominate, based either on fruit trees, vegetables, or high-yielding varieties (HYVs) of cereals.

Agricultural transformation processes are energy-intensive. In the transformed areas, the scenarios for DAP management are beginning to change as the cattle population, and the number of draught animals, is reduced, and plough (and DAP) sharing arrangements are dropped in favour of hiring. Although the transformed areas need more DAP, they produce less animal fodder than areas under traditional agricultural management. Commercialisation of agriculture actually supports intervention towards DAP development, but does not itself contribute to it. The way in which the transformation processes and the DAP system can complement each other should be investigated so that problems with DAP do not emerge as a binding constraint to crop production. Possible actions include providing credit to small and marginalised farmers so that they can raise draught animals in adjoining non-transformed areas and rent out DAP to farmers in transformed villages; and development of support areas like forests and pasture and proper management of agroforestry systems in areas with commercialised farming.

The optimum amount of DAP required for realising defined or maximum levels of production from individual crops, cropping systems, and farming systems needs to be established. This is necessary so that a quantitative analysis can be made of the linkages between DAP and agricultural productivity and sustainability in mountain areas. It is also needed to plan for sustainable use of DAP in agriculture. Planning nutrition will be pivotal in increasing the working capacity of animals. It will be necessary to develop animal feeding systems that involve management of CPRs and formulation of balanced rations for work animals and pregnant mothers and calves. In order to improve the efficiency of the mechanism for transforming DAP into useful work it will be necessary to design new, efficient, and site-specific equipment such as agricultural implements and harnesses. This is one of the keys to realising the full potential of the available draught animal resources.

An appropriate long-term cattle-breeding policy aimed at conserving the uniquely adapted draught qualities of the native breeds may well be valuable for the welfare of the animal sector in the long term. As yet no policies exist on the DAP system as such. A sound, ecozone specific DAP policy to support, promote, augment, and develop DAP systems should be an essential part of our approach to the sustainable development of agriculture in mountain regions.

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Chapter 17

Livestock as a Household Energy Source in the Mountains: Traditional Practices and New Opportunities

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Introduction

Livestock play an important role in the mountain economy. They contribute to the livelihood of mountain communities by providing milk, meat, muscle power (for ploughing and transportation), and dung. Dung is used both as manure and as a source of energy for cooking. The use of dung as a cooking fuel is increasing as a result of the decreasing availability of fuelwood, twigs, and bushes and lack of access (both physical and monetary) to other options for producing energy like fossil fuels or renewable energy technologies. This situation is being exacerbated by the present drop in the number of livestock in response to the increasing pressure on the limited resources. This means that an even greater proportion of the available dung is being used for cooking, even though this affects farm productivity. Research reports indicate that any increase in the number of livestock in the fragile ecosystem of the mountains would lead to overuse of forest biomass resources and negative environmental consequences (Singh 1998; Tulachan and Neupane 1999).

There is, however, a technological option that enables dung to be used both as a fuel and as fertiliser – the biogas digester, which produces both biogas fuel and manure, is a well tested technology. At present, however, this technology is only used extensively in low lying mountain areas (below about 1,500m) because of the inherent temperature limitation. The optimum temperature for production of biogas is 33°C, production seizes if the temperature falls below 10°C. There are various possibilities for maintaining the temperature above 20°C when ambient temperatures

are low, however, for example using solar thermal technologies, or burning some of the biogas or other fuel to prepare hot water to be fed into the biogas digester (Monga and Ramana 1992). There are a few examples of these technologies in operation within the Hindu Kush-Himalayan (HKH) region. Before an effort is made to popularise any of these options, more detailed research needs to be done into the application of biogas technology in cold climates. If biogas digesters can be made technologically and economically feasible at higher altitudes, then it will be possible to meet both the energy and the manure requirements of mountain farmers without compromising the use of dung for one or the other.

Patterns of Energy Use in the HKH Region

Cooking and heating are the main household energy needs (Figure 17.1) in the HKH region (Rijal 1999). A variety of traditional cooking and heating stoves fired by fuelwood, twigs, or dung are used in mountain households. In higher altitude mountain areas, the demand for space heating is greater than for cooking in terms of the useful energy requirement. A typical example is that of Nepal. In the mountains 32% of the useful energy required by the household sector is used for cooking and 56% for heating, compared with 40% for cooking and 36% for heating in hill areas (Rijal 1999). Lighting energy needs are met by kerosene, or electricity where it is available. The final energy consumption of different types of fuel in four countries of the HKH region is shown in Figure 17.1.

Cottage industries (such as agro-processing, charcoal production, potteries, bakeries, blacksmiths, sawmills, carpenters' shops, and village workshops) need energy for lighting, process heat, and motive power. In general, wood is used to provide process

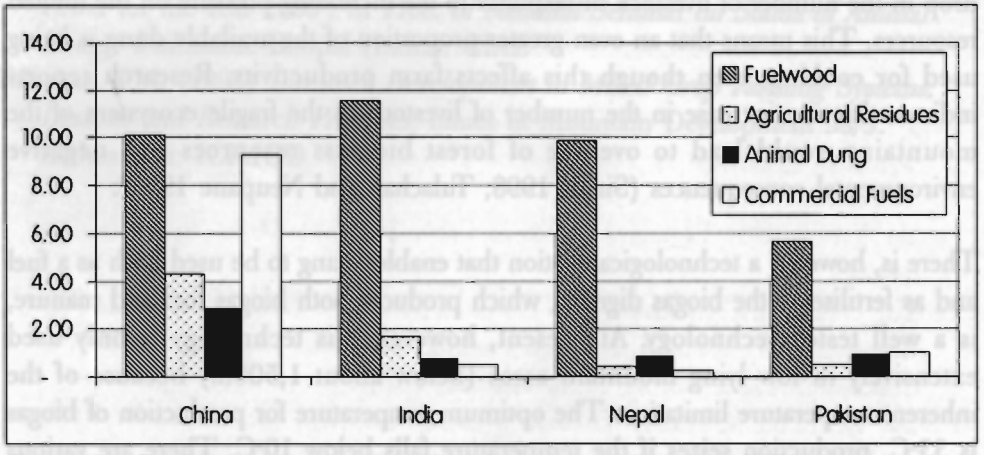

Figure 17.1: **Final energy consumption in selected countries of the HKH region, FY 1994/95**

heat in facilities such as forges, potteries, and bakeries, although in the HKH region of China coal is used extensively for this purpose. Motive power requirements are met by electricity, diesel, and kerosene, where available, or else by human or animal labour using mechanical equipment. Fuelwood is widely used in agro-based facilities such as those for crop drying. The bulk of energy inputs for land preparation, cultivation, post-harvest processing, and transport related to agriculture are in the form of human and animal labour. In the mountain areas, the degree of mechanisation and of use of commercial fuels is generally low.

In general, per capita consumption of energy is lower in the hills and mountain areas of the HKH than the country average. At the same time, the percentage of the per capita energy consumption derived from fuelwood is substantially higher than in each country as a whole. For example, in India fuelwood contributes 66% of the total energy requirement in the HKH region compared to 47% in the whole country (Rijal 1999). These figures reflect the fact that in general the mountain regions are marginalised in terms of access to commercial fuels and are heavily dependent on fuelwood. This situation is worsened by the low level of efficiency of utilisation of these fuels and the creation of health hazards – particularly for women who are the managers, producers, and users of energy at the household level.

Overall, the patterns of energy use in the HKH Region show the following trends (Rijal 1999).

- Biomass fuels dominate the energy scene, with fuelwood being the principle source of energy.
- The household sector is a major consumer of energy.
- Energy demand is increasing as a result of agricultural diversification and intensification, rural industrialisation, and increasing tourism.
- Energy use in mountain households varies with the household size, altitude, ethnic group, income and expenditure, land holding, livestock holding, and the number of cooking/heating stoves employed.
- The requirement for heat energy, primarily for cooking and heating, is higher than that for energy for shaft power as an input to a production process.
- The demand for fuelwood exceeds the sustainable supply, and thus the process of destruction at the margin is a common phenomenon in a large part of the region.
- The cost of energy extraction is increasing.
- The availability of fuelwood is and the time taken for its collection is increasing.
- Continuous unsustainable use of fuelwood from the forest forces rural people to use 'other' biomass fuels, further degrading the environment.
- Access to and availability of energy technologies are improving, but as yet not sufficiently to show a reduction in human (particularly of women) drudgery.

There are no readily available substitutes for biomass fuels in rural mountains. Nor is there any widespread use of energy saving devices to increase the efficiency of biomass fuel use. As a result the mountain's gross biomass energy consumption is reflected in a low useful energy utilisation (less than 20% energy efficiency). The complementary nature of the energy mix, especially in mountain households, shows limited scope for interfuel substitution. The choice of particular energy forms to provide the desired energy services in the mountains is, and will continue to be, based on the availability of and access to particular energy resources and technologies at affordable prices. Thus biomass fuels are and will remain the mainstay of energy sources in the mountain areas in the foreseeable future. The contribution of fuelwood amounts to more than 80% of the total energy requirement in the HKH regions of Nepal and Bhutan, 66% in India, 52% in Pakistan, and 29% in China (Rijal 1999).

There is evidence of increasing use of 'other' biomass resources (agricultural residues, animal dung) as fuels as a result of the decrease in the supply of fuelwood (Table 18.1). The present trend indicates that the use of agricultural residues and animal dung as sources of energy is on the rise in the HKH region. This clearly reflects the ongoing stress on forest resources. At the same time the transition from biomass to commercial energy forms is slow in mountain areas, as a result of both monetary and non-monetary factors and of the lack of suitable technological options, except in some major urban settlements.

Table 17.1: **Population, forest area, and consumption of biomass fuels in the HKH region, FY 1994/95**

Area/Location[1]	Population (millions)	Forest area (million ha)	Annual per capita consumption of biomass		
			Fuelwood (kg)	Agricultural residues (kg)	Animal dung (kg)
HKH, China	19.7	23.6	760	460	321
Eastern Mountains, India	14.7	15.2	758	135	73
Western Mountains, India	18.3	5.6	635	81	88
Eastern Nepal	11.8	2.7	565	47	97
Western Nepal	8.6	6.2	691	26	49
Northern Mountains, Pakistan	22.3	18.5	290	54	87
Western Mountains, Pakistan	6.7	34.7	607	5	87

Source: Rijal 1999

[1]The eastern mountains in India include Sikkim, Darjeeling, and the North East Region of India; the western mountains include Uttarakhand, Himachal Pradesh, and Jammu & Kashmir; Eastern Nepal includes the eastern and central development regions; Western Nepal includes the west, mid-west and far-west regions; the western mountains of Pakistan include Balochistan; and the northern mountains include the North West Frontier Province, Federally Administered Tribal Areas, and Azad Jammu and Kashmir.

Availability of Dung and Present Use

Studies in selected areas of the HKH have shown that the total dung produced would be sufficient to meet 35 to 64% of the total primary energy requirement in the different areas (Table 17.2). However, not all dung is physically available for energy production as most of the animals are not stall-fed. The common practice in mountain areas is to graze animals outside (pasture/grazing land, inside forests, in open spaces, and sometimes on fields with no crops growing), thus dung is scattered in open spaces and not easily available, although in areas where there is a high demand for dung for fuel, low-income households do collect dung from the fields. It is thought that overall 60% or more of the dung produced is effectively available for use. The primary use of dung is for farmyard manure, but because of the decreasing availability of fuelwood and twigs, an increased amount is being used for cooking.

Table 17.2: **Dung production and its present use in selected areas of the HKH Region, FY 1994/95**

	Total dung production (GJ per capita)	% of total primary energy requirement
Nepal	7.5	59
Uttaranchal, India	7.0	41
Himachal, India	9.3	35
Bhutan	7.2	64

Note: Based on Livestock Data from the Agricultural Sector Database prepared by MFS, ICIMOD

Table 17.3: **Dung availability in selected areas of the HKH Region, FY 1994/95**

	Dung availability per capita (kg per year)
Nepal	689
- Terai	543
- Hills	794
- Mountains	938
Uttaranchal, India	645
- Low Hills	372
- Mid Hills	798
- High Hills	946
Himachal Pradesh, India	849
- Low Hills	733
- Mid Hills	981
- High Hills	602

Source: Rijal 1999

There is a substantial variation in dung availability among the different agroclimatic areas in the HKH region (Table 17.3). Dung availability per capita is generally, if not always, higher in mountain areas than in the Terai or the hills. In most places, the availability of dung per capita is decreasing, however, as the human population is growing faster than the livestock population. This is partly the result of the decrease in available fodder associated with deforestation as well as of lack of animal feed in remote mountain areas.

The percentage of dung used as fuel in some typical areas is shown in Table 17.4. The values indicate that the share of dung as fuel increases with a decrease in the availability of fuelwood. For example, the share of dung is about 16% of total energy consumption in eastern Nepal compared with 5% in western Nepal, where the per

Table 17.4: **Percentage of dung used as fuel in selected areas of the HKH region**

	Per cent of dung used as fuel
Eastern Nepal	16
Western Nepal	5
Uttaranchal, India	8
Himachal, India	6

Source: Rijal 1999

capita area of forest is more than three times higher (Table 17.1).

Figure 17.2 shows a diagrammatic representation of the trends over time in the availability of fuelwood and animal dung, the forest area, the human population, and the total energy requirement in the mountain areas of the HKH. There is a clear need for a properly designed intervention package to avoid the development of a big energy deficit and the concomitant problems both for people and the environment. Wide-scale introduction of biogas technology could be one of the options, however there is a need first to adapt the technology to make it a feasible option in the higher altitude mountain areas.

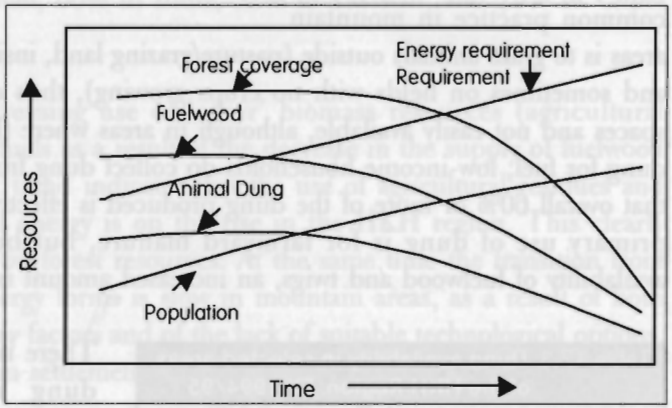

Figure 18.2: **Trends in resource availability in mountain areas of the HKH**

Technological Options for Providing Energy in Mountain Areas

Given the reduction in the traditional sources of fuel for energy and the increase in energy requirements in mountain areas, it is necessary to consider alternative means of energy supply. In general, decentralised energy systems offer an advantage compared with centralised energy options, given the nature of the energy services required and the remoteness of the areas. There are a variety of renewable energy technologies (RETs) available that could be considered based on the area-specific availability of energy resources and energy services. These include mini- and micro-hydropower, various solar technologies, and biogas production – the option considered here.

Biogas technology provides a way of meeting the fuel requirements of mountain communities without losing the benefits of farmyard manure; it obviates the problems associated with the competing use of animal dung for farmyard manure and fuel. At the present levels of dung production per capita (Table 17.2), more

than 25% of the total energy requirement could be met from biogas. Not only is the fertiliser value of the dung retained, the slurry from biogas plants can actually be superior to farmyard manure (IT 1979; Rijal 1998), and the slurry can be used to enhance the composting of dung and agricultural residues.

Biogas technology

Biogas is produced by anaerobic digestion of organic wastes and water, thus an airtight digester is a prerequisite. The digestion process ferments the organic materials in the presence of a natural mixed bacteria culture and produces gaseous products and a liquid effluent. The gas consists of a mixture of methane (50-60%), carbon dioxide (30-40%), and other gases including hydrogen, nitrogen, and hydrogen sulphide. Biogas is colourless and non-toxic but the hydrogen sulphide gives it a slightly pungent smell. The yield rate of biogas is temperature-dependent, the optimum temperature being 33°C. The gas is mainly used for cooking and lighting and sometimes as a fuel for internal combustion engines. The mixing ratio of diesel to biogas is theoretically 20:80, although users frequently report a ratio of 40:60. The effluent is used as a wet or sun-dried fertiliser and has a better nutrient content than green manure. The digestion process reduces the level of pathogens within the dung and may therefore generate public health benefits (Rijal 1998). The two main types of biogas plant are the floating steel drum (Indian design) and the fixed dome model (Chinese design) (Rijal 1998).

The drum type consists of a two-chamber underground digester pit with a floating steel drum gasholder. Slurry is fed into the base of one chamber from the cemented inlet pipe. The gas rises and is collected inside the drum, the effluent overflows into the second chamber and the slurry is expelled through an outlet pipe which is at a lower level than the inlet pipe. The design was modified by the Khadi and Village Industries Commission (KVIC), India, to suit Nepalese conditions. In the modified design the pit is designed to taper down into the ground; gas is removed through a central guide pipe; and there is a two-compartment chamber design. The floating drum holds 60% of the daily rated gas output. The gas pressure, which is supplied by the weight of the drum, is 10 cm of water head. The gas drum has to be prefabricated in a workshop and carried to the plant site.

In the fixed roof or dome type model, the steel drum is replaced with a cement dome. As the gas forms, it pushes the slurry down forcing it into the input and outflow chamber. When the gas is used the pressure diminishes and the slurry flows back into the main pit. The plants have been modified slightly for use in Nepal. The major modification is the introduction of a fixed stirrer which breaks the crest on the surface of the slurry in the plant and thereby maximises gas production (Rijal 1998).

This model can be constructed at the site with locally available materials, except cement and GI pipe, so at present 80% of the biogas plants in Nepal are dome type (van Nes and Lam 1997).

After the biogas plant is installed, the owner has to feed the digester with the required quantity of dung and water. The dung is collected from the livestock stall and poured into a dung mixing pit. An equal amount of water is added and the two mixed by hand or foot until no lumps are left, since the pressure of lumps could reduce gas production. Continuous feed type plants need to be fed daily with the amount of dung and water required for the particular capacity. In general, approximately two buffaloes or three cows produce sufficient dung for a four cu.m biogas plant, which produces sufficient gas to fill the cooking needs of an average (six person) family.

Technological innovations for biogas plants to be used in mountain areas

Biogas plants with a metal gasholder (Indian type) are not suitable for mountain areas because of the high transportation cost involved. In contrast, fixed dome biogas plants (Chinese type) can be constructed in inaccessible hill areas. The masonry dome lies below the soil surface, which helps reduce temperature fluctuations within the digester. Dome type biogas plants can be found operating in hill areas up to 1,500m.

At higher altitudes, where the temperatures are lower, it is necessary to develop some method of temperature enhancement to ensure that a suitable temperature is maintained inside the biogas digester. This is a prerequisite to popularising biogas plants in the mountains (Dhar and Sharma 1987). An attempt has already been made in China where there are a number of biogas plants operating in low temperature conditions in which animal excreta is mixed with hot water prior to being fed into the digester (Monga and Lakhanpal 1988; Monga and Ramana 1992).

There are several possibilities for enhancing the temperature inside the digester. Some of the suggested modifications are shown in Figure 17.3. Firstly, the biogas digester pit can be insulated using locally available materials (such as agricultural or plant residues) packed in plastic bags so that the desired temperature can be maintained inside the digester without fluctuation.

Secondly, construction of a solar greenhouse on top of the dome structure would help to increase the temperature of the digester. It could have the added advantage of helping farmers diversify the production of cash crops.

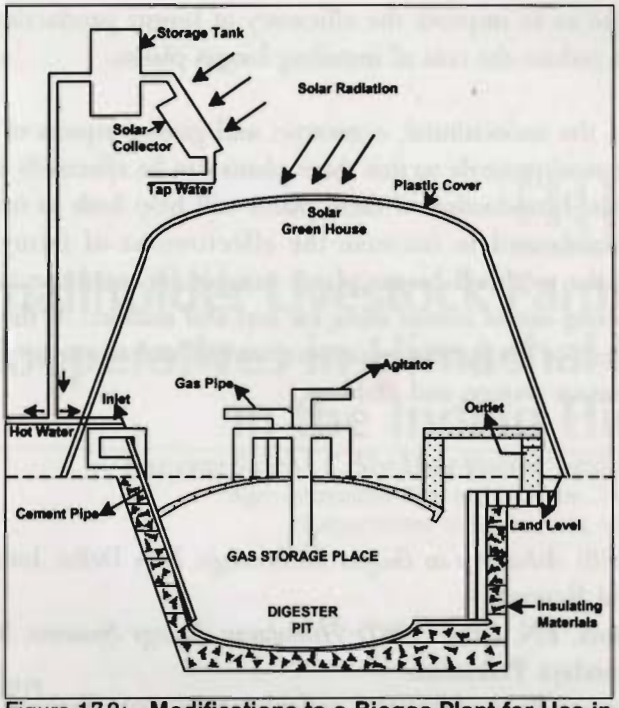

Figure 17.3: **Modifications to a Biogas Plant for Use in Mountain Areas**

Thirdly, mixing the dung with hot rather than cold water would enhance the temperature inside the digester. Hot water could be obtained by installing a solar water heater (which are relatively inexpensive) and/or burning a small amount of biogas. Mixing of some of the slurry coming out of the biogas plant with the input material would also help to enhance the temperature.

These are a few of the modifications that could help maintain the desirable temperature within the biogas digester. Which are needed and the extent would depend primarily on the temperature profile of the specific location. In cold climatic conditions, all of these suggested modifications may be necessary, whereas in other places one or two modifications could be sufficient to attain the desired temperature.

Future Research Agenda

There is a need to carry out on-site research and demonstrations in selected mountain areas to examine the suitability of the various options suggested for biogas technology. A field demonstration should be carried out on the manure value of the slurry so that the beneficiaries can derive maximum benefit from the organic manure. The type of biogas plant linked to a sanitary latrine should be demonstrated and promoted to improve the hygiene in mountain households. R&D activities should

be strengthened so as to improve the efficiency of biogas production under cold conditions and to reduce the cost of installing biogas plants.

At the same time, the sociocultural, economic, and gender aspects of biogas plants need to be understood properly so that these plants can be effectively popularised in the mountain areas. Introduction of these plants will help both to meet the energy needs of households and to increase the effectiveness of farmyard manure. Popularisation of the modified biogas plants suitable for mountain areas will help reduce the competing use of animal dung for fuel and manure. At the same time, it will also help to reduce the increasing pressure on hill and mountain forests and the drudgery of mountain women and children.

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Chapter 18

Smallholder Livestock Farming and Milk Cooperatives in Himachal Pradesh in the Indian Himalayas

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Introduction

In the western parts of the Indian Himalayas, where industrialisation is low and the farm sector is the major employer, the question raised is whether the farm sector alone will be able to absorb the growing labour force and provide a satisfactory income and standard of living to the local people. It has been asserted that there are still ample opportunities to generate more income and employment within this region through diversification and balanced integration of rural activities. The possession of livestock is the largest productive asset in rural areas. The already small landholdings in the region are fast becoming even smaller because of subdivision in response to the increasing population. In such a situation animal husbandry, which largely depends on common property resources, helps to supplement farm income. Livestock are not only direct providers of products like milk, meat, and wool, they also play a vital role in the development of agriculture. In the hilly areas of Himachal Pradesh (HP), one of the mountainous states in the Indian Himalayas, livestock are the main source of energy for ploughing and transportation, as well as of fertiliser in the form of manure. Therefore, keeping of livestock is common to all farming systems in the area. The poor crop productivity, low availability of arable land per capita, substantial availability of common property grazing lands, and lack of other income-generating activities have made the rearing of milch animals an economic compulsion. Besides the small investment, there are other factors, such as regular cash income and employment which have prompted all categories of farmers (marginal, small, and medium) and even agricultural labourers (the weaker section

of society) to supplement their incomes through livestock rearing as a subsidiary occupation. Animal husbandry contributes 10 to 32% of total household income in the different agro-climatic zones in the state.

Despite many development efforts, the livestock sector in hilly areas still suffers from inefficiency and underdevelopment. This paper analyses various aspects of the adoption of dairy farming by Himalayan farmers. It touches upon the following: farm size and livestock composition in different agroecological zones of HP; the dairy livestock population and production and contribution of livestock to household income; the role of infrastructural development in commercialising the dairy sector; the milk marketing system in the state, milk marketing costs, and price spread; reasons for the success and failure of farmers' milk cooperative societies; and some policy implications.

Livestock Farming in Himachal Pradesh

Farm size and composition of livestock holdings

Himachal Pradesh has four distinct agro-climatic zones differentiated by altitude (Table 19.1). More than 80% of landholdings are of small (1-2 ha) and marginal (<1 ha) size. The composition of livestock holdings in the different zones differs somewhat as a result of the differences in climatic conditions and availability of fodder. The values for different species for 1972 and 1992 are shown in Table 18.1. Traditionally cows are the predominant bovines because of the extensive grazing lands available in hilly areas. More recently there has been a trend in low and mid hill areas to substitute buffaloes for cows because of their higher milk productivity. Between 1972 and 1992, the total livestock population increased in all zones except the 'high hill wet zone', but the proportion of cattle decreased slightly and that of buffaloes increased. The average annual growth rate of the buffalo population was 2% in the low hills and 1.1% in the mid hills, compared with 0.3% and 0.2% for cattle.

Dairy livestock population and milk production

Cows and buffaloes are the main milch animals in HP; they contribute about 96% of the total milk production in the state. Table 18.2 shows the number of milch animals (cows and buffaloes) in HP in 1982 and 1992 by type. In 1992, 40% of the total milch population (cows and buffaloes) were over three years old. Sixty per cent of milch animals were cows, but most of them were indigenous breeds, only 17% of cows (10% of all milch animals) were crossbreeds. However, the number of crossbred cows increased at an average rate of nearly 17% per annum over the ten-year period.

The percentage of milch animals in lactation during different seasons is shown in Table 18.3, and the average daily milk yield for the different types of animals in

Table 18.1: Livestock composition, population density, and growth rates in different zones of Himachal Pradesh

	Low hill zone	Mid hill zone	High hill wet zone	High hill dry zone	Total state
Altitude (masl)	350-650	650-1800	1800-2000	2000-3500	350-3500
Human population per sq.km (1991)	225	194	128	40	153
Average farm size (ha)	2.2	2.2	1.0	1.3	1.2
Total geographical area ('000 sq.km)	14.3	5.6	3.0	10.6	33.5
Land Area* (% of total)					
Forests	29	27	25	27	28
Pastures	17	31	42	63	36
Cultivated land	24	24	20	4	17
Not available for cultivation	20	7	7	5	12
Livestock Population (total numbers in millions)					
1972	2.22	1.19	0.49	0.72	4.62
1992	2.36	1.26	0.44	0.76	5.09
Livestock Composition in1972 (%)					
Cattle	45.5	54.2	47.5	28.7	45.3
Buffaloes	20.3	5.7	1.0	2.9	11.8
Sheep and goats	33.5	39.5	50.9	66.8	42.1
Other	0.7	0.6	0.6	1.6	0.8
Livestock Composition in 1992 (%)					
Cattle	39.3	53.1	53.0	28.3	42.3
Buffaloes	22.5	6.4	1.3	3.1	13.8
Sheep and goats	37.4	39.8	44.9	66.6	43.0
Other	0.8	0.7	0.8	2.0	0.9
Annual Growth Rate (1972 to 1992) (%)					
Cattle	0.3	0.2	-0.1	0.2	0.2
Buffaloes	2.0	1.1	0.3	0.6	1.8
Sheep and goats	1.2	0.5	-1.0	0.2	0.6
Other	2.8	2.8	3.2	2.3	2.7
Total	1.0	0.4	-0.5	0.3	0.6
Animals per sq.km of Forest and Pasture Land (1992)					
Cattle	139	178	99	20	88
Buffaloes	74	21	2	2	28
Sheep and goats	37	39	25	13	25
Other	4	2	2	2	2
Total	254	240	128	37	143

*Minor categories of land use like wasteland and fallow not shown

Sources: Directorate of Economics and Statistics, Directorate of Land Records, and Directorate of Agriculture, Himachal Pradesh, Shimla

Table 18.4 (in 1997/1998). The overall lactation rate of crossbred cows was much higher than for indigenous cows, 74% compared with 55%. The crossbred cows in lactation also gave twice as much milk per day as the indigenous cows, 3.2 litres compared with 1.6 litres. Thus, overall, crossbred cows gave nearly three times as much milk per day per animal as did indigenous cows. Buffaloes had a lactation rate of 66% and a milk yield per lactating animal of three litres per day. Thus the overall production per animal per day was somewhat less than for crossbred cows, but more than twice as much as for indigenous cows.

Table 18.2: Productive and unproductive milch animals in Himachal Pradesh					
Milch animals	1982		1992		Growth (% per year) 1982-92
	Number '000	% total	Number '000	% total	
Cows	623	61.8	648	59.7	0.4
a) Crossbred	42	4.2	112	10.3	16.6
In milk	29	2.9	84	7.7	18.5
Dry	13	1.3	28	2.6	12.0
b) Indigenous	581	57.6	536	49.4	-0.8
In milk	308	30.6	301	27.8	-0.2
Dry	272	27.0	235	21.6	-1.4
Buffaloes	386	38.2	436	40.3	1.3
In milk	221	21.9	300	27.7	3.6
Dry	165	16.4	136	12.6	-1.7
Total Milch Animals	1008	100.0	1084	100.0	0.8
Milch Animals That Have Not Calved					
Cows, crossbred	5.6	5.7	10.4	9.6	8.4
Cows, Indigenous	64.9	65.8	65.8	61.1	0.1
Buffaloes	28.1	28.5	31.6	29.3	1.3
Total	98.6	100.0	107.8	100.0	0.9

Table 18.3: Percentage of milch animals in lactation (1997/98) (%)			
Season	Cows		Buffaloes
	Crossbred	Indigenous	
Summer	73	55	69
Rainy Season	75	51	63
Winter	74	59	67
Overall	74	55	66

Table 18.4: Average daily milk yield (1997/98) (litres per day)				
	Cows			Buffaloes
	Crossbred	Indigenous	Difference (%)	
Lactating animals	3.2	1.6	206	3.1
All milch animals	2.4	0.9	278	2.0

The annual milk production in HP is rising continuously, mainly because the number of animals is increasing, but to some extent as a result of the increase in milk productivity with the trend towards more crossbred and improved breeds of animal. The annual gross milk production in the state increased from 0.4 million tonnes in 1984/85 to 0.7 million tonnes in 1997-98 (Table 18.5). The proportion of total milk contributed by cows and by goats increased slightly during this time, and the proportion from buffaloes went down.

Although the population increased, the amount of milk produced increased even more so that the amount of milk available per capita from within the state increased, from 1/4 to 1/3 of a litre per person per day. Even so, of the total milk sold from formal sources only 31% came from within the state. The amount of milk marketed

Table 18.5: **Annual milk production in HP and share of different milch animals in the total**

Year	Total milk production (million litres)	Percentage share			Milk availability per capita (l per day)
		Cows	Buffaloes	Goats	
1984/85	403	41.1	56.5	2.5	0.24
1985/86	431	41.1	56.4	2.5	0.25
1986/87	459	40.5	56.8	2.7	0.27
1987/88	478	39.5	57.8	2.7	0.27
1988/89	500	43.7	53.2	3.2	0.28
1989/90	529	45.8	52.7	1.6	0.29
1990/91	573	45.0	52.5	2.5	0.31
1991/92	597	44.4	52.2	3.4	0.32
1992/93	610	42.7	52.4	4.8	0.32
1993/94	554	42.5	52.8	4.7	0.34
1994/95	663	45.8	50.0	4.2	0.34
1995/96	676	44.8	51.0	4.3	0.34
1996/97	698	46.3	49.1	4.6	0.34
1997/98	714	43.5	50.4	6.1	0.33

formally in 1997/8 from different sources is shown in Table 18.6. The Himachal Pradesh State Cooperatives Milk Producers Federation (MilkFed) procured 9 million litres of which 1.6 million litres was supplied to the National Milk Grid. The remaining amount met 31% of the total demand. The rest of the demand was met by purchasing milk from the neighbouring states of Punjab and Haryana, 33% and 19% of total milk demand from the Milk Federations of Punjab and Haryana, and the remaining 17% from private dairies in Haryana and Punjab. This means there is an in-state deficit of 69% of the milk sold through formal sources. However, it must be remembered that only a little more than 1% of all milk produced actually passes through these formal channels

The farm size also influences the composition of livestock holdings. Table 18.7 shows the number and type of livestock kept on different sizes of farms in different zones.

Table 18.6: **Milk marketing in Himachal Pradesh (1997/98)**

	Quantity million litres	% of Total
Procured by HP MilkFed	9.1	38.0
Processed and marketed by HP Milk Fed	7.6	31.5
Milk supplied by outside agencies		
-Punjab MilkFed/ unions	8.0	33.4
-Haryana MilkFed/ unions	4.5	18.7
Sub-total	12.5	52.0
Punjab/Haryana private dairies		
- Milk time	1.2	5.1
- Others	2.8	11.4
Sub-total	4.0	16.5
Total outside agencies	16.5	68.6
Total marketed	24.1	100

Table 18.7: Number and type of livestock kept on different sizes of farm in different zones in Himachal Pradesh

Zone/farms[1]	Oxen	Cows	Buffalo	Young stock	Sheep & Goats	Total (CEU[2])
Low hill zone						
Marginal farms	2.0	2.8	0.2	1.6	1.5	6.1
Small farms	2.1	2.8	0.8	1.4	6.4	7.7
Medium farms	2.6	3.0	0.9	3.8	6.1	9.6
All farms[3]	2.1	2.7	0.7	1.7	4.1	7.2
Mid hill zone						
Marginal farms	2.2	2.6	0.8	1.1	0.6	6.3
Small farms	2.2	2.2	1.1	1.3	0.7	6.3
Medium farms	2.9	2.2	2.0	1.3	3.0	8.3
All farms	2.2	2.2	1.0	1.2	1.1	6.3
High hill wet zone						
Marginal farms	-	1.5	-	0.8	-	1.9
Small farms	0.2	1.6	-	0.9	0.1	2.4
Medium farms	-	2.0	-	2.0	-	3.0
All farms	0.1	1.6	-	0.8	0.1	2.1
High hill dry zone						
Marginal farms	1.2	1.5	-	0.7	68.9	17.0
Small farms	1.9	3.8	-	1.6	79.7	23.4
Medium farms	2.0	5.1	-	1.5	126.4	35.5
All farms	1.5	2.7	-	1.1	81.9	21.1

[1]marginal farms <1 ha (64%); small farms 1-2 ha (20%), medium farms 2-4 ha (11%)
[2]cattle equivalent units –
one adult cow, bullock, buffalo, or horse = 1 CEU
one sheep or goat = 0.2 CEU
one young stock of cattle or buffalo and other animals = 0.5 CEU
[3]overall averages are weighted according to the number of farms sampled in each category

As expected, within each zone, more animals were kept on larger farms. On similar sized farms, the average number of animals per farm was lower in the mid hill zone than in the low hill zone, and lowest in the high hill wet zone. In the high hill dry zone, however, the economy is mainly pastoral with migratory animal herds, and the number of animals per farm in this zone (mostly sheep and goats) was much higher than in any of the others. Farmers who had a sufficient supply of fodder from crop by-products or other resources preferred to have stall-fed animals with a high milk yield.

Contribution of livestock to household income

In mountain areas livestock can help reduce income inequalities between small and larger farms. This is because livestock rearing in the mountains depends on open access to common property resources (CPR), which are relatively plentiful. The average income from livestock on farms of different size in different zones, and the proportion this represents of total income, are shown in Table 18.8. In most zones, marginal farms had nearly as many animals as small farms, and probably more per farm hectare, but even so the average per household income from livestock was

Table 18.8: **Income from livestock on different sizes of farm in Himachal Pradesh (IRs per farm)**

	Low hills		Mid hills		High hills wet zone		High hills dry zone	
	IRs	%	IRs	%	IRs	%	IRs	%
Marginal farms	1810	19	4240	41	6670	8	8120	96
Small farms	4800	44	4940	31	8370	7	9860	93
Medium farms	6440	30	8450	23	18380	7	15620	93
All farms	3350	30	5910	30	8010[1]	7	9900	95

Note: percentages denote the share of livestock income in total farm income
[1]the much higher overall income in this zone is the result of intensive apple production; the high income from livestock compared to herd size results from the increased number of crossbred cows and improved management practices

markedly lower as the animals on the marginal farms were of poorer quality (particularly in the low hills). The trend on larger farms is to keep fewer animals, each of better quality. These crossbred animals are more costly to buy and to maintain as they require higher doses of concentrate feeds and stall feeding because of their heavy build, which increases risk of slipping and death while grazing on slopes.

The costs of maintaining a buffalo, crossbred cow, or indigenous cow were estimated from data collected in a sample survey. The results are shown in Table 18.9. The net maintenance cost (cost minus the value of dung) was highest for buffalo, somewhat less for crossbred cows, and much lower for indigenous cows. Crossbred cows had a slightly higher yield than buffalo; local cows had a much lower yield. Buffalo milk commanded a higher price per litre because the percentage of fat is higher. Overall the average net return per animal per day was IRs 4.4 from crossbred cows, IRs 3.2 from buffalo, and IRs 0.8 from local cows, indicating that all other factors being equal, crossbred cows are likely to provide the best returns.

There is a need to augment the milk production on small farms. Development of a marketing infrastructure can play an important role in this. If the infrastructural facilities for milk marketing are increased in rural areas the cash flow on small farms will also increase as these farmers could start rearing livestock along commercial lines.

Table 18.9: **Economics of milk production in selected milkshed areas (IRs per day per animal in 1999)**

	Cows		Buffaloes
	Crossbred	Local	
Maintenance cost	35.6	9.4	44.0
Value of dung	4.0	1.6	6.7
Net maintenance cost	30.6	7.9	37.3
Milk yield (litres)	5.0	1.2	4.5
Cost of milk per litre (IRs)	6.1	6.3	8.3
Price of milk per litre (IRs)	7.0	7.0	9.0
Gain per litre (IRs)	0.9	0.7	0.7
Gain per day (IRs)	4.4	0.8	3.2

Role of Infrastructural Development in Commercialising the Livestock Sector

Infrastructural development stimulates and sustains the commercialisation of agriculture, and the commercialisation of agriculture enhances economic development. The infrastructure needed for agricultural development includes rural transport facilities, agro-processing and storage facilities, agricultural research and extension services, and institutions for marketing and credit. Infrastructural facilities affect the basic structure of agricultural production, marketing, and consumption in a variety of ways. The development of infrastructure accompanies the development of a market, and the development of marketing is accompanied by movements towards specialisation, division of labour, monetisation of the rural economy, and use of market-oriented inputs in farm production, all of which are characteristics of advanced agricultural economies. Without adequate rural roads, it is difficult to transport any perishable agricultural surplus to urban areas. Without some minimum level of agricultural infrastructure, efforts to stimulate more rapid increases in agricultural output such as milk production will be frustrated. Improved roads and transport facilities reduce transport losses and input costs of farms. Therefore, the transition of small farmer subsistence dairy farming to small farmer commercial dairy farming is inevitably linked with the development of infrastructural marketing facilities. By marketing we mean all those economic activities that are performed after the produce leaves the original point of production till it reaches the ultimate consumer. The efficiency with which the total marketing task is performed depends on how effectively the different marketing activities, when put together, merge into a total system.

In order to examine the marketing problems for dairy products, we need to understand the total marketing system and the operational characteristics of the system. In the following we describe the present marketing system in HP, including how much surplus milk is actually available on farms.

The Milk Marketing System in HP

A marketing channel is the sequence in which a product moves from producer to consumer through various intermediaries and functionaries in the market. Various middlemen and related agencies are involved in the purchase and sale of milk and its products as they move from producers to consumers. They buy and sell for their own gain. Milk wholesalers are the local buyers or rural assemblers who buy milk and its products from farmers in the producing area and transport the products to the large cities where they are sold to other wholesalers and processors who may handle many different or only a limited number of products. The retailer buys milk and its

products from a wholesaler for re-sale to the ultimate consumers. Wholesalers and retailers secure their incomes from the margin between the buying and selling prices. Milk processors and manufacturers primarily exist to process milk to another form (e.g., butter, ghee, curd, and khoya). They often act as their own agents in the milk producing areas and undertake the wholesaling of their finished products to retailers. Many milk processors attempt to reach the ultimate consumers through advertising.

Our field survey revealed that there are four types of milk marketing channel in HP: (i) producer - consumer, (ii) producer - other producer - consumer, (iii) producer – trader - consumer, (iv) producer- MilkFed - retailer- consumer. The way in which each of these functions is described below.

- Producer-Consumer — This marketing channel is the one most favoured by dairy farmers whose villages lie near to towns. Since there is no middleman involved, farmers receive the full price paid by the consumer. Milk is distributed door-to-door in the morning to a set number of households, and the payment is collected once a month. The animals are milked twice a day – morning and evening – and the evening milk is mixed with the morning milk before selling. Some farmers keep refrigerators for this purpose, while others just keep the milk overnight in a cool place. On average, each dairy farmer supplies 10-15 litres of milk per day to customers. The milk is carried from the farm in plastic cans carried in sling bags or haversacks. In most cases, farmers carry the milk by bus, but milkmen who do not have the means simply walk. In the morning and evening, public transport buses serve major villages near the periphery of cities to provide transport to daily commuters. Villagers who are employed in the city may also carry their farm milk for sale. The farmers have regular customer households to which they supply milk. If they have a shortfall of milk, they will purchase it from other farmers in the village in order to maintain the regular supply to their customers. Some of these milkmen also sell small quantities of fresh vegetables from their own farm to the milk customers. Households usually pay for milk on a monthly basis, but they pay directly for vegetables and other fresh farm products. During 1999 the per litre retail price of milk ranged from IRs 11-13 for cows milk and IRs 13-15 for buffalo milk. The per litre purchase price of milk in villages was about IRs 8 for cow's milk and IRs 10 for buffalo milk.
- Producer-Other Producer-Consumer — This channel is similar to the one above except that the milk vendor in addition to selling his own milk also buys milk from other producers who have a small marketable surplus which they don't find feasible to sell themselves, or from farmers with insufficient manpower available for marketing. Such milk purchases are normally paid for on a monthly basis.

- Producer-Trader-Consumer — In villages without easy access to urban areas, milk traders have become important. Farmers sell milk to a trader who in turn sells directly to consumers. This is the most common milk marketing channel in HP. Small milk producers bring their surplus milk to the nearest road where the trader waits. The milk volume is measured and the viscosity checked with a lactometer before the milk is transferred to a bigger container. The milk price is based on the viscosity. In 1999 the rates were IRs 6, IRs 7, IRs 8 per litre for average lactometer readings of 10, 15, or 20 respectively; and 9 per litre for a reading of over 20. The cow and buffalo milk is mixed and sold to the final consumer at IRs 12-14 per litre. Depending on the size of the business, a trader may hire one or two people to help. Payments are normally made to the farmers at the end of each month. However, traders may give an advance loan to needy farmers to purchase milch animals or cattle feed, or even for consumption. The advance is adjusted in the subsequent milk payments to the farmers. But traders are generally careful about advancing such loans and restrict the amount to a maximum of 70-80% of the monthly milk payment. After collecting milk, the trader carries it to town by bus or on a motorcycle. Milk is sold door-to-door to regular customer households and owners of teashops in the city. This method is popular in those villages that are far from urban consumption areas. Normally, each trader collects milk from 20-30 small dairy farmers and retails this milk to teashop owners and about 50-60 households. Traders generally handle 300-500 litres per day.
- Producer-MilkFed (through VDCs)-Retailer-Consumer — The Government of Himachal Pradesh has encouraged the formation of village dairy cooperative societies (VDCs) in order to provide an efficient marketing channel to small dairy farmers in areas where there is no marketing outlet. The dairy cooperatives are organised into primary milk producers' societies at the village level; these supply the milk to the Himachal Pradesh State Cooperative Milk Producers' Federation (MilkFed), which is responsible for milk procurement, processing, and distribution to urban centres. The VDCs aim both to help their members to increase their milk production and to arrange for the profitable sale of milk to consumers through MilkFed.

The MilkFed was established in January 1980 during the implementation of the Operation Flood-II Project in Himachal Pradesh on the 'Anand Pattern', which envisages developing the dairy sector through development of cooperatives in rural areas. MilkFed has established 3 dairy processing plants and 22 milk chilling plants in various parts of the state (Table 19.10). In 1997-98, MilkFed had 250 village dairy cooperatives through which 18,000 farmer members sold 9 million litres of milk.

Farmers bring milk to the VDC collection centre at a fixed time in the morning when the MilkFed vehicle arrives. The milk is measured and checked for viscosity before it

is accepted. The milk is transported to the nearest milk chilling centre and cooled so that it can be transported to the more distant dairy processing plant without the quality deteriorating. At the dairy plants, the milk is processed into pasteurised milk and ghee. The pasteurised milk (standard with 4.5% fat and about 8.5% solid non fat (snf), or toned milk with 3.1% fat and about 8.6% SNF) is packed in 500 ml and 1,000 ml polypacks which are transported to retailers for sale to the consumers. Chilled loose milk is also sold to consumers from mobile tankers at specified places and times in some cities and towns. About 10-15% of the total procurement is sold loose.

The total capacity of milk chilling plants in the state is 54,000 litres per day, but the average utilisation from 1994/95 to 1998/99 was only 24%, or 4.7 million litres per annum (Table 18.10). The total capacity of the three dairy processing plants in the state is 40,000 litres milk per day (15 million litres per year potential, compared with the 9 million litres actually processed in 1997/98). There is a difference between the amount of milk passing through the chilling centres and the total quantity handled by the processing plants. There are three main reasons for this: part of the total is

Table 18.10: **Capacity utilisation of milk chilling plants in Himachal Pradesh**

Location of plant	District	Year Established	Capacity l/day	Capacity utilisation					Average 1994-1999
				1994-95	1995-96	1996-97	1997-98	1998-99	
Mandi unit									
Bhambla	Mandi	1979	2,000	10.8	8.1	5.5	2.8	2.0	5.8
Sighyani	Mandi	1971	2,000	36.0	25.4	23.5	17.7	7.5	22.0
Kunnu	Mandi	1971	2,000	29.7	21.3	25.1	22.5	14.7	22.7
Kataula	Mandi	1971	2,000	15.9	12.0	10.6	11.3	10.2	12.0
Kotli	Mandi	1971	2,000	23.9	22.9	32.8	30.7	22.0	26.5
Bilaspur	Bilaspur	1980	2,000	21.4	17.4	15.4	23.8	15.4	18.7
Mohal	Kullu	1982	2,000	10.1	12.7	17.7	13.4	8.9	12.6
Kangra unit									
Milwan	Kangra	1977	2,000	30.1	20.6	15.2	17.4	16.3	19.9
Darkata	Kangra	1975	2,000	13.6	9.6	12.1	10.7	10.6	11.3
Raja-ka-talab	Kangra	1982	2,000	8.9	5.9	8.0	4.8	7.1	7.1
Bangana	Una	1980	2,000	2.6	1.4	-	3.4	4.0	2.8
Jhalera	Una	1978	2,000	7.9	4.8	6.5	12.1	10.9	8.4
Jalari	Hamirpur	1978	2,000	6.1	5.3	7.4	5.7	5.4	6.0
Chamba	Chamba	1980	2,000	4.3	3.9	8.3	6.9	6.8	6.0
Shimla unit									
Rajgarh	Sirmour	1970	2,000	72.6	70.9	93.2	99.5	75.3	82.3
Bagthan	Sirmour	1968	5,000	43.3	38.8	43.0	45.1	45.9	43.2
Sarahan	Sirmour	1972	4,000	23.4	22.7	26.2	27.1	25.2	24.9
Renuka	Sirmour	1980	2,000	39.2	33.1	31.5	29.0	27.5	32.1
Nahan	Sirmour	1970	5,000	1.5	15.2	21.8	28.2	35.0	20.3
Maryog	Solan	1970	2,000	12.9	13.6	16.5	14.8	12.4	14.0
Nalagarh	Solan	1974	2,000	6.5	4.0	3.3	5.4	1.8	4.2
Kepu	Shimla	1986	4,000	67.4	67.6	50.5	51.3	56.5	58.7
Total/average			54,000	22	18	24	24	23	24

toned milk, which is prepared in part from reconstituted powdered milk; the quantity of milk is increased by diluting to achieve the appropriate fat concentration; and the packed milk from Punjab traded by MilkFed is included in the total quantity handled.

Milk marketing cost and price spread

Marketing of milk effectively costs nothing except time when the producer sells to the consumer direct from the farm. If a farmer sells milk at a local market there will an additional marketing cost for transportation. If there are middlemen involved between the producer and the consumer the marketing costs will increase accordingly. Normally market middlemen (functionaries or institutions) move commodities from producers to consumers. Every function or service involves a cost. The intermediaries or middlemen must meet the cost of the functions they perform and also make a profit. The actual marketing margins vary from producing point to producing point, commodity to commodity, marketing channel to marketing channel, market to market, and over time.

The price spread is the difference between the price paid by the ultimate consumer and the price received by the producer. It normally reflects the extent of the services given and their costs, for example the cost of labour, transportation, equipment, spoilage, and the degree of risk involved in marketing.

The price spread and marketing margin for milk sold off-farm were estimated from a field survey performed in 1999. The results are shown in Table 18.11. The producer's share in consumer's money was highest, 85%, when milk was sold direct to the consumer. The producers had a slightly higher share in consumers' money

Table 18.11: **Price of loose milk marketed through different channels (IRs per litre)**

	HP MilkFederation		Through Traders		Direct Sale	
	IRs	%	IRs	%	IRs	%
Price per litre received by producer	7.1[1]	64.6	7.0	58.3	11.0	84.7
Costs incurred for						
- Transportation	1.8	15.9	0.2	1.5	0.7	5.0
- Chilling	0.4	3.7	-	-	-	-
- Handling[2]	0	0	0.3	2.5	1.3	9.6
- Other	0.2[3]	1.9	0.2	1.8	1.1	0.7
Sub-total	2.4	21.5	0.7	5.8	2.0	15.3
Margin/profit	1.5	13.9	4.3	35.9	-	-
Consumer price	11.0	100	12.0	100	13.0	100

[1]A coop commission of 2 paise per litre has been deducted calculated on the basis of fat and snf percentage

[2]Handling charges cover the cost of door-to-door distribution of loose milk, not applicable to MilkFed as consumers come to the parked tanker to purchase milk

[3]Includes 3% of the value of milk given as bonus to cooperative by federation

(66%) following sale through MilkFed than sale through traders (58%), mainly because MilkFed charged the consumers less. The costs incurred by MilkFed for transportation, chilling, and handling of milk accounted for 22% of the consumer price, whereas the costs incurred by traders (transportation, handling, and other expenses such as depreciation of utensils) were only 6% of the consumer price. Although the milk isn't chilled, the spoilage costs for traders are low because the milk is delivered directly to the consumers. The profit margins for MilkFed and traders were 14 and 36% respectively. If MilkFed had charged the same price to the consumer as the traders, its profit margin would still have been only 20%. The costs of marketing incurred by MilkFed are much higher than those incurred by the traders or producers.

The urban milk market in HP is highly competitive as packed milk is also supplied from public and private milk plants in the neighbouring states of Haryana and Punjab. For this reason, standard prices are fixed by the dairies in the three states for all brands of marketed milk. The retail price of standardised milk in 1999 was US 36 cents (IRs 16) which is higher than the price of loose milk sold by MilkFed and private traders. The costs involved in marketing toned milk are shown in Table 18.12. Toned milk is sold at IRs 12.5 per litre. MilkFed's total cost of production is IRs 13.85, a net loss of IRs 1.35 per litre. This loss is the result of the low volume procured and processed and thus under utilisation of the plant capacity leading to a higher processing cost per litre of milk. The cost of establishing the plant is the major cost item per litre in processing, 23% of the total.

Table 18.12: **Costs involved in marketing of packed toned milk in Himachal Pradesh (1999)**

	IRs/litre	% of consumer price
Procurement price	6.50	52.0
Transportation	1.20	9.6
Processing	0.62	5.0
Packing	0.45	3.6
Marketing	0.34	2.7
Establishment	2.89	23.1
Administration	0.39	3.1
Repair and maintenance	0.18	1.4
Interest	0.54	4.3
Depreciation	0.24	1.9
Retailer margin	0.50	4.0
Total cost	13.85	110.8
Consumer price	12.50	100.00
Federation margin/loss	-1.35	10.8

Source: Himachal Pradesh MilkFed, Totu, Shimla

Reasons for the Success and Failure of Dairy Cooperatives

Small dairy farmers' problems can be solved by helping them increase their milk production and providing a remunerative market. Small farmers are mostly poor: they don't have assets, are not organised, and don't have sufficient skills. Since small dairy farmers are not organised, middlemen can exploit them and take a big margin from the sale of milk. Dairy cooperatives can play an important role in solving this problem. As in other parts of the country, village dairy cooperatives have been organised in rural areas of HP under the programme of 'Operation Flood' with the aim of ensuring a remunerative market outlet to milk producers and ensuring a regular supply of milk to consumers.

Estimates by the Directorate of Animal Husbandry indicate that at present only 8% of the total milk sold is being collected by the dairy cooperatives. This means they still have a lot of scope to expand. There are 250 dairy cooperatives in HP, a quarter of which are non-functional. Cooperatives fail for a number of reasons, not least because when the principle of cooperation is applied (viz., management by members), vested interests can enter the organisations and turn them into footholds of power and prestige. The worst deficiency in the cooperative movement in HP is inefficient management. Other problems include lack of a proper policy for credit, irregularities in granting loans and maintaining accounts, and lack of trained staff.

The key to the success of dairy cooperatives lies in ensuring sound business practices, having competent managerial personnel, and systematic training of members and office bearers of the cooperative institutions. In addition to organisational factors, business environment factors such as government policies, the presence of competitive organisations, and the attitude of people towards cooperatives, are equally important in making the dairy cooperative society a successful venture.

Despite the failure of so many, most of the remaining dairy cooperatives in HP are functioning well, but some have serious problems. We compared a functional and a non-functional dairy cooperative to discover the factors that can make a particular society a success or failure.

The Tonda village dairy cooperative, in the milkshed area of Rajgarh town MCC in Sirmour district, was selected for detailed study of a successful cooperative. This cooperative is 54 km from the next town and has 85 members who supply 300 litres of milk daily to the VDC (MilkFed). The benefits of the VDC as perceived by its members are summarised in Table 18.13. The most important factor was the timely and regular procurement of milk, followed by the fact that any quantity of milk,

Table 18.13: Perception, satisfaction, and suggestions of members on the functioning of Tonda village dairy cooperative

Working of coop as perceived by its members	% of members	Reasons why members are satisfied with its performance	% of members	Improvements suggested by members	% of members
Timely and regular procurement	90	No other alternative	90	Increase milk price	96
Small quantities also accepted	78	Availability of cattle feed, fodder seed	80	Cash advance facility	87
Provide cattle feed and fodder seed	72	Fair dealing	72	More cattle feed	83
Procurement of milk at convenient point	57	Honest and hard working officials	58	Organise dairy awareness camps in villages	70
Assured and timely payment	54	Milk price on basis of quality	48	Evening milk collection	68
Equal treatment to all members	46	Training for dairy farming	10	Special rebate in snf level for fixing milk price	66
Correct measurement of fat and solid non fats	30			AI and veterinary facilities	61
Training in dairy farming	10			Better pay for secretary	28
				Timely collection of milk	16
				Reduce transportation cost	12

however small, is accepted by the cooperative, thereby safeguarding the interests of very small dairy holders. Other factors included the provision of cattle feed and fodder seeds, and the collection of milk at a convenient point. The main factors that contributed to members' confidence in the dairy cooperative are shown in Table 18.14. Assured payment, regular purchase of milk, and the fact that there was no better alternative were the most important reasons, but honest officials were also a major reason.

Table 18.14: Reasons given by members for staying in the dairy coop

Factors that make members stay in coop	%	Features that can make members stay even if other marketing agencies offer better facilities	%
Assured payment	90	No other alternative as other agencies don't buy very small quantities	65
No better alternative	87	Other organisations offer facilities for short time only	50
Regular purchase of milk	80	Democratic organisation	12
Honest officials	52	Coop help in area development	10
Democratic organisation	41		
Small quantities accepted	38		
Lack of time	27		
Federal officials help in getting loans for milch animals	18		

The Gaura village cooperative, five km from Maryog MCC, was selected for detailed study as an example of a non-functional dairy cooperative. The cooperative society was established in 1985 and had 40 members who supplied 300 litres of milk daily. It ceased to function in 1997. The main reasons given by members for leaving are shown in Table 18.15, together with a list of the conditions that would encourage them to rejoin. The most important reasons for the failure were late and irregular payments to farmers, corrupt co-op officials, and the low price of milk. Some members reported that the cooperative was dominated by rich farmers who cornered the cattle feed and fodder seeds meant for distribution to members. If these conditions were reversed, the members would consider rejoining.

Dairy cooperatives are only popular in those areas where there are no other milk marketing channels. In areas where private marketing channels have emerged, the members have opted out of, or not formed, cooperatives. In peri-urban areas, small dairy holders prefer to sell milk directly to the consumers. This practice has been encouraged by cheap and dependable bus transport facilities and timely payment from the clients. In areas where the marketable surplus of milk is higher and towns are at a distance, milk marketing channels involving non-farmer milk-traders have emerged. These traders purchase milk regularly, offer competitive prices, and also provide loan advances to the suppliers of milk. The main reasons given for preferring to sell milk directly to consumers or to traders are summarised in Table 18.16.

Suggestions and Policy Implications

Proper breeding, feeding, and weeding out of livestock are lacking at present in villages and are urgently needed so that higher returns can be obtained from dairy

Table 18.15: **Reasons given by members for leaving, and considering rejoining, a dairy cooperative**

Reasons for leaving	%	Reasons for re-joining	%
Late and irregular payment	86	Increased price of milk	98
Corrupt coop officials	81	Honest and efficient officials	89
Low price of milk	78	Timely and regular payment	83
No incentives for good milk	55	Correct and regular measurement of snf and fat	75
No proper regular measurement of fat and snf	53	Increase in timely and sufficient supply of cattle feed	45
Dominance of rich people	43	Correct recording of milk quantity supplied	39
Desired quantity of cattle feed not available	40		
No correct recording of milk quantity supplied	35		
Bad behaviour of secretary	22		
No proper records of society maintained	19		

Table 18.16: **Reasons for selling milk directly to consumers and traders**

Reasons for selling milk directly to consumers	%	Reasons for selling milk to traders	%
Better price	100	No other agency	95
Near to town	100	Regular purchase	92
No fat/snf verification	96	Town far away	70
Cheap transportation available	85	Loan against milk	62
Timely payment	82	No fat/snf measurement	36
Permanent customers	60	Near to village	32
Old relationship with customers	30	Technical guidance from traders	9
Can sell vegetables to customers	15		
Advance can be obtained	7		

animals. Agro-forestry on degraded common land for soil and water conservation and to enhance the supply of green leaf fodder has yet to become popular. It is essential to train farmers in integrated dairy development. But there must first be a marketing channel for the extra milk produced. A milk marketing strategy should be developed for a cluster of villages before the producers are organised.

The issues in livestock planning and management include reducing farm income inequalities, improving the production efficiency of milch animals, improving the quality of animals, and meeting fodder needs without degrading the natural resources.

The higher growth rates observed in the number of buffaloes and crossbred cows indicate that farmers are choosing animals with higher milk yields and responding to the consumer's preference for high fat buffalo milk.

The most important difference observed between the successful and failed dairy cooperatives was accountability. To whom is the dairy cooperative accountable? Are its decisions mostly made in the interests of its members or are they shaped in response to government objectives and policies? Do cooperative officials mostly look down to their members or up towards higher officials? Do members see the cooperative as belonging to themselves or to the government? Many factors lie behind the failure of village dairy cooperatives. They include the fact that, because the majority of the farmers are less well educated and have small landholdings, the cooperatives can become dominated by rich aspirants for political power; that there is no genuine cooperative leadership; and that the cooperatives have become a government movement without much scope or incentive to survive and prosper on their own. For a cooperative to be successful, it should be democratically controlled by its members and professionally managed with honest workers who pass on benefits to the members.

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Chapter 19

Gender Roles in Livestock Management: Experiences and Lessons from Projects in the African Highlands

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Introduction

Livestock were a key component in defining status in African communities before the coming of capitalism. Previously people held the mistaken view that "the importance of livestock reflects limited opportunities for cultivation, and rainfall is too unreliable to permit a pastoral economy" (O'Conner 1966). This mistaken view has led to a great dearth of information about livestock production and its importance in the way of life of most African communities. A close examination shows that livestock are considered very valuable; many grain producers regularly convert their grain into livestock, especially in times of uncertainty. Most communities that are able to raise cattle, camels, or goats do so to the fullest extent possible. Among East Africans wealth and cattle are interrelated as cattle represent money, as well as being used for subsistence, and are only slaughtered and eaten on special occasions.

This picture of the value of livestock is changing, however. The time has passed when livestock were used as currency with cattle constituting an almost exclusive hallmark of wealth. Modernisation has brought pressure to accumulate capital in the form of cash rather than livestock, and the pressure on land and the need to modernise agricultural production mean that livestock are no longer as highly valued as in the early part of the 20th century. The political structures have also had a negative impact on livestock ownership; capitalism insists on intensive production, and the time when livestock were kept for aesthetics is long past. Nevertheless, for rural communities, livestock are still very important for household income and wealth.

There are many rural development projects concerned with livestock and agriculture, but few focus on issues of gender and management of livestock, especially in mountain ecosystems. The way that societies construct roles around the biological differences between men and women affects natural resource management. Projects concerned with livestock rearing and general production rarely address the adaptations made by women, and in most cases it is assumed that it is the men who are conversant with the rearing of livestock.

This chapter describes some of the main observations made about gender roles in livestock management during the implementation of a gender and livestock project from the Intermediate Technology Development Group (ITDG), an international non-government organisation based in Rugby, UK, that operates all over the world. In Kenya (East Africa), ITDG is active among the Akamba of Machakos and Makueni Districts, the Adkars and Natoo of Turkana District, the Gabbara of Marsabit District, and the Samburu of Baragoi. Different aspects of gender relations in livestock management were noted in the communities in the project areas. The author describes the relationship to the different livestock roles allocated to men and women in these communities. Most of the observations were made in 1994 as a part of an ITDG project; a few were made in separate research programmes.

The ITDG Approach to Rural Development

In Kenya, as in the other countries where ITDG works, the main aims are as follow.

- To raise awareness of the constraints, inequalities, and vulnerabilities that exist among poor people
- To highlight the technological capacity of disadvantaged groups of people and to improve the use of technologies by giving these groups more control over their lives –thus helping them to contribute to the sustainable development of their communities
- To address women's vulnerability in terms of low socioeconomic status, less political representation, heavier work burdens as a result of arduous domestic tasks and responsibilities, and cultural and religious constraints
- To show that economic hardship and vulnerability severely constrain people's abilities to make choices in life, including technological choices; ITDG works towards enabling both women and men to have equal access to technological choices which could improve their lives
- To recognise that women as well as men have wide-ranging, but undervalued and often unrecognised, technical skills and capacity
- To recognise that violence against women is widespread and cannot be ignored; violence increases vulnerability and restricts women's capacity to choose

The fundamental approach used by ITDG recognises the fact that gender roles are not given but social and ascribed; but nevertheless, such roles may contribute to the relative disadvantage of one sex in relation to the other. Raising gender awareness of constraints, inequalities, and vulnerability where they exist, and highlighting the technical capacities of disadvantaged groups of people, will improve the quality of ITDG's work in all areas.

Internationally ITDG considers gender awareness as a key issue in planning and assessing development projects – a safeguard to ensure equal opportunities for all members of the community, in particular women, who are often marginalised. But are the programmes actually considering gender in all its aspects, or just focusing on the involvement of women? What are the benefits to a development programme of including gender analysis in its planning, monitoring, and evaluation programmes? Is it just a fad of the nineties? There are many answers to these questions, but one important point is that a project is likely to fail in its aims if it discriminates against a group of people who make up more than half the target population.

The ITDG country programme in Kenya has a commitment to gender awareness. By examining ITDG's Kenya projects closely, we hoped to find out how these translated into practice and to answer some of the questions posed above. In this way we hoped to come up with a methodology of approach that is more effective for assessment of progress. The observations reported here are the findings from different mountain communities.

Gender and Livestock Management

Gender and technology

Research has shown that specific spheres of activity become the specialised domains of different genders as they increase their knowledge and skill over time. As a result, knowledge and skills held by women often differ from those held by men. Although women's knowledge and skills dominate certain technologies, many women face barriers to the access and control of essential items (Grundin et al. 1994). Such factors must be taken into account in any consideration of the role of gender and gender awareness. It is not just a question of assessing the 'involvement' of women, but one of access, control, and benefit. The kinds of relationships that exist between men and women will affect hierarchies of access, use, and control, resulting in different perceptions and priorities for the innovation and use of technology by women and men.

The Turkana project

ITDG works with the Natoo and Ngisericho Adakars, two very mobile livestock communities in the north of Turkana in Lokitaung division. These communities

move according to water and pasture availability and the security situation. The main aims of the project are to improve food security, livestock productivity, and the self-reliance of these pastoral Turkana. As a part of this, the project looked at the implications of different types of work for all members of the community. The different roles associated with livestock were investigated to see whether men and women of all ages were involved in and benefited from all stages of the work in an appropriate manner.

The roles of both men and women in society were looked at before the project activities started. The assumption was that any involvement of people in development activities can result in a change in gender roles. Male elders have a strong authority and take the major decisions on the family and herding groups; although women still have a significant position within the society. Women have a clear voice as they are free to talk in front of men and be represented at the community 'tree'. This made it easier for ITDG to encourage an increased role for women in decision-making.

Turkana women play a key role in maintaining household food security. Each married woman is responsible for feeding the members of her day house or 'ekol' (i.e., children, husband, and dependants). She prepares, stores, cooks, and serves all food, whether animal products, or purchased or aid food.

Women play a significant role in the general management of livestock, although men maintain structural authority. Traditionally women tend to milk and water the animals and are solely responsible for the smaller ones. They are usually the first to notice sick animals, and then bring this to the attention of their husband or father.

Women are taking up new responsibilities as much as the men are, and are also very active once trained. Women have gained valuable skills. This has increased their status in the group, and some roles previously allocated to men have been released to skilled women (such as some initial treatment of livestock). As a result of the search for capital, many men have migrated to towns leaving women as the sole livestock keepers. Women have become responsible for animal health care, and are usually part of discussions about herd marketing and family labour. Even so, the study found that women have only a limited role in treating animals with modern drugs.

The Samburu Baragoi project: ethno-veterinary knowledge (EVK)

ITDG has been working with the Samburu in Baragoi since 1989. The original aims of the programme were to assist local pastoralists in animal health care strategies by working with livestock product marketing and improving animal health. Women and men were trained separately in animal health because it was found that their roles in day-to-day life were quite distinct.

The training programme began with a group of men, after which a group of women was trained with the agreement of the men. Training in the diseases of small stock was encouraged because of the frequent absence of men and 'morani' (the young male warriors) from households, which left women to cope with the health of the livestock. At first the men thought that women were not strong enough to carry out the heavier tasks such as holding cattle down for treatment, but women have been known to do such things in the absence of their male relatives.

Women now go to purchase drugs more often than men, and if they have been trained they take a more active role in animal treatment. They are often the first to notice sickness in an animal. Men and women will often diagnose together, but the man will usually make the final decision and supervise the treatment. However, the knowledge of a skilled woman who has received training will be respected, and her opinion will be sought. Some women are recognised to be experts in specific areas (e.g., birthing or retained placentas, or with small stock or cattle).

So far all the training in animal health has used local names and local understanding of treatment as a basis. There is an urgent need to record knowledge of traditional treatments of animal diseases (ethno-veterinary knowledge or EVK) before it is lost. Moreover this knowledge is still very much needed and used by the poorer members of communities who cannot afford 'modern' drugs.

The keepers (owners) of traditional knowledge in formal terms are male, however research in Baragoi has begun to look at the utilisation of EVK by different socio-economic groups, many of which include women. Women also have everyday knowledge of traditional treatments and herbs, although they might not be referred to as traditional healers. There is a difference between men and women in terms of knowledge and dispensation of treatment. Often men and women will have the same general awareness of diseases and basic treatments, but it is women who go to collect the herbs and grasses if they grow close by (if far away, the morani are sent) and then mix them (under supervision of the man). If the problem is serious, however, the man will treat the animal. Gender is therefore important in the analysis of EVK.

The Yaa Galbo of Marsabit Gabbra project

ITDG works with members of the Yaa Galbo clan in Marsabit Gabbra in a project called Decentralised Animal Health (DAH). This is an institutionalised service support for livestock health. Other areas of need are water supply and issues related to livestock product marketing.

Women are responsible for the house and home, and can sell milk products, but men are still in charge of any cash sales of animals or other products. In most

households, decisions on whether to sell, slaughter, consume, lend, or give an animal – and which animal – are usually taken jointly between the senior man and woman. Women are free to make decisions about veterinary matters in the absence of men. Men slaughter and skin the animals, but women are the butchers. Women also do the daily cooking and process meat into jerky and other products. A woman takes all decisions related to milk and to most of the meat and hides produced by the household. Women are generally considered to be more expert at milking (especially sheep); men are thought to be less patient and gentle. Gabbra women take most decisions related to small stock and consider that keeping such animals is the best way to meet their needs. They also need camels to carry water and to move house, and for milk.

Maasai housing

In this project it was clear that women's workload was increasing compared to that of men. Women said that men do less work now because they trade and visit town, whereas the women now herd as well. Some women who could afford it had even employed shepherds (younger men) to look after their herds while they were being trained or were working with the women's group. Women's daily tasks have increased

A typical day in the life of a Maasai woman
(without construction, building, or marketing activities!)

6.00	Wake up, make fire, put on tea to boil, milk cows
7.00	Drink tea and feed children, sweep home and wash dishes
8.00	Go to cattle enclosure and separate cows from calves, let cows graze
9.00	Return to sheep and goat pen and separate the goats from the kids
10.00	Prepare boiled milk and clean gourds; cook ugali and vegetables for family. Make beds, clean house
11.00	Walk to collect water (average five miles one way). Takes about two hours
2.00	Often very tired so may rest for half an hour, children return from school, eat lunch
2.30	Wash up and clean up again after lunch
3.00	Rush to collect firewood from nearby to keep up stock in house, and leave it to dry
4.00	Put tea on to boil again for the children and men, and prepare meat and milk for dinner
5.00	The goats and sheep come home, and are put with the kids and lambs
6.00	Separate goats from kids, and pen up separately. Calves come home
7.00	Cows come home, milk cows
8.00	Separate cows and calves
9.00	Eat dinner
10.00	Clean, wash up, put children to bed. Talk with husband
11.00	Go to bed

in number and duration with the changes resulting from settlement, and many of the women felt that they work much harder than in the past. During building and construction women have to shelve their traditional duties for another day, only ensuring that the essentials (water, cooking) are completed. They will then try to catch up on their tasks the next day, or ask their daughter-in-law to assist.

Farmers projects in Ukambani

ITDG has been working with poor marginalised farmers in Ukambani since 1988 in the more arid areas of settled farming where crop agriculture is not predictable and farmers depend much on livestock.

The main aims of the work in Ukambani were to

- understand the constraints for resource-poor producers of livestock,
- develop an appropriate and self-sustaining network,
- share information and knowledge with other similar groups,
- increase livestock productivity, and
- strengthen liaison between the 'wasaidizi' (assistant para-vets) and the community

In Ukambani both men and women participate in the rearing of dairy cows and goats. Generally it is men who have control of the money used to purchase livestock, i.e., goats and cows for breeding and initiating herds. This is because men control the money generally and are the ultimate owners of the livestock and the land on which the livestock are reared.

The most common practice for rearing livestock that the respondents knew about was extensive grazing. This involves taking livestock out to graze wherever pasture is found and bringing them home in the evening. The system is becoming increasingly less feasible since communal land is decreasing as a result of the main form of land tenure being individual with issuing of freehold titles. Nowadays, in most of Kola, only teenage children take livestock to graze extensively and only during the school holidays. Households that are members of a Konza group ranch also practise extensive grazing.

Tethering of livestock is another common feature of production management. This was more widespread among the farmers in Kola where many gardens were full of green crops than in Kathekani where very little cultivation had taken place. Tethering is meant to stop the animals from spoiling crops. Animals are usually tethered in an area where they are able to graze, they are moved to several locations or are provided with fodder where they are tethered. Some livestock were managed without any

grazing; fodder and water are brought to the animals, which are milked in the morning and in the evening.

Other production activities include dipping animals once a fortnight to prevent ticks. Both women and men farmers in Kola seemed to be well aware of dipping requirements and dipped their animals. This was not so in Kathekani, however. In principle, both women and men performed most of the activities for production. However, in practice in most of the households observed, the men had migrated to towns for off-farm employment and women performed most of the production processes alone.

In most households, men, when present, tended to avoid the most arduous and repetitive tasks such as milking and caring for sick animals. Women do most of these, yet they lack the necessary training and access to money to purchase the necessary materials. Men are very much in control of all transactions dealing with the sale of goats and milk, and have exclusive rights in the slaughter of goats.

There is an almost acknowledged law throughout Ukambani that women should never slaughter a large animal for whatever purpose. The society acts as a check to ensure that women dare not revoke this law. Women are, however, free to slaughter chickens, and they have full control of any money they obtain selling them.

Conclusions

Although women have knowledge and experience of almost all aspects of management of livestock, it is the men who have the upper hand in decision-making and control over household livestock resources. Equality of access to resources does not guarantee control over benefits, and this is one reason why development programmes need to be more perceptive in bringing about empowerment. Without equality of control, women are unable to benefit from the improvements from the development endeavour. A gender sensitive approach to the evaluation of livestock development programmes should help ensure equity.

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Chapter 20

Importance of Alpacas and Llamas in the Changing Context of Development Research

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Introduction

Lamoids (also called cameloids) are ruminants native to South America that belong to the same family as camels but are smaller and humpless. There are two domesticated species, the llamas and alpacas, and two wild species, the vicuna and guanaco.

Lamoids have played a critical role in the Andean agroecosystem ever since they were domesticated, at the same time as plants. In the cold Andean highlands and parts of the Pacific Coast, alpacas became the most important source of wool. Llamas, a secondary provider of wool, became the most efficient pack animal, facilitating transportation of goods over long distances. In traditional villages, both species are still a very important source of dung both for manure for agriculture and for fuel. Although meat has always been considered of secondary importance in the Andean diet, salted and freeze-dried lamoid meat is an occasional but important source of high quality protein.

Lamoid bones provide the main material for work utensils and beautifully crafted items, while sinews are turned into thongs. Lamoid lard, in addition to the health properties acknowledged in the rich Andean medical lore, played and plays an important role in religious ritual. Lamoid foetuses resulting from natural abortion – a common trait of South American lamoids (SALs) – are sold in rural markets and widely used in fertility rites. Similarly, stone formations in the SALs' digestive

system – bezoares – are considered to be charms and are believed to have magical properties.

Literature on the nutrition of llamas (*Lama glama*) and alpacas (*Lama pacos*) indicates that these animals are better adapted to the harsh environment of the Andean region than other domestic ruminants. With their outstandingly efficient digestive system, alpacas and llamas can survive on coarse native grasses, wire sedges, and rushes. Thus, in contrast to sheep and cattle, they require no pasture improvement or other modifications of the unique, high altitude environment. They even thrive on sites where phosphorus and copper are so severely lacking that sheep and cattle suffer from debilitating deficiency diseases.

Species of Lamoids

The llama (*Lama glama*) is the most cosmopolitan member of the SALs. Nowadays they are kept at elevations between 2,600 and 4,800 masl, and are found from south Colombia, to Ecuador, Peru, Bolivia, Chile, and Argentina. Alpaca (*Lama pacos*) rearing is restricted to elevations of 3,850m and above in Peru, Bolivia, and Chile. The zone of the greatest population and productivity lies along the Andean Cordillera between 11° S and 21° S. The number of these animals in different countries in South America is shown in Table 20.1. There are currently 6,500,000 in all; the largest number of alpacas are found in Peru and the largest number of llamas in Bolivia. Smaller populations are found in Chile, Argentina, and Ecuador, where alpacas have very recently been reintroduced, and there is a small population of llamas. Despite their relatively small numbers, domesticated lamoids play a significant role in the economy of the high Andean regions of Peru, Bolivia, Chile, and Argentina.

The two domesticated species and the two wild lamoids – guanacos and vicuna – are described in more detail below.

Table 20.1: **Estimated population of alpacas and llamas in the Andean region**

Country	Alpacas	Llamas
Argentina	400	135,000
Bolivia	324,336	2,022,569
Chile	27,585	70,363
Ecuador	2,085	9,687
Peru	2,900,900	1,006,574
Total	3,255,306	3,244,193

Source: Hoces 1997

Alpaca

The alpaca is smaller than the llama, has short and pointed ears, a woolly face, and a rounded rump. The average height at the wither ranges from 80 to 90 cm; adult males weigh from 55 to 60 kg and females 47 to 57 kg.

Centuries of selective breeding for wool quality (usually called 'fibre' to differentiate it from sheep's wool) have produced two breeds of alpaca, which are distinguished on the basis of their fibre characteristics. The Huacaya breed produces shorter crimped fibres that give the wool a spongy appearance resembling that of the Corriedale sheep. The wool of the Suri breed is characterised by long straight fibres arranged in locks that fall to each side of the body in much the same manner as those of Lincoln sheep.

There is a considerable variation in the quantity of fibre produced by the alpaca, from as little as 0.9 kg to as high as 4.0 kg per animal per year. The average fleece weight is 1.8 kg per animal per year in Huacayas and 1.9 kg in Suris. The average fleece fineness in different breeds of alpacas is 24 lm. The Suri breed is essentially found only in Peru and represents no more than five per cent of the total alpaca population.

As a result of the difficulty in separating multicoloured wool, breeding selection aims at solid colours. Pure white or light fawn are the most abundant colours in Peru (57%) and the most prized, but other colours such as brown, black, grey, and roan are also valued.

Llama

The llama is the largest of the four species. Males stand at about 1.05 to 1.10m and females 0.95 to 1.05m. The average body weight of the adult male ranges from 80 to 90 kg and that of females from 75 to 85 kg. The ears are long and curved and the face is free of wool, with a long, straight to slightly rounded, nose. The back is flat from the shoulders to the rump, ending in a tail that curls up and back. From the time of the Incas, llamas have been used as beasts of burden.

There are two breeds, the Pelada (also known as Kara or Lutica) and the Lanuda (also known as Chaku, Tajulli, or Tampully). Approximately 20% of animals are the 'intermediate type', that is the result of crosses between animals of both breeds. The woolly type or Lanuda has a thicker fleece all over the body, including the neck and proximal portions of the front and hind legs, with a slight crimp and uniform and soft-to-the-touch fibres. Recent studies reported that the average fibre diameter is 28.0 lm with a high coefficient of variation (43.5% - 57.7%). The fibre length varies

from 5 to 21 cm according to the time of growth. Traditionally, these animals are sheared every two years or at even longer intervals, but they can be sheared each year. The average fleece weight is around 1.3 kg per animal per year, but selected animals under good management conditions can produce 4.0 kg a year. The Kara has a less abundant fleece, especially around the face, neck, and legs. There are two easily identified layers of fibre: the 'undercoat' (or 'innercoat') formed by fine wool fibres of small diameter and length (average diameter 25 lm), and the 'outercoat' formed by a layer of longer coarse thick fibres (average fibre diameter 87.0 lm). The wool fibre fineness and length varies considerably. Generally these animals are sheared every three to four years, but annual shearing can produce 0.94 kg of wool.

Overall (both breeds) the fibre thickness ranges from 8 to 144 lm (a high coefficient of variation), reflecting the great variability that exists among different animals of the same breed and between animals of different breeds. This is the result of a lack of selective breeding and uncontrolled crosses between the two breeds (intermediate type). In both breeds, the coat colour can be white, brown (different shades), grey, or black. There is a high percentage of multicoloured animals – spotted or patched.

Vicuna

The vicuna (*Lama vicugna*) is a wild species and is the smallest of the SALs. It is only found in the puna life zone of the Andes, where it is most common at elevations of 4,200-5,200m, with a lower limit of 3,700m. At present, the northernmost distribution of the vicuna is 9°30'S in the department of Ancash, Peru, and the southernmost limit is 29°0' in the province of Atacama, Chile. There are an estimated 104,300 in Peru; 33,800 each in Bolivia and Argentina; and 19,800 in Chile.

The vicuna is a slim, elegant animal with a shoulder height of approximately 80 cm and an average body weight of 35 kg. The head is small with large black eyes, the neck is long and thin, and it has an extremely lively and agile nature. The fleece is characterised by a short growth of extremely fine wool (average thickness12 lm), cinnamon-coloured over the main body with white underparts. The vicuna has the unique characteristic of having a large hank of white fibre on the chest that is longer and much thicker than the fibres on the rest of the body. Its incisors continue to grow almost throughout its lifetime, another distinctive feature that enables the animal to eat tough forage plants that are rich in silicic acid as well as to take very small plants that are close to or lie directly on the ground. Apart from the distinctive teeth, the vicuna has other anatomical and physiological characteristics that enable it to survive in the inhospitable high altitude puna environment more successfully than any domestic animal. These include the extraordinarily fine and thick fleece, an

unusually low energy requirement, and the surprisingly high weight of newborn animals.

Guanaco

The guanaco (*Lama guanicoe*) is the other wild member of the SALs. It lives in a wide variety of wild habitats, unlike other SALs. It thrives from sea level up to 4,500m in both humid and arid zones. It is found in an area that extends from the northern part of Peru (8°S) through the pre-cordillera and coastal areas of northern Chile to Tierra del Fuego, the southernmost region of Argentina and Chile. The largest population inhabits the pampa, or cold steppe, where 'coiron' is the predominant vegetation. The greatest number are found in Argentina (estimated at 579,000) followed by Chile (25,000).

The guanaco is more or less the same size as the llama and weighs between 80 and 120 kg depending on the geographic subspecies, of which four have been described. All four subspecies have the same colour pattern, a light brown upper body, whitish underbelly, and blackish face. The guanaco has always been hunted for its meat and for the fur of young animals, called chulengo, which is mainly sold for export. In the adult animal, the fleece is composed of two layers: an internal or undercoat which is very fine and short; and an external or outer coat which is longer and coarser. Guanacos live in both migratory and sedentary groups. Family bands consist of one adult male and five to six adult females with their young; some occupy permanent territories that the male defends against all other guanacos. Young males unite into migratory troops of up to 50 individuals, but around 8% of the total population remains solitary, challenging the dominant males for control of their family groups and territories, especially during the breeding season. Guanaco populations have been drastically reduced since the arrival of the Spanish, and little has been done to protect this endangered species. It has been suggested that guanacos might be kept with sheep since most of their feed comes from browsing on stunted shrubs and thus there is no competition for grazing.

Genetic diversity

The South American domestic lamoids bred in different areas are sometimes given local names but most are not actually breeds. Recently, the genetic make up of South American lamoids from Bolivia, Peru, and Chile was studied in a survey. The breeds found in the three countries, their main regional names, and their percentage contribution to the total population in each country are summarised in Table 20.2. The survey drew the following conclusions.

- Chile has one breed of alpaca, the Huacaya, and two breeds of llama, the Lutica (or Pelada), and the Tajulli (or Lanuda).

Table 20.2: **Occurrence and regional names of the different breeds of alpacas and llamas**

Country	Alpaca breeds		Llama breeds	
	Huacaya local name	Suri local name	Pelada local name	Lanuda local name
Bolivia	Huacaya (nearly 100%)	Suri (a very few)	Kcara, K'ara (80%)	Tampulli, T'hampully (20%)
Chile	Huacaya (100%)	(none)	Lutica (60%)	Tajulli (40%)
Peru	Huacaya (95%)	Suri (5%)	Kara (80%)	Chaku (20%)

- Bolivia also has effectively only one breed of alpaca, the Huacaya, (although there are a very few Suri breed in the northern part of the country close to the Peruvian border), and two breeds of llama, the Kcara or K'ara (or Pelada) and the Tampulli (or Lanuda).
- Peru has two breeds of alpaca, the Huacaya and the Suri, and two breeds of llama, the Kara (or Pelada) and the Chaku (or Lanuda).
- Approximately 20% of the llamas in the three countries are 'intermediate breed or type', that is the result of crosses between animals of both breeds. In the survey, these animals were classified as belonging to the Pelada breed. There are no phenotypic intermediate types of alpacas.
- The predominant colour of alpacas is different in the different countries. In Peru, the most frequent solid colour (unicoloured) in both breeds is white, followed by different shades of brown, black, grey, and roan. Patched animals (with two, or very rarely three, colours) comprise 14% of the total population of both breeds. In Bolivia and Chile, the predominant colour is brown (in different shades), followed by black, white, grey, and roan. Patched animals comprise 18 and 14% of the populations, respectively. The grey colour (in different shades) is actually a mixture of white and black hairs in the fleece; the roan colour is a mixture of white and brown hairs in the fleece. The shade of grey or roan depends on the quantity of white hairs in the fleece.
- There is a similar variation in the colour of llamas. In Peru, the most frequent solid colour (unicoloured) is white (33%), followed by brown, grey, and black. Patched animals (two colours) comprise 31% of the total population. In Bolivia, dark colours, such as brown and black, are abundant, followed by white (11%) and grey (9.5%). In Chile, the solid white is the most abundant (12%) followed by brown and grey. Patched animals comprise 43% of the total population in Bolivia and 69% in Chile. In Bolivia, there is some variation in size, conformation, and fleece characteristics of llamas, but there are no types that are recognised as being distinct. The variation here is probably greater than elsewhere, but no local strains have been described.

Variation or genetic diversity is the raw material that the breeder has available for herd or flock improvement. Both heredity and environment are important in

producing differences among individuals, and in some cases this variation is the result of their joint action or interaction. By studying variation alone, we cannot determine which part is the result of heredity and which environment. The relative importance of hereditary and environmental influences in the variation of individual traits has been determined by other means in other domestic species, but not in alpacas or llamas.

Currently, most of the small herds of alpacas and llamas are kept by a single family of people, and male animals are used for years, with minimal or no rotation, leading to inbreeding and a reduction in genetic diversity, as well as other resultant problems. Overall. however, the Andean region contains numerous genetically different populations of alpacas and llamas, populations that have been geographically isolated, thus increasing the genetic diversity. Recently, renewed interest has been shown in the preservation of genetic variation in livestock. This has mainly come from the desire of breeders and geneticists to store the genes or 'germplasm' of minority breeds, some of which were on the verge of extinction. Germplasm can be stored in the form of semen (the haploid state), fertilised ova (the diploid state), or live animals kept at zoological gardens, in National Parks, on privately-owned game ranches, or elsewhere. In Peru, we know of at least three state farms where an attempt is being made to increase the population of alpacas or llamas of a particular colour whose numbers are very low.

Lamoids in the Andean Agropastoral Farming System

Domesticated cameloids play a critical role in the traditional subsistence strategy. Their high and cold habitat has a limited net production of biomass. Despite the crucial domestication of plants for human consumption, no crops grow over 4,300m. Thus, in contrast to cattle and sheep, cameloids do not compete with agriculture for land since they normally graze on pastures above the limits of agriculture, or on agricultural plots under fallow.

The dung from SALs is an essential part of the agricultural system. Dung enables an effective transfer of energy from grazing areas into agricultural plots. This transfer is accomplished either by allowing the animals to graze on land in fallow, or by collecting dung manually and spreading it on the fields prior to ploughing.

The dung cake from SALs is called 'taquia' and is a very important cooking fuel at high altitudes where firewood is scarce or non-existent. It burns well and has high heating properties. Currently, kerosene is used widely for cooking in the Andes. However, it is too expensive for the poor 'campesinos' (peasants). Reforestation with native Andean trees and shrubs that have a potential as firewood has been promoted

in some areas. However, because of the slow growth of plants at high altitude, this provides few benefits in the initial stages. Nowadays, it is not uncommon to see small industrial activities, such as bakeries, in highland villages that are based on the intensive use of taquia bought cheaply from landless herders.

Transportation of goods on llama back represents an efficient as well as cheaper and more appropriate alternative to vehicles, which are particularly costly on steep and winding roads. This is especially true for self-subsisting peasants with little access to cash. The advantages became particularly evident during the oil crisis of 1968 when fuel prices went up dramatically and there was a resurgence of llama caravans in certain regions of the Central Andes. During the rainy season landslides cut off highland roads, which again provides an opportunity for llama herders to provide their services at good rates. Each llama can carry a load of 25 to 30 kg over distances of 20 to 25 km per day, and a llama caravan may be as big as 100 to 120 animals. A whole caravan can be handled by one or two persons. On their way the animals feed on wild grass and natural fodder.

The fibre market may also be analysed from the perspective of energy flow. Wool from SALs provides an efficient means of energy conservation through its use as clothing, and in addition it commands a good price in the market. In many cases, particularly in highland communities with little or no access to agricultural land or off-farm employment opportunities, the wool market is the only source of cash income. In these highland communities, cash is converted into much needed additional food energy and other supplementary nutritional requirements. (The highland diet is deficient in iodine, which can be obtained through consumption of dry sea kelp, and in certain vitamins, calcium, and others, most of which can be obtained in some form through trade and barter or at the rural markets). SALs also provide a direct source of food. Both llamas and alpacas yield significant amounts of fibre and meat as shown in Table 20.3.

SALs offer other benefits, too. As with other forms of livestock in rural societies, SALs function as a way of accumulating a capital reserve that can be easily and

Table 20.3: **Production parameters for llamas and alpacas**

Species	Llama	Alpaca
Natality, %	47	45
Mortality at birth	25	30
Adult mortality, %	8	10
Adult live weight kg	90	50
Carcase yield, %	55	54
Extraction, %	10	12
Fibre weight, kg	2.0	1.6
Frequency of shearing (per year)	3	1.5

Source: FIDA 1990

readily converted into cash when needed. And finally, the use of children to perform herding tasks contributes significantly to an energetically efficient strategy for the division of labour at high altitude. The efficiency of an agropastoral family is related to the number of children over six years old, the age after which they can take care of animals.

Herding lamoids together with cattle and sheep

Nowadays SAC herders can be characterised as 'poly-pastoral'. Although lamoids constitute the dominant species among traditional herders, there is always a place for sheep and cattle, depending on the region and altitude. Throughout the puna it is quite common to run into mixed herds of lamoids and sheep. In general alpacas are the most numerous species in mixed herds (from 30 to 120 alpacas) because of the value of their fibre. They are followed by ovines (10 to 80) and llamas (5 to 50). Occasionally, the herder may have two or three cows and possibly a bull, either kept separately in corrals or sometimes allowed to graze with the rest of the herd. The proportion of different species in mixed herds varies from region to region. In northern Chile, for example, llamas dominate together with sheep (Gundermann 1984).

Handling a mixed herd is more complicated than having a herd of lamoids only. The latter can be managed by one herder – even in large numbers – because of their docility and habit of following a leader. Sheep require much more concentration. In many cases dogs are used to help with sheep. Finally, when bovines graze together with the herd, they are fastened with ropes to stones or poles to prevent them dispersing.

Mixed herding, in addition to the sanitary risks, can affect the status of pastures. Sheep grazing patterns have been seen to seriously affect the short and slow growing highland pastures. Little research has been done on the effect of mixed herding on pastures compared to pure lamoid herding, but given the lower productivity of sheep compared to SALs at high altitudes, it seems likely that mixed herds will lead to more overgrazing than unmixed ones. Appropiate alternatives for mixed herding should be based on sound agrostological [systematic study of grasses, ed.] research and adequate rangeland and herd management. Each animal species also has preferences for certain pastures, a factor that can be taken into account in order to optimise the use of the highland prairies. In the long run, it is better to have an adequate balance in the consumption of the different grasses than to have degraded pasturelands.

Conclusions

There are large numbers of people living in high altitude ecosystems (in the Andes, Himalayas, and others), and they all need animals for subsistence since crop

production is not possible. The Andean people domesticated the llama and alpaca, and the Himalayans the yak (*Bos grunnensis*). Alpacas and llamas (the domesticated SALs) are remarkable animals upon which millions of the poorest people in Latin America depend for their survival.

SALs are native to high altitudes. They are used to living in a fragile ecosystem, with constant exposure to cold, heat, and intense solar radiation (ultraviolet), and surviving on a coarse dry diet. Most llama and alpaca production occurs under such conditions. Domestic cameloids constitute the most reliable breeding animal in the highlands or punas of the Andes. Introduced species like sheep, goats, and cattle adapt poorly to the environmental stresses of the high altitude regions and give reduced yields of inferior quality, even after almost five centuries of acclimatisation.

Biological research over the past 30 years has clearly documented the productive superiority of llamas and alpacas at high elevations and in harsh environments. Lamoids could undoubtedly be raised even more profitably on better quality pastures and in less harsh environments. Recent introductions of alpacas and llamas into the United States, Israel, Canada, and New Zealand, have shown that these animals can be reared in areas outside the Andes with successful commercial production.

There is worldwide concern about environmental degradation and unsustainable agriculture. Llamas and alpacas offer potentially big advantages in the fragile-high-altitude ecosystems since they are possibly the most environmentally gentle ruminant livestock in the world. With their soft-padded feet, they do not scour steep hillsides. With their sharp front teeth, they clip off grass rather than tear it off like sheep and cattle. Moreover, with their outstandingly efficient digestive system, they can survive on coarse native grasses. Thus, in contrast to sheep and cattle, they require no pasture improvement or other modification of the unique, high-altitude environment and they are able to utilise marginal pastureland that would otherwise be ungrazed, or improperly used, thus causing damage to the ecosystem.

In order to increase animal production in the last fifty years, impoverished countries of the developing world have imported different livestock species from temperate developed zones, usually with disappointing results. High-yielding cattle, or sheep that produce fine wool, used to high quality balanced diets and high-tech management in their countries of origin, are unable to perform to the expected level when confronted by poor feeding conditions, improper management, parasitism, and difficult climatic environments. The problems with exotic stock have already been recognised to some extent. People are realising that the benefits are fewer than expected; that introduction of exotic (lowland) stock is often based on the use of modern technical resources, like freezing of semen and embryos, that are not

available; and that the introduced stock lack resistance to local diseases and the sturdiness needed for survival under poor conditions. Nowadays there is a tendency to avoid introducing pure-bred exotic domestic animals, particularly in environments already sensitive to ecological degradation. Instead of introducing exotic breeds from lowland areas, it would make more sense to transplant domestic species that are adapted to harsh and high altitude environments.

In the late 1970s, the UN Food and Agricultural Organization defined the ideal animal of the future. The animal, said FAO, should be a ruminant, should need little water, should be highly fertile, and should provide people with protein and other products. The llama and alpaca fit that ideal choice. To find the animal of the future, people need to look no further than lamoids.

When all the advantages are considered, lamoids would appear to offer a good substitute for the sheep presently grazing the vast arid lands of the developing world with marginal profitability. The llama's adaptation to the forage and water supplies present in high arid lands, its nutritious meat, the wool used by artisans and the modern textile industry, and their overall hardiness and adaptability, make them 'super species' with fascinating qualities and global utility. Llamas do not compete with native sheep or cattle for grazing areas, and complementary grazing should be considered in potential recipient areas such as the Himalayan rangelands. Lamoids need water much less frequently than other domestic species and so can be kept in places where the water supply is scarce. Lamoids can be integrated easily into the farming and economic system of traditional rural villages because rearing costs very little in terms of labour and technology. The medium fine quality llama wool, can be used in the local production of tapestry and garments. Also, the animals can be used as beasts of burden for transporting goods over rugged mountains and provide nutritious meat for the owners.

One point should be observed, however. When lamoids are introduced to an area, special care must be taken to prevent transmission of infectious diseases from local livestock and intoxication from some plants. Otherwise there should be no serious problems if the animals are managed according to our recommendations and common sense.

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Annex 1
Programme

DAY 1: December 7, 1999

8:15 - 10:00	Inaugural Session • Opening statements ICIMOD – Egbert Pelinck ILRI – Jimmy Smith FAO – Maki Hokkonen Juhani GMP– Roberto Quiroz • Inauguration by the HMGN Minister for Agriculture • Keynote address – Hugo Li Pun • Vote of thanks
10:00 - 10:30	*Tea/Coffee*
10:30-13:00	Session 1: Chair Hugo Li Pun **Global Perspectives: Livestock in Mountain/Highland Production Systems** (20 minutes presentation and 10 minutes discussion for each paper)
10:30-11:00	Livestock production systems in mountains/highlands: challenges and opportunities *Narpat S. Jodha*
11:00-11:30	Market induced transformation of livestock-based production and supply systems in mountain/highland regions (including globalisation, liberalisation) and implications for the early decades of the next millennium *Steve Staal*

11:30-12:00	Livestock biodiversity in the mountains/highlands – opportunities and threats *Anne Valle-Zarate*
12:00-12:30	Technological and institutional changes affecting smallholder integrated crop-livestock farming systems *Roberto Quiroz*
12:30-13:00	Highland livestock production systems – need for specialised livestock product processing and marketing? *Gunther Heinz*
13:00-14:15	*Lunch*
14:15-18:15	Session 2: Chair Juhani Maki-Hokkonen **Regional Perspectives: Livestock in High-pressure Mountain/Highland Production Systems** (30 minutes presentation and 10 minutes discussion for each paper)
14:15-14:55	Trends of livestock production and management strategies in the high-pressure Andean Region *Alvaro Zapata*
14:55-15:35	Livestock Production in mixed crop-livestock farming systems in areas of high land and human population pressure in East Africa *Jeroen Dijkman*
15:35-15:55	*Coffee/Tea*
15:55-16:35	Trends of livestock production and management strategies in high pressure areas of the Hindu Kush-Himalayas *Pradeep Tulachan*
16:35-17:15	Outcome of the global electronic conference *Jeroen Dijkman/Mohamed Saleem*
17:15-18:15	**Discussion (Sessions I and II)**
19:30 -	*Reception Dinner (cultural dance display)*

DAY 2: December 8, 1999

8:15-13:00	Session 3: Chair Tej Partap **Regional Perspectives: Sustainability Concerns of Livestock-based Livelihoods** (20 minutes presentation and 10 minutes discussion for each paper)
8:15-8:45	Livestock-based food security in the highlands: trends and options from an HKH case study *Nyima Tashi*
8:45-9:15	Sustainability concerns of livestock based livelihoods in the Andes *Carlos Leon-Velardi*
9:15-9:45	Animal agriculture and watershed management: reconciling private and public goods *Ralph von Kaufman and M. Saleem*
9:45-10:15	Draught animal power in mountain highland agriculture: issues and options *Vir Singh*
10:15-10:45	Livestock as a household energy source: implications for sustainable management of natural resources *Kamal Rijal*
10:45-11:05	*Tea/Coffee*
11:05-11:35	Smallholder dairy farming initiatives: success and failure of milk cooperatives in the HKH *Ranveer Singh*
11:35-12:05	Gender roles in mountain household livestock management: changing contexts and R&D implications *Esther Iganau Njiro*
12:05-13:00	Interregional cooperation for exchange of livestock resources and information: scope and implications *Alejandro Camino*

13:00-14:30	*Lunch*
14:30-18:00	**Panel Discussion: Synthesis of Emerging Issues** Session 1: Convenor Mahesh Banskota Session 2: Convenor Jimmy Smith Session 3: Convenors Narpat Jodha and Mohamed Saleem
18:00-19:15	Meeting of the core group

DAY 3: December 9, 1999

8:15-13.00	Working Group Sessions: Plenary Chair Beth Miller
8:15-10:15	Working Group Sessions
10:15-10:45	*Tea/Coffee*
10:45-11:45	Working Group Finalisation for Presentation
11:45-13:00	Working Group Presentations in Plenary Session by Jeroen Dijkman, Zinash Sileshi, Mohamed Saleem, and Hugo Li-Pun for Working Groups 1,2,3, and 4 respectively
13:00 -14:15	*Lunch*
14:15-15:15	Discussion of common programme and follow-up
15:15-17:15	Livestock-related regional contributions towards preparation for the International Year of Mountains 2002
17:15-19:15	Meeting of the Core Group

DAY 4: December 10, 1999

7:00-12:00	Field visit to smallholder livestock farming areas • Smallholder dairy operation • Livestock-crop systems • Livestock and biogas energy system • Livestock and land degradation

12:00-14:00 PM Closing Session

- Pokhara Call for Action on Livestock in Sustainable Livelihoods in Mountain and Highland Areas – presentation in and approval in plenary session
- Closing statements by ICIMOD/ILRI/FAO/CIP

14:00 *Lunch*

Annex 2

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Pradeep Man Tulachan

Pradeep Man Tulachan has a BSc (Hons) in Agriculture from Haryana Agricultural University, Hissar, India, an MSc from the University of Illinois, USA, and a PhD in Agricultural Economy from Cornell University, USA. He began his career as a Lecturer at the Institute of Agriculture and Animal Science, Rampur, Nepal, worked in Papua New Guinea as a Senior Farming System Economist, and then for the US Agency for International Development (USAID) as a Senior Project Manager and Agricultural Economist. Since 1995 he has been working as a Farm Economist at ICIMOD. At present he is involved in various research projects including research into the main issues and options for marginal farms in the HKH (funded by ACIAR), and an eco-regional project funded by ISNAR under the ICIMOD Regional Collaborative Programme (RCP II).

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Mohamed Saleem is an environmental agronomist with 30 years of experience in Africa. After obtaining his PhD at the University of Ibadan, Nigeria, he became a Senior Lecturer at the same University. From 1980, he was an agronomist with the International Livestock Centre for Africa (ILCA) at its sub-humid site in Kaduna, Nigeria, until his transfer to ILCA HQ, now re-designated as the International Livestock Research Institute (ILRI), in 1995. Since 1989, he has led ILRI's Highlands/Mountain Research Team in Addis Ababa. At ILCA he was also serving as the Thrust Coordinator for Feed and Natural Resources' improvement from 1991 to 1995. Most of Mohamed Saleem's research career has been in Africa, and his principal interest is in improving livestock feed resources at different levels of land-use intensification, and developing strategies for efficient on/off farm resource use and conservation to improve human and environmental health. Mohamed Saleem has authored about 130 scientific papers.

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Tej Partap

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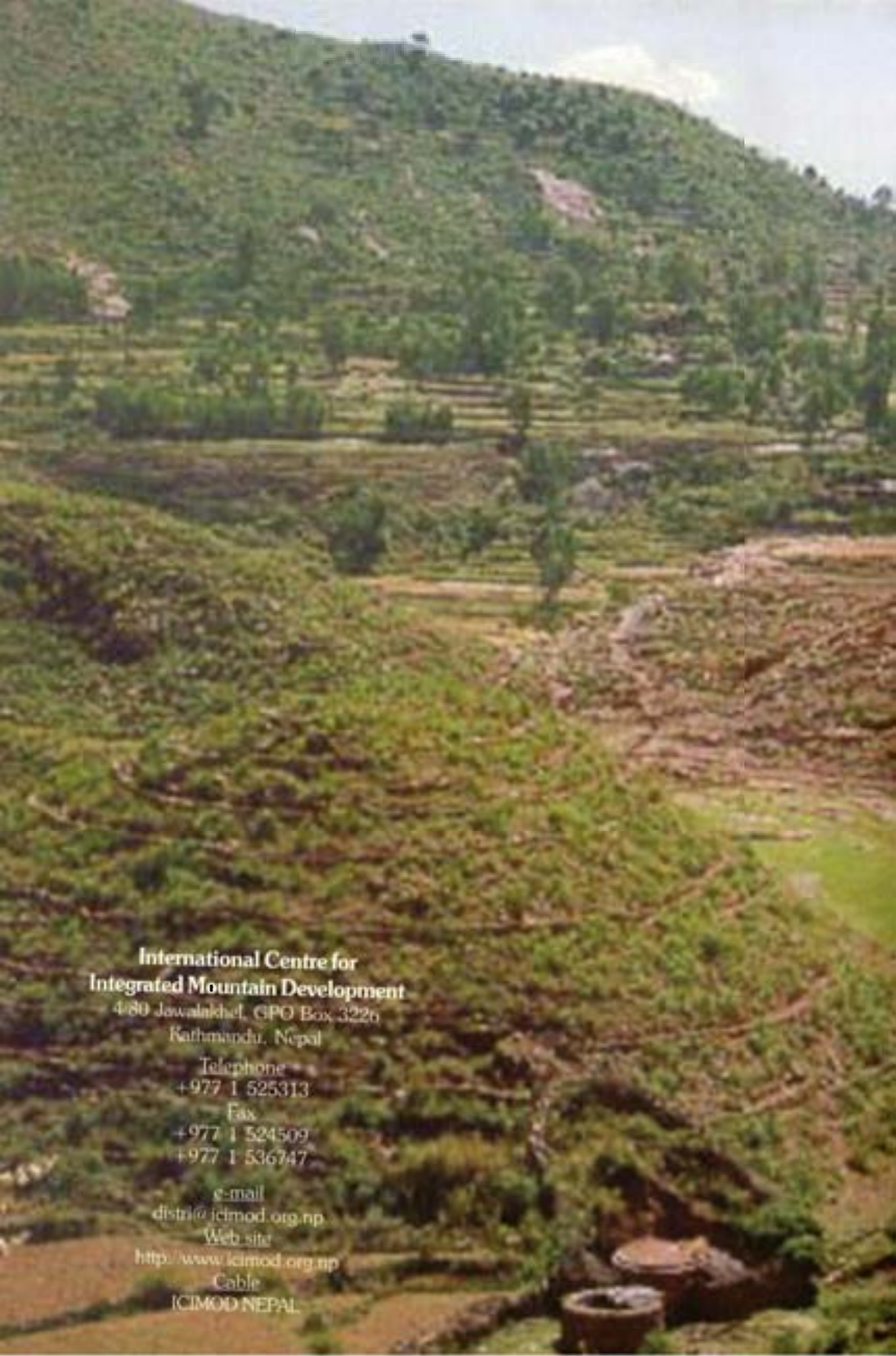

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