



# The Role of Livestock in Developing Communities:

*Enhancing Multifunctionality*

Frans Swanepoel  
Aldo Stroebel  
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Frans Swanepoel, Aldo Stroebel  
and Siboniso Moyo

*sb* **SUNBONANI  
SCHOLAR**

The Role of Livestock in Developing Communities:  
Enhancing Multifunctionality

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**Siboniso Moyo** is the Regional Representative of the International Livestock Research Institute (ILRI) in southern Africa, based in Maputo, Mozambique. She obtained an MSc in animal husbandry (Zootechnica) from the Patrice Lumumba University in Moscow in 1984, and a PhD in Animal Science (Breeding) from the University of Pretoria in 1997. In the same year, she became a Fellow under a three year Rockefeller Foundation Fellowship on Initiative for Development and Equity in African Agriculture (IDEAA). Before her current position, she conducted livestock research in Zimbabwe and the region for 21 years. She has mentored a number of young researchers and students in her different leadership roles as head of the Matopos Livestock Research Station in Zimbabwe (1997-2002) and as a National Director for Livestock Production and Development in the Ministry of Agriculture, Zimbabwe (2002-2006). Since 2008, she is a Mentor under the programme for African Women in Agricultural Research and Development (AWARD), facilitated by the CGIAR Gender and Diversity Programme. Her fields of specialisation include breed performance evaluation, smallholder livestock-production systems, livestock research and management, and partnership development.

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The chapters in this book have been reviewed by persons chosen for their diverse perspectives and technical expertise in accordance with procedures required by the Department of Higher Education and Training (South Africa) and CTA Wageningen as co-publisher. In order to maintain and ensure the highest quality, a two-stage review process was followed: each chapter was independently blind-reviewed by at least two acknowledged experts to provide candid and critical comments to improve the chapters and ensure scientific soundness, and to warrant international expectations of objectivity, evidence and responsiveness.

## Preface

This book is the product of a Satellite Symposium on the Role of Livestock in Developing Communities: Enhancing Multifunctionality, held as part of the 10th World Conference on Animal Production (WCAP) in Cape Town, 22 – 28 November 2008. The Symposium, jointly organised by the University of the Free State (UFS) and the International Livestock Research Institute (ILRI) aimed to stimulate critical thinking on the role of livestock in livelihood strategies for the poor in the developing world as a contribution to address the Millennium Development Goals (MDGs).

The livestock sector in developing countries contributes more than 33% to agricultural Gross Domestic Product (GDP), and is one of the fastest growing agricultural sub-sectors. The livestock sector has been experiencing what has been coined the “Livestock Revolution”. Population growth, urbanisation, and most importantly, increasing income have resulted in a rapid increase in demand for livestock products, which is likely to continue well into the future. This growth of the livestock sector presents both enormous opportunities and challenges. This book therefore comes at an opportune time for both policy makers and practitioners in developing countries, and the international community. Livestock is a major contributor to food and nutritional security, and serves as an important source of livelihood for nearly 1 billion poor people in developing countries. Its importance in attaining the MDGs should therefore not be underestimated.

The book aims to provide critical information and knowledge on the importance of livestock in the global effort to alleviate poverty and promote human health. It describes and evaluates case studies, examines theoretical frameworks, and discusses key global policy development issues, challenges and constraints related to smallholder livestock-production systems around the globe. The book is written for academic professionals, industry experts, government officials and other scholars interested in the facts and issues concerning the contribution of livestock to the social and economic progress of developing countries.

The introductory chapter is followed by a chapter outlining a conceptual framework for the role and contribution of livestock in the livelihoods of developing communities. In the subsequent three chapters, cross-cutting themes are addressed, namely promoting gender equality and empowering women through livestock, livestock-environment interactions, and food, nutrition and health systems focusing on food from animal origin. Thereafter a chapter analysing the interactions between these three components follows. Subsequent chapters address the role of livestock against risk and vulnerability in smallholder communities, sustainable intensification and value chains and innovation in smallholder production systems. The book is

concluded with a chapter on implications and innovative strategies for enhancing the future contribution of livestock to developing communities. All the chapters are well illustrated with case studies from developing countries, focusing on Sub-Saharan Africa, South Asia and Latin-America. We are confident that the book will assist in generating renewed interest in the livestock sector.

## Foreword

Animal agriculture is the most widespread use of the world's land surface. In many areas it is the only means of producing food from inedible vegetation. In almost all farming systems it is essential for converting inedible by-products and waste materials into food and hence it is no coincidence that as crop production intensifies so too does livestock production. For most of the 2.6 billion people depending on smallholder farming systems livestock production is essential for diversifying income sources and maintaining soil fertility and providing draught power and transportation. This is particularly important to women for whom the value adding activities in processing and marketing products such as eggs, butter, cheese, leather goods and wool and woven products make vital contributions to their household budgets. The options for landless production provided by livestock are critical to the livelihoods of millions especially in urban and peri-urban communities. Possibly most important of all is the contribution that animal-source foods make, not just to children's growth and health, but also to their cognitive development. Healthy and bright children in the classroom are the wellspring of national development.

As in all agricultural systems animal agriculture has its down sides. Too much animal fat in the diet, which is not a problem for the vast majority of poor people, is not healthy. Badly managed livestock can also be ruinous to land and water resources and can result in producing unacceptable amounts of greenhouse gasses and effluence, which can negatively affect people far removed from the offending livestock enterprises. The increasing numbers of both humans and livestock continues to heighten the threats posed by present and emerging zoonotic diseases for which there must be effective detection, monitoring and control systems.

Livestock produce about 30% of the agricultural gross domestic product (AGDP) in the developing world, and about 40% of the global GDP. Due to growing populations, increasing urbanisation, which raised the demand for easily cooked nutritious food, and rising incomes which allow people to express their food preferences, the demand for livestock products is the fastest growing agricultural market, especially for the products in which smallholders can be competitive.

There is no way to reach the goal of doubling of food production by 2050 without making livestock production more efficient, but this must be achieved while at the same time reducing the negative impacts of livestock products on human health and livestock on the environment. In countries such as China, India, Nigeria, South Africa and Uganda there are doubts about the capacities of their animal industries to respond to the rapidly increasing demand for foods of animal origin.

In this context, this publication on **The role of livestock in developing communities: enhancing multifunctionality** is a very timely and valuable contribution. It is timely because of the urgent need to properly direct the renewed interest in agricultural development that was catalysed by the 2008/9 global food price crisis, which provided vivid warnings of the dire consequences of continuing to neglect agriculture. It is valuable because of the need to find innovative ways of dealing with the contradictions between the legitimate demands of consumers in developing and emerging economies for more animal-source foods and the equally valid concerns of the international community about the negative environmental impacts of animal agriculture. This calls for science-based critical assessments of current trends, the development of innovative strategies and future directions. This book presents the consensus of discussions on these issues that were held in a satellite symposium involving eminent scientists and practitioners from all regions of the world as part of the Tenth World Conference of Animal Production, held in Cape Town, South Africa, November 2008.

The authors recognise that the analyses, assessments and development strategies presented in the book's 10 key chapters are by no means complete but they do make a compelling case for improving efficiency in the use of production resources, constant monitoring of the dynamics of the systems and of the changes imposed by various externalities. It provides examples of major issues that will need further attention. These include, but are not limited to, the potential for expanding the use of less favoured rainfed lands for productive agriculture, support for small farm systems-based agricultural growth, the role of livestock in reducing poverty and hunger, improved use of natural resources to reach technical potentials, increased investments in agricultural research aimed at achieving sustainable yield increases and improved productivity from animals, and reduced negative impacts on climate change.

I congratulate the editors for their initiative, the authors for their efforts, and recommend this book to researchers, practitioners, development agents, decision makers and planners. I am confident that it will play an important role in improving understanding of the contributions of livestock to developing communities and the opportunities that animal agriculture could, and must, make to enhancing economic growth and prosperity.

**Prof Monty Jones**

*Executive Director, FARA and Chairperson, GFAR*

*World Food Prize Laureate, 2004*

*Extraordinary Professor, University of the Free State, South Africa*

# 1

## Multifunctionality of Livestock in Developing Communities

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### Abstract

Livestock play multiple roles in the livelihoods of people in developing communities, especially the poor. They provide food and nutrition, work, economic and social status, and ensure environmental sustainability. With the livestock sector experiencing rapid change – mainly driven by the rapidly changing livestock production systems, demographics, environmental impacts, technologies, policies and institutions – this “multifunctionality of livestock” becomes an even more complex issue, intertwined with other research and development challenges.

This chapter presents an overview of the multifunctionality of livestock, looking at the trends and drivers of livestock production in developing communities. Bringing this topic to the table is meant to draw the attention of the research and development community to the issues concerning the contribution of livestock to the social and economic progress of developing communities and thus attract both public and private sector investments in this sector.

**Keywords:** multiple roles of livestock, trends and drivers of change, opportunities

### 1. Introduction

The majority of the world’s estimated 1.3 billion poor people live in developing countries where they depend directly or indirectly on livestock for their livelihoods (World Bank, 2008 and FAO, 2009). Globally, livestock contributes about 40 percent to the agricultural gross domestic product (GDP) and constitutes about 30 percent of the agricultural GDP in the developing world (World Bank, 2009). These estimates highlight the important contribution of livestock to sustainable agricultural development.

The contribution of livestock to the world’s food supply, family nutrition, incomes, employment, soil fertility, livelihoods, transport and sustainable agricultural production continues to be a subject of significant review and debate (LID, 1999;

ILRI, 2002; Ellis and Freeman, 2004; Kitalyi *et al.*, 2005; Chilonda and Otte, 2006; Thornton *et al.*, 2006; Perry and Sones, 2007 and Randolph *et al.*, 2007). Furthermore, estimates show that globally, livestock provide animal traction to almost a quarter of the total area under crop production (Devendra, 2010). Livestock also provide a safety net in times of need in the form of liquid assets and a strategy of diversification for food production (Freeman *et al.*, 2007). All these reviews and studies thus far have shown that livestock play multiple roles in the livelihoods of people in developing communities, especially the poor.

This chapter presents an overview of the multifunctionality of livestock production in developing communities, focusing on some of the trends and driving forces of livestock production and their implications for developing communities. It also introduces research-for-development challenges of critical importance to livestock production in developing communities, some of which will be addressed in detail in later chapters.

## 2. Multifunctionality of livestock

### *Food and nutrition*

In order to increase livestock's contribution to the livelihoods of developing communities requires improved understanding of livestock's multiple and complex roles. The contribution of food from animal origin to the nutritional status of the world population is well documented (Bwibo *et al.*, 2003, Randolph *et al.*, 2007 and Ndlovu, 2010). Livestock products account for almost 30 percent of human protein consumption (Steinfeld *et al.*, 2006).

### *Social functions*

Beyond the important role that livestock play in the provision of food and nutrition in people's diets, they also have important social functions. They raise the social status of owners and contribute to gender balance by affording women and children the opportunity to own livestock, especially small stock (Waters-Bayer and Letty, 2010).

### *Risk buffer*

In marginal areas with harsh environments, livestock provide a means of reducing the risks associated with crop failure and a diversification strategy for resource poor small scale farmers and their communities (Freeman *et al.*, 2007, Thornton *et al.*, 2007 and Vandamme *et al.*, 2010).

### *Contribution to crop production*

The contribution of livestock to crop production through the provision of draught animal power and manure cannot be overemphasised (Herrero *et al.*, 2010). Livestock contribute to achieving more efficient and more sustainable resource use through enhanced energy and nutrient cycling. For instance, animal manure increases soil fertility, soil structure and water-holding capacity. About two-thirds of the world's livestock-“walking crops” – are utilised in farming systems in developing countries where nutrients are scarce and limited (Stroebel *et al.*, 2010).

### *Income generation/wealth accumulation*

It is evident that livestock enable saving, provide security, allow resource-poor households to accumulate assets, and help finance planned expenditures as well as those that are unplanned (i.e. illness). Livestock function as insurance policies and bank accounts in many parts of the developing world (Pell *et al.*, 2010).

### *Economic role*

As improved incomes and urbanisation shift diets towards high value commodities such as meat and milk, the contribution of livestock to economic growth increases through its multiplier effects with agriculture and other sectors outside agriculture. Increased economic activity in livestock fosters forward linkages through growth in livestock processing and marketing, and backward linkages through increased demand for inputs and livestock services (van der Zijpp *et al.*, 2010 and McDermott *et al.*, 2010).

### *Livestock and the environment*

Livestock has an important function in sustainable land use and, in fact, can have both positive and negative environmental impacts, especially due to the rapidly evolving livestock systems. Thus, it is important to increase the understanding of livestock's effect on the environment and undertake the management needed to achieve sustainable use and development of resources (Herrero *et al.*, 2010).

In order to support the enhancement of the multifunctionality of livestock in the developing communities effectively, it is important to understand the trends and drivers of livestock production and their implications. The next section briefly presents some of the major trends and drivers of livestock production in developing communities.



### 3. Trends and drivers of livestock production in developing communities

#### *Rapidly changing livestock systems*

Livestock systems are changing rapidly, especially in developing communities, due to a number of factors that include, *inter alia*, demographics (population growth and urbanisation), general economic development, environment and climate change, available technologies and knowledge (Steinfeld *et al.*, 2006 and Moyo *et al.*, 2007).

Two broad livestock production and marketing systems are important for the poor in developing communities. The largest – smallholder mixed-livestock systems – supports the livelihoods of more than 600 million people. The main challenge for these systems is determining how to intensify sustainably in order to meet the increasing demand for agricultural products under the constraints of limited land, water and other natural resources. The second – broad livestock systems – is more marginal. These systems are more vulnerable and subject to shocks, making the need for adaptation more critical.

#### *Population and urbanisation*

The human population is expected to increase from 6.5 billion in 2010 to 8.2 billion by 2020 (Rosegrant *et al.*, 2009). The parallel increase in food demand will of course increase demand for livestock and its products. This demand for livestock products and the subsequent and associated increase in production and production methods is commonly referred to as the “livestock revolution”.

Furthermore, the World Bank (2008) has projected a rapid rise in the urban population of all developing countries. Urbanisation is generally associated with higher average household incomes and changing lifestyles with more food consumed outside homes (Delgado *et al.*, 1999). This helps fuel the demand for food including livestock products. Current consumption data show that the share of livestock products in household diets has increased steadily in developing countries over the past two decades.

#### *Consumption patterns*

Consumers in developing countries have diversified their diets by increasing consumption of meat, milk and eggs. Poultry, pork and eggs have experienced the fastest rates of increase, although beef and milk consumption have grown steadily in the world’s fastest growing economies. Annual meat consumption in developing countries with fast growing economies doubled from 14kg per capita in 1980 to 29kg in 2002, while milk consumption increased by 35 percent (FAO, 2006). There

are predictions that in the upcoming decades, there will be a general increase in per capita consumption of livestock products globally when compared to other agricultural products, such as cereals, and that the livestock revolution will have the greatest effect in the developing world (IAASTD, 2007 and Seré *et al.*, 2007).

### *Environment and climate change*

Livestock production is the largest land use system on earth. Pastoral systems occupy at least 45 percent of the global land area (Reid *et al.*, 2008). Livestock can have both positive and negative environmental impacts, especially due to rapidly evolving livestock systems, mainly associated with increased intensification. Furthermore, as population density increases, the related increased pressure on limited land and water resources will lead to degradation of the natural resource base. As these competing demands and tradeoffs intensify, so will the need to find ways to balance them in the future (Thornton *et al.*, 2009).

The increasing risk and uncertainty related to climate change and associated shocks add another dimension to changes observed in livestock production systems. Farmers, particularly in developing communities, are threatened by climatic changes such as shifting rainfall patterns and more extreme and unpredictable weather events. Weather variability is likely to increase in the near future. Strategies and adaptation options will need to be enhanced if the production systems and people that derive their livelihoods from livestock are to cope.

### *Policies and Institutions*

Policy needs are evolving, and new roles for the public and private sectors are emerging as the livestock sectors of developing communities respond to the different drivers of change. In India and Kenya, for example, private sector companies play an increasing role in the milk supply chain and new models of vertical integration are developing. Public/private sector involvement will need to pay attention to how the poor can benefit from these emerging opportunities. India recently became the largest milk producer in the world, mainly through smallholder producers (Cunningham, 2009).

These and other trends and drivers of change in the livestock production of developing communities have implications that require technological, institutional and policy interventions. The following section presents implications and development challenges in the livestock sector of developing communities.

## 4. Implications and challenges

### *Rapidly changing production systems*

Those farming with mixed crop-livestock systems face a key challenge in determining how to intensify sustainably to meet the increasing demand for agricultural products under the constraints of limited land, water and other natural resources. They must also support improved participation of poor people in livestock markets for income growth and employment generation, while improving the efficient use of land and water resources and livestock biodiversity.

More marginal systems face further challenges of reducing risks from shocks. They must also have adaptation options and increase the resilience of both the systems and the local people.

Both of these systems share livestock research-for-development challenges of critical importance to the poor, such as determining how to address widespread feed scarcity, how to better conserve and utilise available and adapted livestock genetic resources, and how to provide vaccines and diagnostics for neglected tropical animal and zoonotic diseases. Some of the broader global issues that are also important in these systems include adaptation to and mitigation of climate change, and the increasing risks and impacts of emerging human diseases, 75 percent of which are of animal origin.

### *Intensification*

In part, the increased demand for livestock products that has led to the livestock revolution will be met by expansion and intensification in poultry and pig production systems, particularly in Asia. In addition, there will be a need for increases in sustainable ruminant production, within the available natural resource base, in order to meet the meat and milk requirements of the developing communities, especially in sub-Saharan Africa. This offers opportunities for poor livestock keepers in the developing communities to earn increased returns from increased productivity and better marketing of their produce.

It is estimated that the developing world currently produces 50 percent of the world's beef, 41 percent of the milk, 59 percent of the pork and 53 percent of the poultry (Steinfeld *et al*, 2006; Herrero *et al*, 2009 and Rosegrant *et al*, 2009). The ability of smallholder livestock producers in developing countries to increase their production has been confirmed by examples in India, which recently became the world's largest producer of milk, most of it produced by smallholders. Similar developments have been reported in the smallholder dairy sector in East Africa (SDP, 2007). The key

livestock development challenge remains, determining how to generate productivity growth while improving the efficient use of land and water resources.

### *Access to markets and smallholder farmer's competitiveness*

The rapid increase in demand associated with income growth, urbanisation and expanded regional markets, plus the relatively higher prices for livestock products compared to other agricultural products, open up new opportunities for poor people in domestic, regional and international markets (ILRI, 2007). However, throughout these different levels, the major challenge is to ensure the competitiveness of smallholder farmers. Along with higher value markets come increased requirements for sanitary and phyto-sanitary (SPS) compliance. This presents additional challenges to smallholders who must meet the higher food quality and safety standards. An additional development challenge is whether or not poor people, especially those living in risky marginal areas with high transaction costs or without access to adequate information and knowledge, can be productive and competitive and subsequently benefit from these market-driven opportunities.

### *Policies and Institutions*

Farmers and public, private and community-based organisations in developing communities need support in strengthening their capacities to face the demands of evolving opportunities and challenges. Areas that need policy support include:

- ▶ delivery of veterinary services;
- ▶ provision of credit;
- ▶ delivery and uptake pathways of technologies;
- ▶ improvement of market infrastructure;
- ▶ strengthening the capacity of livestock keepers and communities to adapt to shocks and change; and
- ▶ mitigation of the negative impacts and increase the positive impacts on the environment.

## **5. Conclusion**

This chapter has highlighted that the livestock sector is a critical component of developing communities and identified the multiple roles that livestock play in the livelihoods of people in developing communities. A good understanding of how multifunctionality can be enhanced is necessary for this sector to continue to contribute to poverty reduction and increase the income of the people who derive their livelihoods from livestock while sustaining the environment. Research and

development practitioners face challenges in enhancing multifunctionality related to the uses of livestock in communities and still achieve the required impact levels. Practitioners should consider this potential in all phases of project development, from design through implementation and finalisation.

Livestock production trends in developing countries where there is increased demand for livestock products indicate that there are opportunities for livestock keepers to increase their returns through increased productivity and better marketing of their livestock and livestock products. A single individual or organisation cannot address the research and development challenges presented above. Instead, research and development agencies representing public, private and civil society organisations need to come together to tackle the challenges in a more comprehensive manner.

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# 2

## Livestock Development Projects that Make a Difference:

*What Works, What Doesn't and Why*

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### Abstract

A conceptual framework is proposed, based on a set of six working principles that underlie sustainable poverty reduction for livestock research and development. Arising from empirical examples and lessons, the principles recognize: i) livestock ownership forms part of rural people's *livelihood strategies*, which usually are a series of complex trade-offs given the many issues and problems faced by smallholder farmers; ii) livestock play *multiple roles* in providing livelihoods for the poor, and the implications of all these contributions should be considered in assessing their benefits, improving household nutrition, and maintaining social capital; iii) the outcomes and impacts of livestock-related interventions generally are relatively *long-term* compared to those from crops, and often require significant initial investment; iv) livestock production is constrained by *institutions, markets and policies*, as well as technical issues and requires interdisciplinary approaches; v) successful livestock programmes are contingent on *broad stakeholder involvement* from initial planning to project conclusion; vi) and *women* make significant contributions to livestock rearing and should benefit from these inputs. These principles are elucidated by practical examples of research for livestock-focused development projects. Supported with evidence from the literature, the examples illustrate applications of these principles. It is concluded that they can increase the likelihood that research for development efforts related to livestock will contribute to poverty reduction and sustainable natural resource management.

**Keywords:** livestock, livelihoods, sustainability, innovation, gender, multifunctionality

### 1. Introduction

This chapter proposes a conceptual framework based upon a set of working principles derived from empirical examples and lessons, all of which have been discussed and confirmed by practitioners with extensive field experience. Application of these

principles can increase the likelihood that livestock research and development efforts will contribute to poverty reduction without depleting the natural resource base that sustains people and animals across the developing world.

- i Livestock ownership is part of people's livelihood strategies, which usually involve a series of complex trade-offs necessitated by the many issues and problems with which the resource poor must contend, such as increasing food prices, conflict, land and labour constraints, and poor health.
- ii Because livestock play multiple roles in providing livelihoods for the poor, assessments of the benefits of livestock ownership should include all of these contributions, such as enabling saving, providing security, accumulating assets, financing planned expenditures, providing livestock products (meat, milk, eggs, manure, draught power), improving household nutrition and maintaining social capital.
- iii Realisation of the outcomes and impacts of livestock-related interventions generally is relatively long-term compared to those from crops because of long generation intervals, and often such initiatives require a significant initial investment.
- iv Livestock production is constrained by institutions, markets and policy as well as by technical issues and mandating interdisciplinary approaches to solving livestock-related livelihood problems.
- v Successful livestock programs are contingent on broad stakeholder involvement from initial planning to project conclusion, including involvement of public and private sector actors, local communities, researchers and development practitioners from diverse parts of the economy.
- vi Women make significant contributions to livestock rearing and should benefit from these labours. Thus, livestock research and development projects should incorporate gender analysis.

This chapter elaborates these six working principles by providing some examples of research for livestock-focused development projects, exploring what it means in practice to apply these principles and providing further evidence from the literature supporting them.

## 2. Conceptual Framework – Discussion and analysis

### *Livelihood strategies*

Of the 1.3 billion people living in absolute poverty worldwide, slightly less than half (600 million) keep livestock (Thornton *et al.*, 2003). The close interactions between crops and livestock in most developing countries differ from those found

in developed countries. Mixed crop-livestock systems account for most of the meat and milk production in Asia, and 40–60 percent of the cattle, sheep, goat and poultry meat production in sub-Saharan Africa (Herrero *et al.*, 2009). These resource-poor households typically grow crops, often at the subsistence level, earning whatever off-farm income they can, while raising a few chickens, sheep, goats, pigs or cattle. In Africa, grazing systems are also important, contributing nearly two-thirds of the beef produced and three-quarters of milk produced (Herrero *et al.*, 2009). Huge projected growth in the human population, increasing demand for land and food, coupled with serious water, land and labour constraints are becoming increasingly evident in both mixed crop-livestock and grazing systems (World Bank, 2008). Smallholders often have few options for enhancing household welfare and even when new technologies are available, they often are risk averse and reluctant to adopt the innovations. Adopting new technologies or livestock management strategies are rarely the highest priorities of families facing concerns such as increasing food prices, food insecurity and conflict.

It is evident that livestock enable saving, provide security, allow resource-poor households (and women, who typically cannot own land) to accumulate assets. The keeping of livestock also helps finance planned expenditures as well as unplanned events such as illness. They provide livestock products including meat, milk, eggs, manure and draught power. Livestock contributes to the improvement of household nutrition and help maintain social capital and status within communities. Livestock function as insurance policies and bank accounts in many parts of the developing world. Despite the fact that for several decades, researchers have been aware of the multifaceted roles played by livestock, much current research still focuses on individual elements, such as feed efficiency or a particular disease or breed.

### *Multiple roles*

Livestock play multiple roles for the poor. Table 1 summarises benefits and products derived from livestock by smallholder farmers.

In response to the need to consider the multiple functions of livestock, Dorward *et al.* (2005) and Misturelli *et al.* (2003) developed guides and toolkits that provide methods and indicators for assessing the contributions of livestock rearing to the livelihoods of poor people and for assessing poverty and well-being among poor livestock keepers. These tools can be used to understand the needs and capacities of poor livestock owners, to prioritize and design interventions to improve livelihoods, to monitor and evaluate livestock projects, to conduct retrospective assessments of animals on livelihoods, and to determine whether projects affect segments of the population differentially (e.g. women or the poor).

**Table 1:** *A summary of benefits and products derived from livestock (Stroebel et al., 2010)*

Benefit	Products
Food	Milk; meat; eggs; blood; fish; honey; processed products.
Clothing	Wool; hides; skins; leather.
Work	Draught power – cultivation; transport of goods and people; threshing; milling; pumping water.
Monetary	Capital wealth; investment and savings; income from hiring working animals; sale of products and animals.
Social	Bride price “ <i>Lobola</i> ”; ceremonial; companionship; recreational; status.
Manure	Fertiliser (soil amelioration); fuel; flooring.
Other benefits	Feathers; bone meal; soap production.

Livestock in Development (LID) reviewed the potential for livestock interventions to reduce poverty and identified three approaches that livestock development could follow:

- ▶ increase market supplies of livestock products for consumption by the poor;
- ▶ increase the demand for labour and services of the poor by creating growth in the livestock sector; and
- ▶ work directly with the poor to enhance the contribution livestock make to their livelihoods.

LID (1999), concluded that of the three, a livelihood-based approach would most likely have the greatest impact on reduction of rural poverty. This is because most of the poor who rear livestock face many constraints that, if resolved, could increase the contribution livestock make to their livelihoods. LID therefore suggests that livestock development, if correctly targeted towards supporting the livelihoods of the poor, has great potential as a tool for reducing rural poverty.

### *Long-term*

The third principle asserts that outcomes and impacts from livestock-related interventions generally are not achieved quickly. Agricultural interventions such as planting higher yielding crop varieties provide results in a few months, while some livestock-related interventions such as improved breeding programs often take many years to have an impact on livelihoods. This is due to the long generation interval in livestock breeding, the time it takes to see changes in soil quality from improved

management, or the huge partnership challenges and length of time involved in developing a vaccine against major livestock diseases, as illustrated in Box 1. Other important interventions that can improve animal productivity significantly such as protein supplementation and availability of adequate quantities of potable water produce responses within a few days.

**Box 1:** Vaccine development research

East Coast Fever (ECF) is a livestock disease that causes production losses of US\$300 million per year, primarily among smallholder, resource-poor households in eastern, central and southern Africa. A unique vaccine development project to combat ECF, designed and implemented as a partnership among public research organisations, advanced research institutes, universities and a private company was evaluated by Spielman (2009). Built on International Livestock Research Institute (ILRI) research, the project was conceptualized in the late 1990s and came to fruition in 2001.

In addition to seeking suitable antigens to form the basis of an effective vaccine against ECF, the project's researchers needed to identify both potential vaccine targets and feasible delivery systems. Major project outputs that resulted from these parallel approaches included antigen identification, antigen delivery systems, a series of laboratory trials and optimisation of high-throughput assays (Taracha and Taylor 2003).

These project outputs were used to clone candidate vaccine antigens into the private sector partner's drug delivery system that was tested on live cattle in 2003. The ECF vaccine did provide some protection against ECF, but only in 30 percent of the cattle tested. This was too low to provide "proof of concept" and the ability to produce measurable immune responses in cattle consistently. Thus, its partnership-based research effectively ended in 2007.

**Lessons.** Despite failing to meet its objective of developing a cost effective, easy-to-use ECF vaccine, this project generated significant scientific findings and, importantly, critical lessons for future partnership-based efforts to promote sustainable development and alleviate poverty in sub-Saharan Africa. The project found that:

- ▶ clear contractual agreements are needed and they must be open to review, renegotiation and amendment as the project evolves,
- ▶ contract review, renegotiation and amendment require regular planning, evaluation and adjustment,
- ▶ bringing public- and private-sector expertise to bear on a specific research problem is not easy.

The project recognized that partners need to be engaged in the joint planning and execution of research through repeated and durable interactions, i.e. joint processes of technological innovation or “co-innovation”. It is likely that this back-and-forth exchange of knowledge and technology among partners accelerated the pace of research and made outcomes possible that neither ILRI nor its partners could have achieved in isolation.

### *Institutions, markets and policies*

The fourth principle highlights the need for interdisciplinary research, emphasising a systems approach. Institutional, market and policy-related constraints need to be identified and tackled along with technical constraints. This is particularly important in countries where agricultural decision makers and research and extension services lack resources and capacity. Transportation, infrastructure, markets and institutions (e.g. contract enforcement) are critical for establishing efficient markets, but are often severely lacking in livestock-raising areas (Pica-Ciamarra, 2005). Identifying the policies needed to support the evidence-based approaches developed by research teams is often an issue, as is seen in the example of a collaborative disease-resistance research project in West Africa (Box 2).

#### **Box 2:** Improving the management of trypanocide resistance in West Africa

Trypanosomosis, transmitted by tsetse flies, is the main killer of cattle in Africa and an important threat to human health. Historically, the tsetse belts extend from the Sahara to the Kalahari, thereby excluding cattle from an area of Africa larger than the United States. However, the needs of a rapidly growing human population led to agricultural expansion, while inexpensive and effective drugs allowed cattle to be kept in the tsetse-infested areas. Today, due to the demand for frequent treatment, the flies have developed a resistance to the most effective drugs and trypanosomosis has re-emerged.

In the late 1990s, a diagnostic and basic science research project, carried out in Burkina Faso by ILRI, national research institutes and a European university, produced the first spatial mapping of drug resistance tsetse flies and they also developed laboratory and field tools for disease detection (Grace *et al.*, 2007). Initial success led to a more ambitious project with the objective of assessing the drug resistance in neighbouring Mali and Guinea and testing “best-bet” strategies for resistance management. The project also included capacity building and policy analysis components.

The project team mapped disease levels and drug resistance across a broad swath of West Africa’s cotton belt, identified the drivers of resistance, and assessed the

associated economic losses and impact (Grace *et al.*, 2007). The team rigorously tested a range of options for managing resistance and found that improving how drugs were used was the best way to manage the problem. Several “rational drug use” tools were developed and tested with a range of stakeholders. Policy analysis revealed a huge gap between regulation and reality, which had encouraged misuse of drugs. Stakeholder approaches started untangling the web of different interests and incentives that maintained this disparity between policy and practice. Over a five-year period, the project generated many publications, reports, extension tools and training materials, tested strategies and attracted funding for a third phase aimed at further scaling up the strategies that successfully reduced drug resistance. Its achievements were largely due to the research project team’s willingness to build diverse partnerships and involve communities and policy makers in the creation of solutions – namely improved management practices, and policies encouraging and supporting them.

Recent agricultural revitalisation efforts confirm that a more pragmatic understanding is required of the role of agricultural education and training (AET) in promoting innovation, development and growth and that this calls for an agricultural innovation system (AIS) approach (Rajalahti *et al.*, 2008). In essence, an agricultural innovation system blends institutional capacities, coordination mechanisms, communication networks and policy incentives that foster innovation-led gains in agricultural productivity. It emphasizes the understanding of key actors and their roles, behaviours and practices, and the institutional context within which they interact. All of these are key conceptual elements in innovation systems analysis (World Bank, 2007). Davis *et al.* (2007) argued that while AET is conventionally viewed in terms of its role in building human and scientific capital, it also has a vital role to play in building the capacity of organisations and individuals to transmit and adapt new applications of new information, new products and processes, and new organisational cultures and behaviours.

Twenty years ago, the Farmer-First Workshop held at the Institute of Development Studies, University of Sussex, UK, launched a movement to encourage farmer participation in agricultural research and development. This was in response to farmers’ needs in complex, diverse, risk-prone environments, and promoted sustainable livelihoods and agriculture. Revisiting recent methodological, institutional and policy experiments that were conducted around the world, Scoones and Thompson (2009) highlighted the importance of going beyond farm scale to a wider innovation system. This incorporated market interactions as well as the wider institutional and policy environment. It also called for a major rethinking of agricultural research and

development in order to boost the knowledge and capacities of farmer organisations to innovate and then to strengthen networks and alliances that would support, document and share lessons on this farmer-led innovation and, in turn, transform agricultural higher education.

A recent World Bank synthesis report (World Bank, 2007) argued that an innovation systems perspective could assist in understanding how best to reform AET and offered useful insights into the role of AET in livestock sector development, namely:

- ▶ innovations depend on the ability of stakeholders (farmers, livestock officers, input suppliers) to learn and use information creatively in response to market and other opportunities;
- ▶ learning depends on the ability of these stakeholders to interact and exchange information and knowledge (Fagerberg, 2005);
- ▶ innovation is constrained by complexity and/or the inability to change critical variables within a system, which means that individual stakeholders may not have all the resources required to innovate fast enough to remain competitive (Powell and Grodal, 2005);
- ▶ successful innovation systems balance the search for existing information with the creation of original knowledge (Renzulli, 2003);
- ▶ economic and social performance of a country depends on participation of diverse, innovative stakeholders or agents who interact to form an innovation system and establishes effective interaction between a country's scientific base and its business community (Powell and Grodal, 2005).

At the project level, taking an innovation systems approach involves first identifying the boundaries of the system and then targeting key partners, sometimes referred to as "boundary partners" (Earl *et al.*, 2001), and creating the incentives and space for collaborative work with them (Kristjanson *et al.*, 2009). In practical terms, the methodology for systems research has several distinct sequential steps that occur in partnership with farmers (Devendra, 2010). Box 3 highlights a traditional fodder research project that evolved into an innovation systems project.



**Box 3:** Enhancing livelihoods of livestock-dependent poor people through increasing use of fodder in India and Nigeria

The use of innovation is demonstrated in a project aimed at increasing feed availability in order to enhance livestock productivity in India. Built from the premise that the most effective way to address fodder scarcity was to identify and disseminate new, improved varieties of fodder or dual-purpose crops. A whole-farm approach was used in the project's first phase, to identify technical options for overcoming local feed constraints. It built upon existing work and baseline data, developed site-specific "baskets of options" and offered advice to farmers regarding fodder options that best suited their particular environments.

It was envisaged that the project would have the full participation of farmers, local communities and change agents, and would involve community meetings, stakeholder workshops and extensive group discussions to identify priorities related to feed constraints and degradation of natural resources. Scaling-up and out was to take place through farmer-to-farmer exchanges and the dissemination activities of development organisations partnering with the project. However, as the constraints limiting such scaling-up became clear, there was a realisation that a systems approach was needed that would take into consideration the roles played by a broader range of actors.

The second phase of the project, implemented in India and Nigeria, shifted to a focus on building partnerships, community involvement and a learning environment. This was done specifically through empowering a multi-stakeholder network to increase adoption of fodder plants, including dual-purpose food-feed crops, by smallholder farmers. The aim of the project was to build and support capacity to innovate. Investigations into the nature of groupings or networks of individuals and organisations, and the factors that affect their ability to work coherently and systemically to bring fodder-related knowledge and services into productive use in the specific context of poor livestock keepers were conducted by Bezkorowajnyj and Hall (2008).

This approach resulted in farmers pursuing new ways of doing things in India. For example, the provision of Napier grass (*Pennisetum purpureum*) to farmers with access to irrigation initially excluded the landless and farmers without water access. However, farmers themselves developed new institutional arrangements whereby wealthier landowners leased small plots to poorer farmers for fodder cultivation. Landowners provided planting material, protection of plots and access to water while the livestock owners provided fertiliser and were responsible for harvesting and general plot maintenance.

Market failures and lack of private sector incentives were overcome by institutional innovation in the Nigeria segment of the project. The project team initiated meetings that brought private seed suppliers and extension workers together to discuss how seed supply constraints could be overcome. The project initially ended up underwriting half of any losses the seed companies incurred as a result of poor sales of improved seed, thus lowering their risk and providing the needed incentive for the seed company to provide the solution to a major constraint limiting farmers' productivity.

A number of existing productivity-enhancing technological options for animal production are gaining wider and more intensive application in many parts of Asia and elsewhere. One such example is the three-strata forage system (TSFS) in Indonesia (Box 4).

**Box 4:** Three-strata forage system (TSFS) in Bali, Indonesia

Productivity-enhancing technologies provide a technical basis for development and are appropriate to systems combining animals with annual and perennial cropping. The three-strata forage system (TSFS) adapted for the dryer environments (600–900 mm annual rainfall and 4–8 months dry season) of Bali and Indonesia, integrates cash cropping and ruminant production (mainly cattle and goats) in a sustainable crop-animal system. This system enhances efficient use of natural resources, especially for small farms. The system and its replicability, developed over nine-and-a-half years of research and development, has potential for application in semi-arid areas of sub-Saharan Africa (Devendra, 2010).

The TSFS integrates planting and harvesting of forages so that a source of feed is available year round. The core area is the centre of the plot where maize, soya bean and cassava are grown for predominantly human consumption while the peripheral area is utilised for fodder crops for animals. The peripheral area consists of three strata.

**Strata 1 – Grasses and legumes for use during the wet season**

Grasses: Buffel (*Cenchrus ciliaris*) and Green Panic (*Panicum maximum*)

Legumes: Stylo (*Stylosanthes gracilis*), Centrosema (*Centrosema pubescens*)  
Caribbean stylo (*Stylosanthes hamata*)

**Strata 2 – Shrub legumes for use during the middle of the dry season**

Shrubs: Gliricidia (*Gliricidia sepium*) and Leucaena (*Leucaena leucocephala*)

**Strata 3 – Fodder trees for producing feeds for the late dry season**

Fodder trees: *Ficus* (*Ficus poacellie*), *Hibiscus* (*Hibiscus tilleacius*) and *Lannea* (*Lannea corromandilica*)

The major highlights of the systems were:

- ▶ increased forage production enabled higher stocking rates (3.2 animal units/ha) and total live weight gains of 375 kg/ha/year in the TSFS compared to 2.1 animal units and 122 kg/ha/year in the non-TSFS;
- ▶ cattle in the TSFS gained 90% more live weight and reached market weight 13% faster;
- ▶ farmers benefited with a 31% increase in farm income;
- ▶ introduction of forage legumes into the TSFS reduced soil erosion by 57% in TSFS compared to the non-TSFS, and also increased soil fertility;
- ▶ presence of 200 shrubs and 112 trees logged twice a year produced 1.5 tons/year of firewood, which met 64% of the farmers' annual firewood requirements;
  - ◆ integration of goats, in addition to cattle, into the system, further increased the farmers' incomes.

*Broad stakeholder involvement*

The fifth principle, closely related to the argument for taking an innovation systems approach, states that local communities, public sector, private sector, non-governmental and civil society organisations (NGOs and CSOs), development practitioners and researchers need to work together. Furthermore, actors from different sectors such as tourism, health, water and agriculture should be involved from the project planning stage, as needed.

**Box 5:** Better policy and management options for pastoral lands: Assessing the trade-offs between poverty alleviation and wildlife conservation

A project to improve management of pastoral lands was designed to create the knowledge and relationships needed to enable poor Maasai agro-pastoral communities to influence local and national land use policies affecting their livelihoods. These were policies related to access to pasture or water, and the sustainability of biodiversity (wildlife) in the areas where they live. Researchers worked closely with communities in four principal large landscapes in Kenya and Tanzania to generate new knowledge that would contribute to:

- ▶ understanding the impact of livestock-wildlife systems on biodiversity;

- ▶ understanding the implications of changing land-use practices on pastoralist livelihoods and the environment;
- ▶ defining processes and actions that would empower local communities to improve management of their livestock and landscapes; and
- ▶ determining and supporting policy changes that would help alleviate poverty and conserve natural resources.

The research was carried out by an integrated community-facilitator-researcher team that represented a wide array of collaborating institutions. The information from the project was exchanged with communities and policy makers through various means, including: feedback workshops, target group presentations, conferences, community meetings, posters, policy briefs, radio programmes, exchange visits of local communities and field visits of pastoralists from other parts of the world.

Some of the tangible benefits of this project at the local level included the provision of information and advice on appropriate improved livestock breeds, livestock marketing and rangeland conditions by the collaborative team. As a result, community members began accessing and using improved sheep and cattle breeds, increasing productivity and reducing incidence of disease. Participatory mapping of land use and wildlife catalysed inclusion of community members (for the first time) in new local and national policy debates and actions that affected pastoralists' livelihoods, the use of their lands and how they would benefit from wildlife conservation (Nkedianye, 2003; Reid *et al.* 2007; Nkedianye *et al.* 2009). In the study by Homewood *et al.*, (2009) and Reid *et al.*, (2009) on household economics that included research on an ecosystem-service payment programme to reduce poverty, the need for higher payments for services and the difficulties of managing such a scheme became evident. Local women's groups benefited from linkages to viable markets for their traditional Maasai artefacts and beadwork. Exchange visits with pastoral communities from other wildlife-rich sites in East Africa exposed these communities to alternative attitudes and livelihood options that successfully combined extensive livestock rearing and wildlife conservation.

## Women

The sixth principle suggests that livestock research and development efforts aimed at sustainable poverty reduction are more likely to be successful if poor women's access to, and benefits from, livestock are incorporated. The need to include woman is discussed in depth by Waters-Bayer and Letty in Chapter 3. A literature review by Tipilda and Kristjanson (2009) identified critical issues that affect, can enhance or limit opportunities for improved well-being of women and their families through

livestock-related activities. These included women's ownership and control of livestock and livestock profits, women's access to capital and livestock markets, and their health and nutrition concerns (both human and animal). They further reviewed the importance of urban livestock with regards to health and food safety, livestock services delivery, women's groups, and issues related to risk, vulnerability and climate change. They concluded that rigorous research and peer-reviewed articles in this area remain limited. Much of the knowledge on this topic comes from unpublished and non-academic sources, which provide valuable, but still quite limited, field experience and lessons as to what is working where, how and why with respect to livestock-related efforts that are enhancing the well-being of poor women and their families.

### 3. Conclusion

The conceptual framework presented in this chapter – based upon a set of working principles arising from the experience of a range of diverse projects and supported by literature – was developed to help increase the likelihood that livestock research for development efforts will contribute to poverty reduction and sustainable natural resource management. This experience led to the conclusion that how the research is conducted matters immensely. This seemingly simple statement has huge implications for future research and educational approaches. It implies, first and foremost, that including diverse partners is critical to such efforts. Complex partnerships are never easy. The objectives of individual partners and organisations vary considerably and will not always be initially aligned with overall project objectives. Furthermore, nurturing these partnerships generally involves fairly high transactions costs (particularly researchers' time). Therefore researchers need to be exposed to training tools, processes and strategies that help limit the transaction costs and increase the efficiency and effectiveness of such partnerships.

The length of time required to achieve desired outcomes and impacts must also be considered. Diverse project experiences suggest that outcome changes in behaviour, policies and institutions are achieved over periods of 5–10 years, much later than research outputs (knowledge, scientific papers, new technologies, people trained, etc.) are generated. Monitoring and evaluation take place within the project funding period, typically 3–5 years, and thus are destined to miss important institutional, environmental and behavioural changes. It is estimated that impacts of many sustainable development projects are not evident for 15–20 years (Walker, 2000; Adato and Meinzen-Dick, 2007).

Livestock researchers also have to realize that tackling technical constraints in these systems is seldom sufficient, due to existing and widespread institutional, market, gender-related and policy-related limitations. Including policy makers as integral

partners in projects through, for example, establishing a policy advisory group, is one strategy for addressing this. Projects that include gender analyses and participatory processes often succeed at identifying not only these types of constraints, but also strategies for dealing with them. Interdisciplinary teams that take a systems approach are more likely to have the necessary expertise to deal with these broader issues. Inclusion of biophysical scientists who look at aspects of the natural environment (e.g. water, soil fertility, biomass production) is essential to ensuring that farmers' livelihoods are not improved at the expense of long-term damage to the environment.

With respect to the huge challenges identified in this chapter, it is important to emphasize that there are many relevant tools, processes, lessons and strategies that can help research teams deal with these problems. These include, for example, processes aimed at efficiently and effectively developing public-private partnerships, learning platforms, joint outcome and impact strategies (Kristjanson *et al.*, 2009). The behavioural change needed for researchers to conduct this more inclusive research can be learned. Educators have a responsibility to ensure that the next generation of scientists learn how to conduct research based on the principles that have been outlined in this chapter.

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# 3

## Promoting Gender Equality and Empowering Women through Livestock

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### Abstract

Despite years of gender sensitisation in many institutions, the role of women in livestock production and in marketing animals and their products continues to be underestimated. Some encouraging initiatives do focus on women livestock keepers, but most projects still tend to assume that men are the major actors in livestock production. Such actions may strengthen the position of men versus women in households and communities. Key issues that influence gender equality when livestock-related interventions are made in the name of development are examined in this chapter. Particular attention is paid to the multifunctional and changing role of livestock, and the additional challenges faced by women livestock keepers in households confronted by HIV/AIDS. Several initiatives that have led to greater gender equality are highlighted, as these entail various forms of women's empowerment. From the review of livestock-related interventions, key lessons are drawn for the promotion of gender equality and women's empowerment through livestock. The foremost lesson is that gender analysis is a must, and it cannot be confined to a once-off exercise, as the situation changes over time. Moreover, only by recording processes and data in a gender-differentiated way can one monitor the impact of livestock interventions on women. Further lessons from the review include: the need to focus on women, as they need more support to attain equality with men; strengthen local women's organisations; improve women's and girl's access to education and training; recognise dynamism and openings for positive change in resource-poor households; and seek gender equality in livestock services and organisations. It is necessary for continued, deliberate and detailed efforts within agricultural research and development (R&D) institutions to focus attention on women through their policies. However it is also necessary to translate policies into their day-to-day practices, so that women can make a greater contribution to livestock R&D and can derive more benefits from it.

**Keywords:** livestock interventions, gender, equality, impacts, roles, ownership, control, information access, decision making

## 1. Introduction

Why should animal scientists working within developing communities be concerned about gender equality and empowering women? In essence, it is vital for improving animal production and thereby improving the livelihoods of millions of rural and urban households in these communities.

The recent upsurge of interest in women and livestock, such as the Challenge Dialogue on this topic initiated by the International Livestock Research Institute (ILRI, 2008), is partly in response to calls to attain the Millennium Development Goals (MDGs). It is increasingly recognised that livestock can contribute to reducing hunger and poverty (MDG 1) by providing food, income, transport, insurance and other services to households. Moreover, experience has shown that low-cost investments in small-scale livestock keeping – a dairy cow, a few goats, a few chickens or guinea pigs – offer opportunities for women not only to increase household income but also to control a larger portion of it, thus reducing gender inequality (MDG 3). Increased livestock production for both home consumption and the market, diversification in income sources from livestock, and women's stronger positions as livestock owners helps reduce their families' vulnerability to the impacts of HIV/AIDS and other diseases, thus contributing to MDG 6. Recognition of these links between livestock production and tackling hunger, gender inequality and vulnerability to debilitating diseases has helped turn the development spotlight on women and livestock.

Above all, attention needs to be given to women with a view to alleviating poverty. As was succinctly expressed by ILRI when launching the Challenge Dialogue:

*"Poverty has a woman's face. Women do two-thirds of the world's work and produce half the world's food yet earn only a tenth of the world's income and own less than a hundredth of the world's property. Of the 600 million poor livestock keepers in the world, around two-thirds are women" (ILRI, 2008).*

After decades of gender sensitisation and efforts to mainstream gender in agricultural research and development (R&D) organisations, women continue to be overlooked in many livestock-related interventions. There is still a strong tendency for project planners and implementers to assume that the major actors in livestock production are men, particularly when large ruminants such as cattle or camels are involved. These projects may unknowingly strengthen the position of men versus women if they:

- ▶ deprive women of traditional realms of responsibility, social recognition and income in the livestock sector;
- ▶ prevent women from benefiting equitably from various development initiatives;
- ▶ ignore possibilities of involving women in livestock activities that were traditionally in the realm of men; and

- ▶ restrain women from fulfilling their full potential to contribute to development.

Fortunately, the situation has improved over the past 20–30 years. Since the late 1980s, NGOs such as Heifer International and FARM-Africa have recognised the role of livestock in alleviating poverty in rural communities and in strengthening the position of women in these communities. Additionally, in the last few years, international funding organisations such as IFAD (Niamir, 1994), bilateral development organisations such as Germany’s GTZ (Richter, 1997), and national professional organisations such as the Ethiopian Society for Animal Production (ESAP, 1998) have given increased attention to gender issues. Numerous studies have revealed the gender impacts of interventions in livestock systems and have led to guidelines in dealing with gender issues in livestock-system development, including livestock-related interventions to help households affected by HIV/AIDS (e.g. FAO, 2005; IFAD, 2009; World Bank *et al.*, 2009).

Nevertheless, it appears to be difficult for many specialists in animal production R&D to relate these findings on gender issues to their own work. Appreciation of the roles of women in livestock husbandry and of the values that women – half of humanity – place on different products and services of livestock will deepen the understanding of multifunctionality of livestock in developing communities. This, in turn, should give direction to research and interventions that strengthen the functions of livestock that are for alleviating poverty in both rural and urban areas.

## 2. Gender impacts of livestock-related interventions

Interventions in livestock systems will have different impacts on women and men and, at the same time, the possibilities of success of these interventions will depend on gender-related differences in the following areas:

- ▶ **Roles and responsibilities:** Women do much of the daily work with livestock behind the scenes, meaning that their roles and responsibilities often are not immediately obvious to people coming from outside the community. In settled mixed-farming systems, women and girls usually carry out most of the work related to collecting and cutting feed, bringing water and cleaning pens. If interventions are aimed at intensifying livestock production, such as by shifting from grazing to stall-feeding systems or by keeping potentially higher-yielding but also higher-demanding breeds, it is highly likely that the workload of women and girls will increase due to the fact that intensification lies in their traditional tasks (Okali & Sumberg, 1985; Wangui, 2008). In many livestock systems, women customarily care for sick and very young animals kept near the home. If only men are trained to be community animal health workers or “paravets”, women’s role in animal healthcare is undermined and their knowledge assets are underused. Similarly, when livestock

research is conducted in realms where women normally do most of the work, a major part of relevant local knowledge is foregone if the researchers interact only with male household heads rather than including the female members of the household.

- ▶ **Ownership and control over livestock and livestock products:** In some societies, women may “own” some animals (e.g. having brought them into the family upon marriage or acquiring them later through inheritance) but have little say about selling or slaughtering them (Talle, 1988). However, in other societies, women may have a say, even though they do not “own” the animals (Oboler, 1996). Women often have rights to use the milk, but there are big differences in the extent to which they control the proceeds from selling it. In some societies, the proceeds go to the husband, while in others, the husband has no idea how much his wife earns through milk sales (Waters-Bayer, 1988). If interventions demand additional work by women who have little control over the products, then their motivation to participate is likely to be lower – as will the level of improvement in livestock production.
- ▶ **Access to livestock services and markets:** Livestock extension, input-delivery and financial services staff are usually dominated by men who are most likely to talk with male family members about, for example, how to improve livestock feeding and housing. The women and girls who carry out the actual work receive the relevant information only indirectly, if at all. Information days are often held for existing groups, such as livestock associations or dip-tank committees, which tend to be composed mainly or purely of men. In some parts of the world, particularly in Moslem areas, there are cultural barriers to direct communication between male advisors and rural women, and as a result, women do not have the same access as men to information that could help increase their work efficiency and productivity. Time-consuming training sessions held far from the women’s homes may not fit into their busy daily work schedules (including care of livestock), and some men may forbid their wives to attend such training. Women are usually less mobile than men and find it more difficult to access services and obtain relevant information. In many countries, because of changing economic circumstances, women are taking on responsibilities for types of livestock that had traditionally been the realm of men, such as cattle in southern Africa. However, livestock service providers are often oblivious to women’s changing role and do not give them enough technical, organisational and capacity-building support.
- ▶ **Decision-making powers regarding the use of production resources such as land, water or purchased inputs:** If men migrate to seek labour elsewhere, as has happened on the group ranches in Kenya, an increasing number the women cannot exert control over land use or group governance, and their families were

disadvantaged (Mwangi, 2005). In central Nigeria, where pastoral women of the Fulani ethnic group are highly involved in informal milk marketing, a study revealed that about one-third of the total cash income of the Fulani households came from milk sales. This was a regular source of income with which the women could meet the family's daily needs. Interventions intended to increase milk production by encouraging Fulani men to grow improved pastures and to feed supplements to cows did not lead to significantly higher milk offtake/yield, because the men did the milking and thus controlled the offtake, but the women controlled the income from milk sales and decided how this was used. The women seldom invested the milk income in the inputs needed for pasture and feeding, this being the role of men. The men controlled the income from animal sales, so targeted the use of the inputs and the intensity of milking with a view to reducing animal mortality and increasing livestock offtake rates, i.e. meat rather than milk production (Waters-Bayer, 1988).

If these factors are not considered when planning livestock interventions, if prior analysis is not made of possible gender impacts and if unexpected gender impacts are not identified frequently and mitigating action taken, the outcomes of development projects may be quite different than intended and gender inequality may even be worsened.

### 3. The additional burden of HIV/AIDS

In many parts of the world, gender inequality makes women more vulnerable to HIV and AIDS and the additional burden of HIV/AIDS can exacerbate gender inequality. This is reflected also in the rights (or lack thereof) of women in families affected by HIV/AIDS to livestock and in the attention (or lack thereof) of livestock services to the particular needs and opportunities of women involved in livestock keeping.

Where a woman owns few or no animals, where her rights to use livestock and land depend on her husband and she has no rights to inherit, she may completely lose her access to these resources when her husband dies (Bekele and Padmanabhan, 2008). She becomes dependent on surviving male family members for continued access to accommodation and means of subsistence, if she is not shunned completely, as may happen where the HIV/AIDS stigma is great. Even where legislation is meant to prevent asset grabbing, there are still often cases of a husband's relatives taking the livestock and other resources away from a widow after the man's death. The woman thus loses her own and her children's source of food, income, draught power and fertiliser for crop production (FAO, 2000). Yet such families – if they are themselves living with HIV/AIDS – are in particular need of the nutritious food (milk and meat) provided by animals, in light of the important role of nutrition in AIDS treatment (Randolph and Sammons, 2005; Waters-Bayer *et al.*, 2005).

There are cases where the wife and children may keep the livestock when the male head of household dies and may assume responsibilities for managing them. However, their lack of access to livestock extension and credit services compared to that of the man may leave them without the knowledge and support needed to manage the livestock effectively (Haslwimmer, 2000).

Livestock services need to address these gender dimensions that can lead to even greater inequality and vulnerability of women in HIV/AIDS-affected households. They need to guide women in using livestock to help reduce the impacts of the disease.

#### 4. How livestock interventions can favour gender equality

There are positive examples of projects that focus on people-centred rather than purely livestock-centred development, as well as specific examples of working with and empowering women livestock keepers. In such cases, women are gaining opportunities to generate income, improve family wellbeing, and gain more self-confidence and influence in the community. Reducing poverty with a woman's face means not only increasing economic assets but also increasing women's capacities, their power to act and to change the rules that govern control over resources (Sparr and Moser, 2007). It includes increasing both women's and men's capacities to question the established order of the day and to gain a greater say in societal decisions above the level of the household and local community.

The impact of livestock interventions on women's equality therefore cannot be measured only in terms of increased economic status of the women compared with men. It should also be measured in terms of reduction in their work inputs compared with benefits they perceive and changes in their relative contribution to decision making at various levels. The following examples illustrate how this has been achieved through livestock-related support.

**Heifer International**, formerly known as Heifer Project International (HPI), launched a Women in Livestock Development (WiLD) initiative in its programmes throughout the world 20 years ago. WiLD sought to empower women by creating opportunities for them to own more livestock. HPI provided women with cows, goats, buffalo or poultry, but also other resources needed for livestock production, such as easier access to water. It offered training in literacy and numeracy, strategic planning and gender equity, so as to strengthen women's positions in the community. Given these opportunities, women were able to generate and handle income for the benefit of their families. HPI found that, for families and communities to bring about real change toward gender equality, both women and men had to be involved in planning and analysing the outcomes of the women-focused activities (Miller, 2001; Tipilda and Kristjanson, 2008).

**FARM-Africa**, an NGO based in the UK and working in southern and eastern Africa, has provided support to increasing women's access to resources and skills for livestock keeping. It has made small-scale credit available to individual women within groups, initially to buy goats. Over time, some of the women started investing in other stock, such as cattle, and in other income-generating activities, using the income from the livestock. FARM-Africa has also trained women as paravets to treat basic ailments, especially in goats (Peacock, 2005). Several other NGOs have also provided small amounts of credit to individual women and women's groups that allowed them to invest initially in small animals such as poultry and goats and eventually in cows and bullocks, such as landless women in India who have started renting out bullocks to farmers for ploughing (Todd, 1998). Such initiatives involving small-scale credit have been most successful when combined with development of women's technical, marketing and managerial skills (Tipilda and Kristjanson, 2008).

**Pastoral Risk Management (PARIMA)**, under the American-funded Collaborative Research Support Program (CRSP), is enhancing pastoral women's ability to organise themselves so as to strengthen their negotiating position and access to benefits. For example, the project has supported women in southern Ethiopia to learn from pastoral women in northern Kenya about how they organise themselves to undertake social and economic activities based on savings and credit, income diversification and small enterprise development. Livestock income provides capital for small non-livestock business ventures, and *vice versa*. The women feel empowered, as their incomes have increased and their livelihoods have been diversified (Coppock *et al.*, 2008).

**National Dairy Development Board (NDDB)** of India has helped form cooperatives for family-based dairy development and has placed great emphasis on women's education and participation in these circumstances. It has trained women extension workers so that they can help strengthen the role of female members in governance of the cooperatives. Through the Women's Dairy Cooperative Leadership Programme, women in livestock-keeping households have gained more control over the sale of milk and the use of income from it. Men were sensitised to the role of women in dairying, while women were encouraged to join dairy cooperatives, to assert their rights as members and to stand for membership of managing committees. It was a slow process but, after a decade, the percentage of women members in the dairy cooperatives rose from 14 percent to over 20 percent (Patel, 1998).

**Institute of Indigenous Studies at the University of Chiapas, Mexico**, invested time in learning about the role of women and culture in the husbandry of Chiapas sheep by Tzotzil Indian families. Weaving traditional textiles is an important source of income and cultural identity for these families. For their specific purposes, the women have empirical criteria and a complex system of fleece grading, which is contrary to the



conventional definition of high-quality fleeces. Through identifying the local uses of livestock products and recognising the women's knowledge, the scientists changed their attitudes toward the illiterate livestock keepers and incorporated Tzotzil women as co-researchers in genetic improvement of local Chiapas sheep through selective breeding. For over ten years, the women's expertise in assessing fleece quality has guided this programme for site-specific breed improvement, taking into account the needs of smallholders living in this relatively remote mountainous area of Southern Mexico. Thus, participatory research has been institutionalised, based on local functions of livestock, locally-defined traits of economic and cultural importance, and locally identified requirements for improvement (Perezgrovas *et al.*, 2002).

**Promoting Local INNOVATION (PROLINNOVA)** operates in various countries in Africa, Asia and the Andes region, supporting innovation in ecologically oriented agriculture and natural resource management and encouraging agricultural R&D staff to recognise and stimulate women's innovativeness in livestock keeping. This raises the women's self-esteem in their own eyes as well as in the eyes of their communities and R&D staff, and gives the women confidence to engage in participatory research. Some examples of local innovation that have been discovered include Ethiopian women who developed improved beehives (Hailu *et al.*, 2007) and South African women who developed site-appropriate ways of improving poultry and goat husbandry and feeding (see Box 1). In some cases, these same women innovators have become local leaders in farmer-led experimentation to develop these technologies further. They have access to local innovation support funds for their experimentation and can use these funds to draw in the expertise of external advisors. Village women are among the members of the selection committees that decide on allocation of the innovation grants to farmers. This experience may eventually prepare these women for representing farmers in higher-level entities that decide on R&D activities and funding.

**Box 1:** Examples of innovation by women livestock keepers in South Africa

**Collecting eggs.** At a PROLINNOVA–South Africa workshop, an extension officer presented the case of Mrs Sarah Martha Mbuyisa of KwaMhlanga, Mpumalanga Province, who had developed a system of raised grass baskets in which her hens lay eggs which made it easier and quicker for her and her children to find the eggs. The innovation also increased productivity (J S Maphosa, Pers. Comm., Mpumalanga Department of Agriculture and Land Administration, Nkangala District Office, 2008).

**Herding goats.** In Msinga, KwaZulu-Natal (KZN), many households have indigenous goats and women in the household are often involved in managing them. The goats

go out to graze during the day and must be brought home in the evening so that they are not stolen or taken by predators. Because the goats must cover long distances to be able to find enough feed, much time is often needed to find them and bring them home at night. Development workers documenting local innovations encountered Mrs Maduba Mbila, who had found a way of ensuring that her goats returned to the homestead every evening on their own accord. She offered them various palatable leafed branches (e.g. *Schotia brachypetala*) and water when they return to the holding pen. This innovation saved her time that she would otherwise have had to spend fetching the goats (Swaans and Malinga, 2006).

## 5. Lessons from experience

From studies of gender roles and relations in livestock-keeping households and communities, and from experiences over the past several decades in research and development related to livestock keeping, some lessons can be drawn for promoting gender equality and women's empowerment through livestock.

### *Gender analysis is a must*

A first essential step towards addressing gender inequality in livestock-system development is gender analysis. Planning of interventions should not be based on assumptions of gender roles derived consciously or unconsciously from other cultures or other areas, even of the same country. Research and development agencies tend to plan on the basis of over-generalisations. This may seem to make planning easier, but does not necessarily help in achieving the objectives of the plan. For each area in which livestock interventions are foreseen, it is vital to understand the actual situation of the local women, men and children – not how it was or how it should be, but how it is.

Gender analysis leads to better understanding of: i) gender relations in livestock-keeping households, division of livestock-related work between women and men, and differences in their access to and control over productive resources, ii) women's and men's needs and interests, and opportunities to support them in an equitable way, iii) constraints to women's involvement in livestock development and how these might be overcome and iv) different expected and – over time – experienced impacts of livestock-related interventions on women and men, and how to address the consequences.

Gender relations and customs can differ markedly between ethnic groups, even within one country. In some societies, e.g. among the Zulu in South Africa, women of child-bearing age are not allowed to enter the cattle holding pens and therefore cannot

handle or treat animals where they are kept overnight. Yet, in other parts of Africa, women are often responsible for the care of sick and weak cattle and other animals. In India, in scheduled caste families (a population grouping officially recognised by the national constitution as being previously “depressed classes”, such as indigenous peoples and untouchables), the elderly men care for livestock kept near the house; in non-scheduled caste families, the elderly women do so. In scheduled caste families, most wage-earning women give the money to male members of the family and have little say in how it is used; in non-scheduled caste families, most women – even if they do not generate income directly themselves – have a say in how the household income was used and hold joint bank accounts with their husbands (DARE/ICAR, 2007).

Nevertheless, some similarities can be found across several countries and ethnic groups with respect to gender patterns for ownership and care of livestock. The family members who keep backyard poultry and other small stock near the home are often the women and girls. In most parts of the world, women can decide about vaccinating, slaughtering and selling of poultry without consulting their husbands, and they control the income from selling poultry products (IFAD, 2007). Likewise, milk processing and marketing in the informal sector tend to be women’s work, even where women are not involved in the actual task of milking. This means that livestock research and development activities that focus on poultry and other small stock and on small-scale dairy development are likely to be – or should be – concerned with women and could provide opportunities to improve women’s positions.

**Box 2:** Important contribution by pastoral dairywomen to family income

In pastoral societies, at least in Africa, women are involved in the milk trade to a far greater degree than most development planners assume. Women buy milk from other women in villages, produce fermented milk products, and sell them on larger markets, sometimes in combination with cereal products. For example, the Fulani women in West Africa sell *fura da nono* (spicy millet balls mixed with sour milk). They have complete control over the income from marketing dairy products. Compared with the proceeds from selling live animals, the earnings of pastoral women can constitute a significant and crucial income. In Nigeria, it was found that the milk trade generated up to one-third of a household’s annual income and provided regular income that the women used to meet basic household needs, while the men sold live animals only sporadically and used the proceeds for larger once-off expenditures or investments (Waters-Bayer, 1988).

Within gender analysis, the dynamics in the roles of women need to be recognised. Roles and responsibilities can change with a woman’s age, for example. In many parts of Africa, a young milk maid making butter under her mother’s supervision eventually becomes the manager of her own small-scale dairy operation and, with

increasing age, may also take on increasing responsibilities for deciding on herd management and in owning stock purchased with her own earnings. Women are also taking change into their own hands, without the support of development projects. In northern Ethiopia, for example, some women have challenged the cultural taboo against ploughing by women. Widows and other female household heads started to do their own ploughing with oxen or donkeys, and a few are even earning additional income by ploughing for other male and female farmers on a sharecropping basis (Fetien *et al.*, 2001).

Changes in gender roles also occur in families and communities under stress, e.g. because of labour shortages due to illness or death of family members, or because of changing socio-economic conditions. In many parts of the developing world, when male family members migrate to seek wage labour outside of agriculture, the women take over the tasks of managing the crops and animals – not only the small but also the large stock. There may be considerable differences, however, in the extent to which the women can make decisions about disposal of the animals without having to consult male members of the family, who may return home only once or twice a year (see Box 3).

**Box 3:** Loss of livestock income and assets because of inability to decide

In South Africa, where men often work far away from their homes, women – assisted by their children – play an important role in the day-to-day care of all types of livestock. However, they may not be in a position to make major decisions such as selling or treating an animal, and they normally rely on their husbands to purchase veterinary drugs. At cattle sales, a woman selling an animal on behalf of her husband sometimes cannot decide to sell at a lower price than stipulated by her husband and returns home with the animal instead. The danger to household assets caused by women's lack of decision-making capacity was also evident in a case encountered in South Africa, where a researcher visited a household where a female goat was having difficulties in kidding. The woman in the homestead had not intervened because her husband was not there and she did not have the authority or confidence to decide. She was comfortable, however, for the outsider to intervene. With little effort, the kid was freed – unfortunately, already dead. Without this intervention, the mother goat would probably also have died.

Because many gender issues become evident only during the course of interaction between R&D professionals and local people, and also because changes occur over time, gender analysis needs to be repeated at intervals. To be able to see whether there is any positive change toward gender equality and where greater efforts need to be made to get there, it is extremely important that the processes and data be

recorded and differentiated according to sex. Still, after decades of experience in monitoring and evaluating development projects, the data collected are still seldom differentiated by gender. Why is it so difficult to distinguish between and count women and men – the most basic data needed to be able to assess progress in achieving gender equality? This is to say nothing of other, in-depth information about women’s and men’s changing perceptions of their roles, relations and influence on decision-making.

### *Focus on women*

The shift in approach over the years from looking at *women* in development to looking at *gender* in development has sometimes led to a loss of focus, with the result that insufficient attention is paid to those who need most support to attain equality, this being the women. It is easy to include a superficial reference to “gender inclusiveness” in official documentation but, when one looks at the actual activities and decision-making roles in such supposedly gender-inclusive livestock projects (e.g. the Industrial Development Corporation Nguni Project in South Africa, Mabunda, 2008), it is often difficult to find evidence that rural women are involved or that attention is being given to the impacts these projects may have on women.

In a recent review of project interventions related to gender and livestock, ILRI found that cases with positive impact on women were those that focused on women – rather than integrating women into main project activities – and specifically those that dealt with dairy-product marketing, building women’s capacities to manage livestock and improving women’s access to livestock marketing, health services and information (Tipilda and Kristjanson, 2008). Women in developing countries usually have lower literacy levels than do men. They usually have less access to land or other collateral for loans. They also tend to have fewer opportunities to travel long distances even within the district, let alone to other parts of the country. These and other specificities of women mean that they need to be targeted specifically and deliberately. To be gender-inclusive, it is certainly not sufficient for projects to state that they are benefiting “communities”, it must be made clear what this means specifically for men and for women within the communities.

Focusing on women in livestock keeping starts with focusing on the livestock they keep and on their livestock-related tasks which can be identified through gender analysis. The most promising interventions for women in resource-poor households appear to be small-scale, low-external-input income-generating activities involving goats, dairy cows, poultry and other small livestock such as guinea pigs, bees and silkworms, including not only production but also processing and marketing. Attention must be given to reducing women’s workloads for activities such as fetching water and feed, cleaning pens, small-scale processing of livestock products and transporting

products to market. Considerable success in promoting livestock keeping by women has been achieved by making small-scale credit available to women's groups.

### *Strengthen local women's organisations*

Particularly good results in empowering women have been gained through encouraging women to organise themselves around production and/or processing of livestock products. It is usually easier for groups of women rather than individuals to access resources for production, also through credit, and to achieve economies of scale in marketing the products. Groups also offer a "safer" setting for male researchers and extension agents to work together with women, compared with visiting individual households. Moreover, it is more time efficient for agricultural R&D staff – whether male or female – to reach a large number of women if they can contact them through groups. Existing informal groupings – whether traditional or more recently developed by the women themselves – can provide good starting points for enhancing women's managerial and leadership skills. This can eventually lead to women becoming more active in community-based organisations involving both men and women.

### *Improve women's and girls' access to education and training*

Women and girls need better access to general education as well as to specific training and information related to livestock keeping. To improve livestock husbandry and value addition to animal products, women need to be trained directly, not through second-hand information via male family members. They need training in literacy and numeracy, small-enterprise management, and group management and leadership.

Extension agents for crop and livestock husbandry are usually male, whereas those for home economics – in countries where such advisory services are offered – are usually female. If female agricultural extension and home agents are trained in livestock production, marketing and participatory experimentation for local adaptation of technologies, they will be able to give relevant support to rural women. Extension staff – both male and female – should also be capacitated to facilitate community discussion on gender issues that affect family welfare, such as property and inheritance rights to livestock, land and other resources, particularly where HIV/AIDS is destroying traditional safety-net systems for widows and orphans. Rural women can more easily take part in training and other extension activities that take place in or near their villages rather than in district towns. Ways need to be explored further to improve women's access to livestock information, such as through radio and village-based information and communication technology (ICT), and their access to livestock services such as veterinary care, e.g. by training both men and women as paravets. In addition, where transmission of knowledge and skills to younger

generations is being ruptured by HIV/AIDS, civil war and disasters, it is vital to offer orphaned girls and boys possibilities to develop their livestock knowledge and skills.

### *Recognise dynamism and openings for positive change*

Livestock plays multifunctional and changing roles in poor households, especially those that are confronted by rapid changes in their livelihood possibilities, such as pastoralists obliged to settle or families affected by HIV/AIDS. In efforts to survive despite these changes, local people develop their own coping mechanisms and adaptations and explore alternative ways of making livelihoods from livestock, such as the women in Ethiopia who started to plough using animal traction and experimented with using donkeys instead of oxen for ploughing (Fetien *et al.*, 2001). In response to changes in settlement patterns and in transport and communication possibilities, some women have developed new ways of organising themselves and collaborating with men (e.g. truck drivers) so as to gain better access to more lucrative markets for livestock products, such as in areas of Somalia, Sudan and Nigeria (Nori *et al.*, 2006; Pantuliano, 2002; Waters-Bayer, 1988). Many of these innovations, including changes in women's roles and activities, serve to maintain or enhance the multiple functions of livestock.

It is especially necessary to recognise and understand how women and men in resource-poor households are responding to change as a positive starting point for joint development efforts. This is in contrast to the conventional approach of dwelling on problems to be solved with outside support. The endogenous innovations can become foci for community discussions about what advantages and disadvantages these bring for families and communities, and how the new ideas can be further improved and spread. This approach not only reveals low-cost ideas for improving livelihoods, it also generates pride and self-confidence and some hope in the face of adversity, such as in women struggling to deal with the effects of labour migration or HIV/AIDS.

Thus far, the work of PROLINNOVA partners in exploring women's innovativeness suggests that giving recognition to this benefits not only the women but also contributes to finding paths towards pro-poor development. In northern Ethiopia, Fetien *et al.* (2001) found that women are more likely to develop low-external-input innovations that suit resource-poor households. This has been confirmed by more recent work in South Africa, where ingenious women are using locally available resources to improve the husbandry of goats and chickens (see Box 1). Moreover, women appear to be more open to sharing their new ideas than men, who tend to be more possessive and want to "protect" their knowledge. However, even in countries such as South Africa, where a large number of women innovators have been identified among rural people, it is the men who have the confidence and time to display their accomplishments at

innovation markets or agricultural fairs (Salomon, 2008). Thus, there is still some way to go to heighten women's self-confidence and to create enabling conditions for them to make their innovations and their own creativity more widely known, which also would serve to benefit others.

It is also important for research and extension staff to take the step from identifying female innovators to actually working together with them to improve their innovations or to explore together with them how to address the challenges they are facing. This will show that they truly value the input provided by these creative women. The extension worker with the Mpumalanga Department of Agriculture in South Africa has not only showcased the innovativeness of Mrs Mbuyisa with her chicken nests (see Box 1), but has also started working with her to improve her system further, e.g. by growing supplementary feed for the chickens to encourage them to stay at home rather than wandering to other households. Giving this woman the opportunity to share her knowledge with other farmers has further strengthened her self-confidence as well as the gender sensitivity of the Department.

Not only in South Africa but also in many other parts of the world, women in crop-farming and pastoral societies often lack confidence and undervalue their own achievements. Therefore, important steps to empower women are to raise awareness of how they contribute to livestock development through their own innovation and to support this innovation process.

### *Seek gender equality in livestock services and organisations*

In addition to recognising the situation and seeking gender equality at grassroots level, it is also necessary to sensitise people in organisations working with livestock keepers (research, extension, education, private sector) about gender issues at the grassroots level and to seek gender equality in these very organisations. Although their numbers are growing in relative and absolute terms, particularly in the industrialised countries, women are still in the minority among graduates in animal sciences, range and pasture science and veterinary medicine, as well as in research, development and education institutions concerned with livestock production.

Over the years, the Gender and Diversity Programme within the Consultative Group for International Agricultural Research (CGIAR) has worked to improve this situation by helping the 15 international agricultural research centres in the alliance to capitalise on their staff diversity so as to enhance their research and management capabilities. It promotes an organisational culture of inclusion and opportunities for women and for people from different areas and backgrounds. Also other international organisations such as FAO and IFAD have sought gender equality in their policy and practice, e.g. in recruitment. However, we are still a long way from a gender



balance in agricultural R&D organisations and governing bodies. Beintema *et al.* (2010) found that, on average, women made up less than 22 percent of professional staff trained in animal sciences in 15 African countries. At higher policy-making levels and on the international level, the imbalance is even greater. The Chief of FAO's Animal Production Service estimates that women make up no more than 10 percent of participants in professional and inter-governmental meetings related to animal production (I. Hoffmann, Pers. Comm., 2008). This imbalance could partly explain the weak capacities and interest at lower levels to give due attention to gender equality.

## 6. Conclusion

Experience in many parts of the world has shown that, if women's roles and responsibilities in animal production are recognised, if women have more rights of ownership over livestock, if women have better access to livestock services and markets, if women have more say in decision-making about inputs and outputs of animal production and have more control over the income from this, then family welfare can be improved and poverty and hunger can be reduced. In addition to meeting the basic needs of women and their families, enhancement of the role of women in the livestock value chain helps address their strategic needs, giving women a higher status in their own eyes, in the eyes of men, of children and elders, and in the community. It thus strengthens their self-confidence and self-reliance to take greater control over their own lives and to make a larger contribution to the community and beyond.

Applying a gender lens in livestock-related interventions means paying particular attention to: i) their implications for women's workloads; ii) their implications in terms of women's control over the means of production and benefits from it; and iii) their use and enhancement of the knowledge and innovativeness of women, e.g. through their participation in adaptive research at grassroots level.

A major contribution to focusing attention and action on empowering women through livestock can be made by spreading powerful images of women who use livestock to meet family and community needs and to address their strategic interests. In the livestock sector, the spotlight needs to be put on local women and women's groups who are innovating, who are taking collective action to solve their problems and who are openly expressing their views about the changes they seek. The spotlight needs to be put on cases of women taking an active part in decision-making bodies in the communities, in project planning, as partners in livestock research and development, and as members of related advisory groups. Such high-profile documentation would give strong messages to women and men at all levels about women's actual and potential contributions to livestock production, and help to change perceptions and

attitudes at all levels. It will be especially important that these messages be conveyed in educational institutions from primary school up to university level.

But even then, if the message becomes widely spread and known, it will still be necessary for continued deliberate and detailed efforts within agricultural R&D institutions not only to include focus on women in their structures and policies but also to translate the policies into their day-to-day practice, so that women can make a greater contribution to livestock R&D and can derive more benefits from it.

Many misconceptions and prejudices related to women in livestock keeping still prevail after so many years of gender sensitisation. It is obviously an uphill struggle to change the perceptions of many agricultural R&D professionals about the contribution that women can make to livestock development and the contribution that livestock can make to enhance the economic and socio-political status of women. However, there are some positive examples of such change and this need to be celebrated and made more widely known.

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# 4

## The Way Forward for Livestock and the Environment

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### Abstract

Livestock provide many benefits to society, but at the same time, they generate considerable pressure on land, water and biomass resources and are responsible for 18 percent of total greenhouse gas emissions. The total demand for livestock products may almost double by 2050, mostly in the developing world due to increases in population density, urbanisation and incomes. At the same time, existing trade-offs and competing demands for natural resources with other sectors will intensify, making it necessary to take a combination of measures to reduce the environmental footprint of livestock production. Measures such as sustainable intensification of crop-livestock systems, payments for ecosystem services, income diversification in pastoral systems, regulation of industrial systems and livestock-product demand management could play a significant role in ensuring sustainable livestock production, livelihoods and environmental protection. This chapter examines the main environmental interactions of livestock production and suggests ways to improve them.

**Keywords:** environment, livestock

### 1. Introduction

Livestock systems, especially in developing countries, are changing rapidly in response to a variety of drivers. Globally, the human population is expected to increase from around 6.5 billion to at least 8.2 billion by 2050 (Rosegrant *et al.*, 2009). More than 1 billion of this increase will occur in Africa. Rapid urbanisation and increases in income are expected to continue in developing countries and consequently, the global demand for livestock products will continue to increase significantly in the coming decades.

Livestock systems have often been the subject of substantial public debate because, in the process of providing societal benefits, some systems use large quantities of natural resources, cause pollution and emit significant amounts of greenhouse gases.

Considering that the demand for meat and milk is increasing, and that livestock is only one of many sectors that will need to grow to satisfy human demands, more trade-offs in natural resource use can be expected. This chapter examines the key global livestock livelihoods and environment linkages. These linkages not only have global consequences, they also have local impacts on livelihoods and the environment.

This information is used to propose research and development areas that require further attention in order to move the debate on livestock and environment from one that often exacerbates the negatives to one that embraces the complexity of livestock systems and tries to find solutions so that livestock can continue to provide important livelihood benefits while improving the sustainability of agro-ecosystems.

## 2. Livestock: A key global commodity

Livestock systems occupy 45 percent of the global surface area (Reid *et al.*, 2008) and are a significant global asset with a value of at least US\$1.4 trillion. Globally, livestock industries are also a significant source of livelihoods. They are organised in long market chains that employ at least 1.3 billion people globally and directly support the livelihoods of 600 million poor smallholder men and women in the developing world (Perry and Sones, 2007). Keeping livestock is an important risk reduction strategy for vulnerable communities, as animals can act as insurance in times of need. At the same time, they are important providers of nutrients and traction for growing crops in smallholder systems (Herrero *et al.*, 2010). Livestock are also an important source of nourishment. Livestock products provide 17 percent of the global kilocalorie consumption and 33 percent of protein consumption globally, but there are large differences between rich and poor countries (Rosegrant *et al.*, 2009).

## 3. Livestock and land-use change

Land inextricably links livestock to natural resource management. Livestock is the largest land-use system on Earth in terms of feed production, grazing, water and nutrient use, and biodiversity largely depends on land use and its potential change (Lambin *et al.*, 2001).

Different types of livestock systems have different impacts on land use and its change. Some of these impacts are direct and others indirect (Reid *et al.*, 2008 and Steinfeld *et al.*, 2006). They are explained below.

### *Land-use change and evolving livestock systems*

Livestock systems are evolving at rapid rates, especially in the developing world (Herrero *et al.*, 2009). Several theories of agricultural intensification and change exist to explain this phenomenon (McIntyre *et al.*, 1992 and Baltenweck *et al.*, 2003) and several types of transitions can be observed.

***From pastoral to agro-pastoral systems.*** This transition occurs as a result, for example, of pastoralists having to become sedentary due to rangeland fragmentation, or because of social changes that demand income diversification and entry into the cash economy (Hobbs *et al.*, 2008). This transition does not occur in parts of the world where land is not suitable for cropping, and pastoralism remains the sole livelihood system.

Conversion of grasslands to croplands can result in loss of carbon (C) and fertility, increased soil erosion, decreased water quality through increased sedimentation, and non-point chemical pollution by salts, nutrients and pesticides (Safriel and Adeel, 2005). It can also contribute to further fragmentation and loss of traditional dry-grazing areas. It is therefore important to adjust livestock husbandry practices in order to avoid these potential negative side effects.

***From agro-pastoral systems to mixed crop-livestock systems with different degrees of intensification.*** This transition occurs mainly as a result of increased human population densities and associated increases in services and markets. In these systems, farm sizes usually decrease as population increases. Through the years, and in the absence of land for fallow, significant losses of soil fertility (carbon and other nutrients) often occur with subsequent decrease in farm productivity (Lal, 2004). At the same time, the value of livestock increases with its provision of manure for crops and of cash flow from the sales of animal products. In places with good market access, these systems could intensify sustainably by replenishing nutrients from inorganic sources and promoting better-regulated management practices.

In some cases, climate change is likely to reverse this transition, especially where losses in the length of growing period might reduce the possibility of cropping in marginal areas. Farmers may then have to revert to livestock rearing as their only viable livelihood system (Jones and Thornton, 2009). An example is shown in Box 1.



**Box 1:** Farming crops to keeping livestock: Livelihood transitions due to climate change

The impacts of climate change are expected to be generally detrimental for agriculture in many parts of Africa. Studies estimate that warming and drying may reduce crop yields by 10-20 percent overall by the middle of the century, with increasing frequencies of heat stress, drought and flooding events will result in even further impacts on crop and livestock productivity. The local effects of climate change may be severe in places, to the point where the existing livelihood strategies of rural people may be seriously compromised. These places are likely to include parts of Africa that are already marginal for crop production. As these areas become increasingly marginal, livestock may provide an alternative to cropping (Figure 1), especially in sub-Saharan Africa where such transitions are expected to occur.

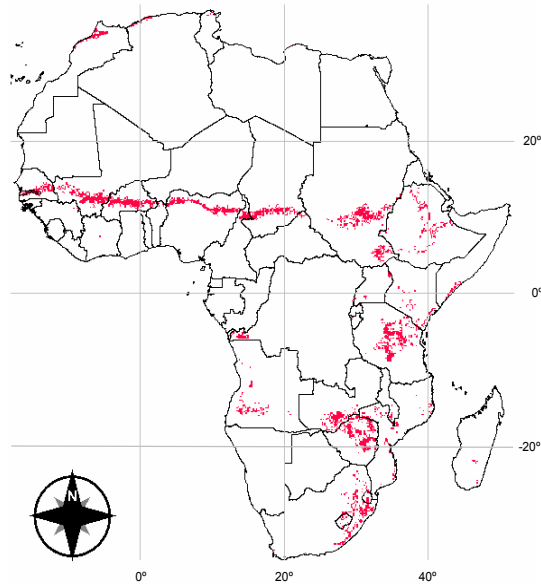
For the cropped areas of the continent, a recent study compared probabilities of failed seasons under current climate conditions, with estimates of future climate conditions (2050). Using a downscaled climate model output for two contrasting greenhouse-gas emission scenarios, the study indicated that even under a moderate greenhouse gas emission scenario for the coming decades, there are likely to be substantial shifts in the patterns of African cropping and livestock keeping by the middle of the century.

The potential livelihood transition zones that have been identified differ in their accessibility, which may have considerable impact on which adaptation options may be viable. For those that are relatively close to large human settlements, there may be options for both integration of livestock systems into the market economy and for off-farm employment opportunities. Those that are more remote, on the other hand, may have considerably more limited market and off-farm employment opportunities. There are significant populations of people in the more remote transition zones, who are widely spread throughout West, East and Southern Africa. Substantial changes may be required in people's livelihoods and agricultural systems if food security is to be improved and incomes raised.

The study also highlights the fact that poverty rates in the marginal cropping lands of Africa are already high, and generally increase as accessibility decreases. It is expected that there will be an increasing need in these areas for highly targeted schemes that promote livestock ownership and facilitate risk management where this is appropriate, as well as efforts to broaden income-generating opportunities in parts of the continent where this is feasible.

**Hotspots in the Mixed Rainfed Arid-semiarid (MRA) systems**

Areas where RCGD changes from  $> 90$  in 2000 to  $< 90$  in 2050 (HadCM3, A1FI)



**Figure 1:** *Crop farming to keeping livestock: Livelihood transitions to 2050 in Africa due to climate change (Jones and Thornton 2009)*

**From mixed crop-livestock systems to specialised industrial landless systems.**

According to Naylor *et al.* (2005), once market-orientated smallholder production systems have intensified to significantly close yield gaps in crop and livestock production, increases in efficiency gains and opportunity costs for the land determine their viability. As a result, farms tend to specialise, produce high-value commodities, or shift towards industrial and landless systems that have more limited dependence on labour and resources produced in surrounding areas. These systems, however, remain dependent on resources elsewhere and transport of raw materials, imports of grains, and heavy nutrient loadings due to large concentrations of animals become important issues (Steinfeld *et al.*, 2006). Studies also suggest that in sensitive areas these systems need to de-intensify or be regulated in order to ensure the viability of some ecosystems, notably water (Herrero *et al.*, 2009, 2010).

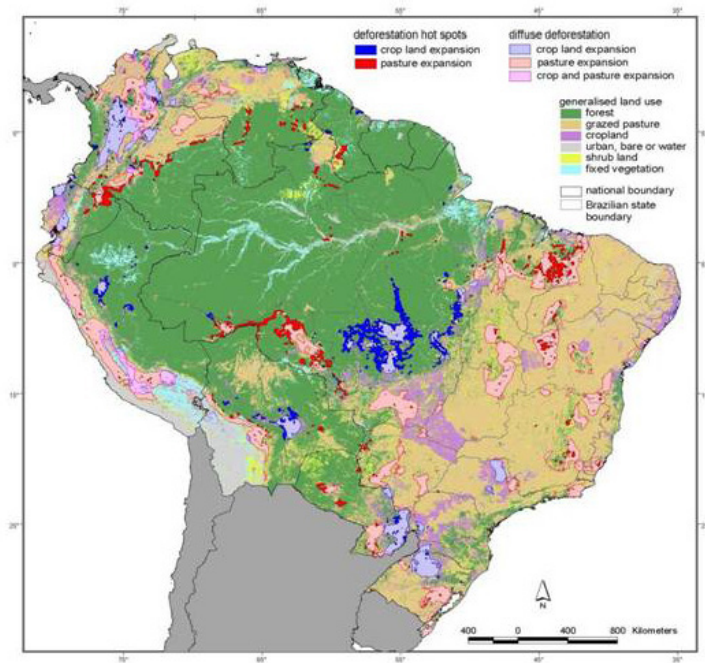
The combination of these systems is shaped significantly by agro-ecology, among other factors, which determines agricultural potential and makes certain systems predominant. A similar transition has occurred throughout Europe since the industrial revolution and is now the subject of significant environmental regulation (Haalberg *et al.*, 2005).

### *The livestock and deforestation debate*

The linkage between livestock and deforestation has been a topic of considerable research (Fearnside, 2005 and Nepstad *et al.*, 2006). The debate centres on two main phenomena related to different livestock production systems and their evolution.

**Forests into pastures.** The first phenomenon is the direct conversion of forests into pastures for extensive cattle production, primarily in the neo-tropics (Fearnside, 2005). According to several authors (Nepstad *et al.*, 2006; Morton *et al.*, 2006 and Wassenaar *et al.*, 2007), extensive cattle enterprises have been responsible for 65–80 percent of the deforestation of the Amazon (forest loss of 18–24 million ha/yr). Some of these systems are changing and intensifying towards mixed crop/livestock systems and dairy production (Morton *et al.*, 2006; Caviglia-Harris, 2005 and Kirby *et al.*, 2006) as a result of new roads and markets and conversion of pastureland into cropland (Fearnside, 2005 and Wassenaar *et al.*, 2007). This is expected to reduce deforestation rates as farmers increase efficiency and obtain more product per unit of resource used (Steinfeld *et al.*, 2006), although this view has been recently contested (Morton *et al.*, 2006).

**Forests into fields.** The second phenomenon is when forests are directly cleared for growing crops, such as soybeans, mostly to feed pigs and poultry in industrial systems and to provide a high protein source for concentrates in dairy cattle rations (0.4–0.6 million ha/yr) (Nepstad *et al.*, 2006 and Wassenaar *et al.*, 2007). The rate of forest loss to cropping is projected to increase as the demand for pig and poultry meat is expected to increase at faster rates than the consumption of red meats (Steinfeld *et al.*, 2006). The combined forest loss from cattle and feedstock production accounts for approximately 2.4 billion tonnes of CO<sub>2</sub> emissions worldwide (Steinfeld *et al.*, 2006). Figure 2 shows the areas in South America that are likely to experience forest losses as a result of these phenomena.



**Figure 2:** Predicted deforestation hotspots in South America 2000-2010 (Wassenaar *et al.*, 2007)

### Environmental impact of trade

Most soybeans are grown for export. This introduces the additional indirect effect of environmental impacts embedded in the trade of animal products or in resources for livestock production, in this case feeds (Nepstad *et al.*, 2006). The EU and China are the largest importers of soybeans from Brazil, making their livestock industries accountable for a part of the CO<sub>2</sub> emissions from the deforestation of the Amazon. The EU and China are slowly accepting their accountability, as the EU applies a trade regulatory framework and certification scheme for environmental compliance, but such schemes have proven difficult to apply locally (Nepstad *et al.*, 2006). Embedded CO<sub>2</sub> and methane emissions are becoming more and more relevant as countries trade greenhouse gas emissions globally in the form of carbon credits (IPCC, 2007). Several studies have also applied embedded emissions to ecological footprints (Haberl *et al.*, 2004), water (Chapagain and Hoekstra 2008) and some nutrients, notably nitrogen (Goulding *et al.*, 2008), but it will eventually be applicable to a range of other resources.

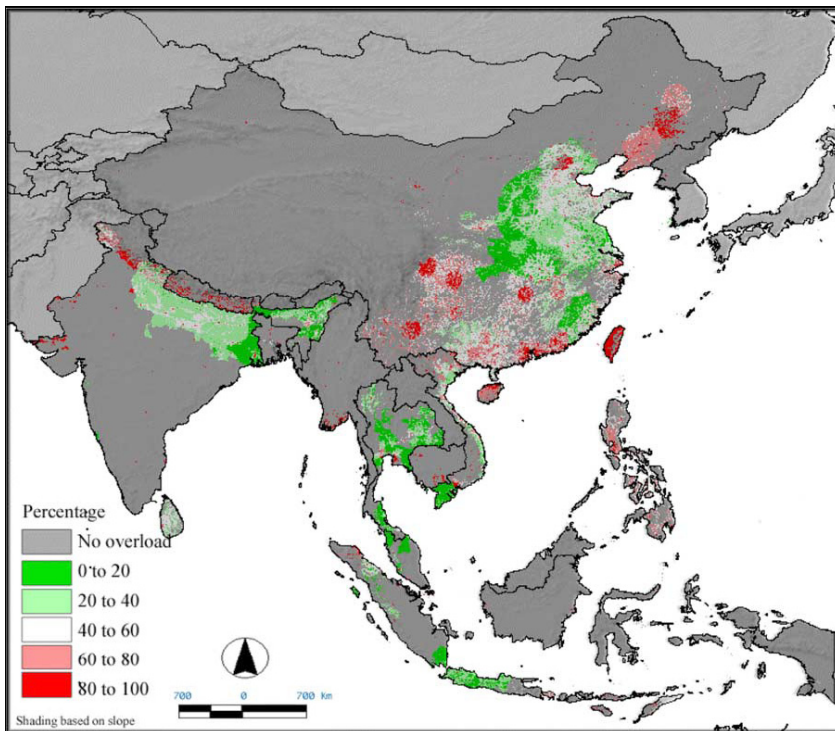
## 4. Livestock and nutrient cycles

The role of livestock in nutrient cycles has received a wealth of attention in the developed (Liu *et al.*, 2010; Oenema *et al.*, 2007 and Sheldrick *et al.*, 2003) and the developing worlds (Liu *et al.*, 2010; Rufino *et al.*, 2006 and Sheldrick *et al.*, 2003). According to Sheldrick *et al.* (2003), nutrients in manure as a proportion of total soil-nutrient inputs account for 14 percent of nitrogen (N), 25 percent of phosphorus (P) and 40 percent of potassium (K). However, there is large spatial heterogeneity depending, for example, on the type of system, resource endowment, crops planted and soils (Rufino *et al.*, 2006). Livestock have become more important as a source of soil nutrients in situations where reliance on fertiliser is low, such as in sub-Saharan Africa, as they are often the only source of carbon, nitrogen and other nutrients (Goulding *et al.*, 2008 and Rufino *et al.*, 2006).

Cattle are the largest contributors to global manure production (60 percent). Pigs and poultry account for 9 percent and 10 percent respectively. Recovery of nutrients from manure is highly variable and depends significantly on infrastructure and handling. European-wide analyses (Oenema *et al.*, 2007) show that approximately 65 percent of manure N is recovered from barns. Almost 30 percent of the N is lost during storage. Considerable variation in N-cycling efficiencies (NCE) is also found in manure management systems in the developing world (Rufino *et al.*, 2006). According to their results, manure handling and storage, and synchrony of mineralisation with crop uptake are key ways of increasing NCE in smallholder systems. This is a subject that still requires considerable research as animal numbers increase to satisfy human demand for livestock products and therefore the importance of manure may also change. More attention will have to be paid as systems intensify, because more manure could be beneficial in some systems, but the potential for increased leaching and subsequent contamination of water sources will also increase.

Large concentrations of animals in industrial systems occur in areas that offer easy access to urban markets or are close to feed supplies. Separating livestock production from the growing of feed crops is a defining characteristic of the industrialisation of livestock production (Naylor *et al.*, 2005). Concentrated, large-scale livestock production often creates concentrated, large-scale environmental problems. Large industrial farms bring in large quantities of nutrients in the form of concentrate feed, and they often produce far more waste than can be recycled as fertiliser and absorbed on nearby land (FAO, 2005). Nutrient loading is caused by high densities of animals, particularly on the periphery of cities, and by inadequate animal-water treating system being put in place. Issues of nutrient loading are present in developed countries, but they are particularly pronounced in emerging economies with rapid industrialisation of the livestock sector, such as Brazil, China, Mexico, the Philippines and Thailand (Steinfeld *et al.*, 2006).

Figure 3 gives a regional overview of areas facing nutrients loading on the periphery of cities for Asia. Large areas of eastern China, Indonesia, Thailand, Bangladesh and India present significant (more than 15 kg/km<sup>2</sup>) loads of livestock-originated phosphates. In India, the load is especially important in the Ganges basin, whereas in China, it has more of a peri-urban pattern. In the other countries, livestock P<sub>2</sub>O<sub>5</sub> excretion is generally lower, except around urban centres, such as Bangkok, Ho Chi Minh, Hanoi, Singapore or Manila, and on the island of Java (Gerber *et al.*, 2005).



**Figure 3:** *Estimated contribution of livestock to total P<sub>2</sub>O<sub>5</sub> supply on agricultural land, in area presenting a P<sub>2</sub>O<sub>5</sub> mass balance of more than 10 kg per hectare. Selected Asian countries – 1998 to 2000 (Gerber *et al.*, 2005)*

## 5. Livestock and water

The linkages between livestock and water use have not received as much attention as other aspects related to livestock and the environment. Recent analyses show that water use for livestock represents 31 percent (2180 km<sup>3</sup> per year) of the total water used for agriculture (7000 km<sup>3</sup> per year) (de Fraiture *et al.*, 2007). This represents 840 km<sup>3</sup> transpired from grassland systems and 1340 km<sup>3</sup> for growing feeds. Scenarios

projecting water use have shown that, if the demand for livestock products is to be met, water use from agriculture will need to almost double to 13500 km<sup>3</sup> per year, due to the increased needs for feed production throughout the world. Trade-offs with other sectors and competition for water will be significant in this case, especially with water for human consumption and industry. If unregulated, water pollution could increase because of additional intensification of production, especially in developing countries (Steinfeld *et al.*, 2006).

Significant variation exists in estimates of livestock-water productivity (livestock benefits/water input) from different livestock-production systems and/or livestock products (Peden *et al.*, 2007). The main source of variation is not the direct water consumption of animals (10 percent) but the water embedded in feed production (90 percent). This varies significantly depending on location, type of system, feed resources available, diet diversity and intensification (grains vs. forages vs. crop residues), and level of production (van Breugel *et al.*, 2010). Hence, depending on the systems that dominate, different regions are associated with different proportions of the water use for feed production or for grazing (van Breugel *et al.*, 2010). Using the Nile Basin as an example, Box 2 shows the marked heterogeneity of water productivity in different production systems and parts of the Nile Basin. In rangeland systems, water productivity can be significantly improved by rangeland management (Rockström *et al.*, 2007). According to their results, this source alone has the potential to reduce additional water use in agriculture by 45 percent by 2050. This possibility remains untapped and needs to be the subject of significant research.

One of the biggest trade-offs in water use happens in irrigated crop-livestock systems with significant feed deficits during parts of the year when water has to be used on crops that are for direct human consumption rather than for green fodders. As much as 15 percent of evapotranspiration in these systems is associated with feed production (Steinfeld *et al.*, 2006) but if demand for livestock products increases, the trade-off for irrigation water use between food and feed will increase. At the same time, there are options to manage water productivity in these systems (Peden *et al.*, 2007), two of which are explained below.

**Water pricing.** Water, at present, is considered a free or low-cost resource in most parts of the world (Molden *et al.*, 2007). This needs to be revisited if this crucial resource is to be protected. Water pricing is likely to play a key role in water management policies and could improve water-use productivity, as water would be used more sparingly. However, it is also important to ensure that water-pricing policies do not affect the poor by further limiting their access to this resource.

**Payment for services.** Ecosystems services payments to livestock farmers to protect water sources could be part of the solution in certain places. Meeting the demand

for livestock products under water pricing scenarios is an area that still requires significant research.

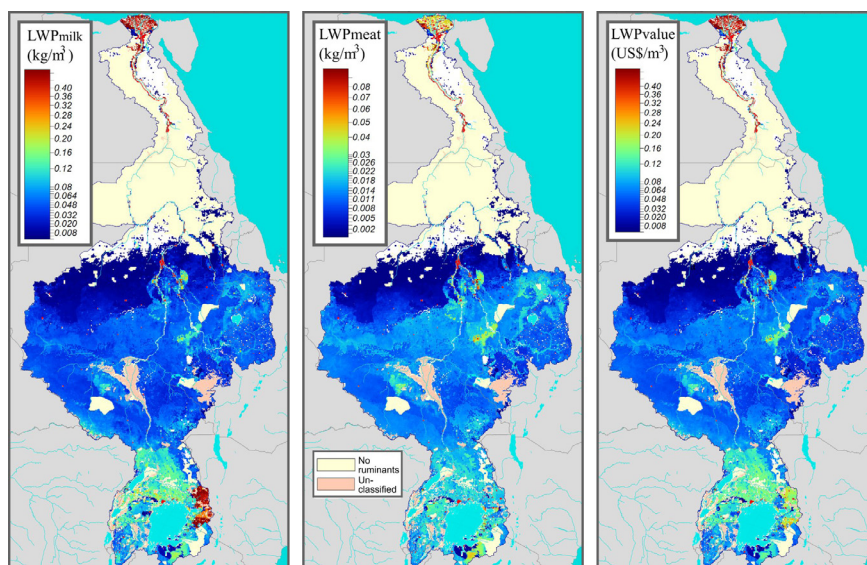
**Box 2:** Livestock water productivity in the Nile Basin

In regions where water is a scarce commodity, such as the Nile Basin, there is a need for strategies to improve livestock water productivity (LWP). LWP is defined as the ratio of the sum of the net benefits derived from animal products and services to the amount of water that is depleted or used in the process of producing these goods and services. A spatially explicit understanding of livestock water demand versus water availability is crucial to identify best options to increase agricultural water productivity and the role of livestock therein. Van Breugel et al. (2010) quantify livestock water use and productivity within the Nile Basin through a spatially enabled analytical framework that links models on ruminant digestion, feed baskets and crop water requirement linked to spatial data on dry matter production and evapotranspiration.

Total water need for feed production was estimated to be roughly 94 billion m<sup>3</sup> by Van Breugel et al. (2010), which amounts to approximately 5 percent of the total annual rainfall (68 billion m<sup>3</sup> or 3.6 percent of total annual rainfall when excluding water for residues). The study shows that livestock water use at the aggregated basin level is a small proportion of the total water depleted through evapotranspiration. However, differences are considerable across the basin. There are large areas in the arid and hyper-arid regions where the availability of water for feed is limited. In other areas, however, livestock water requirements are only a small fraction of the total water that is annually depleted through evapotranspiration.

Figure 4 shows that in most areas, LWP is less than 0.1 US\$/m<sup>3</sup>, with only a few areas showing a LWP of 0.5 US\$/m<sup>3</sup> and higher. This is largely related to very low livestock meat and milk production on the one hand, and very variable, but in general, low feed water productivity. On average, livestock water productivity is low, but large differences exist across the basin, both within and between livestock production systems. These are related to differences in livestock production as well as a large spatial variation in water depletion as a result of livestock production. These differences suggest that there is scope for improvement of LWP, which could lead to significant reduction of water use at the basin level while maintaining current levels of production.





**Figure 4:** Livestock water productivity in the Nile Basin expressed as (a) the ratio of milk production and depleted water, (b) ratio of meat production and depleted water, and (c) the ratio of summed value of produced meat and milk and the water depleted to produce the required livestock feed (Water for residues is not included in the calculation of depleted water).

## 6. Livestock and climate change

The linkages between livestock and climate change are two-way and dynamic. On the one hand, climate change has significant impacts on several aspects of livestock production such as feed quantity and quality, animal and rangeland biodiversity, distribution of diseases, management practices and production systems changes. Significant adaptations will need to occur in different production systems to cope with these changes. On the other hand, livestock have impacts on climate change through emissions of greenhouse gases (GHG), which creates a need to identify suitable GHG mitigation strategies in livestock systems.

Livestock contribute 18 percent of global anthropogenic GHG emissions (Steinfeld *et al.*, 2006). The main sources and types of greenhouse gases from livestock systems are carbon dioxide (CO<sub>2</sub>) from land use and its changes (feed production, deforestation) and nitrous oxide (N<sub>2</sub>O) from manure and slurry management, which account for 32 percent and 31 percent of emissions from livestock respectively. This is followed by methane (CH<sub>4</sub>) production from ruminants, which accounts for 25 percent of emissions. However, large differences exist between regions and production systems.

There is a complex balancing act of resource use, GHG emissions and livelihoods, which requires better understanding. Weighing the environmental impacts *vis-à-vis* the social benefits is a subject that deserves significant new research, methodologies and indicators to inform the debate more accurately. The same applies to the comparison of GHG emissions (total and per unit of output) among systems of different intensification levels and among sectors. Life cycle and value chain analysis play significant roles in this regard (Wood *et al.*, 2006 and Thomassen and de Boer, 2005).

### *Climate change adaptation*

Climate change is likely to have major effects on livestock production systems. These impacts will include changes in the productivity of rainfed crops and forage, reduced availability of water and widespread water shortages, and changes in the severity and distribution of important human, livestock and crop diseases. Faced with imminent climate change impacts, farmers and livestock keepers will have no option but to adapt.

Adaptation consists of changing certain aspects of livestock systems in order to increase their resilience to a variety of climate change effects or to change them to take advantage of new opportunities that may arise because of climate change (Feenstra *et al.*, 1998). Different generic types of adaptation exist (Abildtrup and Gylling, 2001).

**Reactive and anticipatory adaptation.** Reactive adaptation measures are those that institutions, individuals, plants and animals are likely to make in response to climate change after the fact, whereas anticipatory measures are taken in advance of climate changes.

**Autonomous and planned adaptation.** Autonomous adaptation refers to adjustments made within the system, and planned adaptation means adjustments made outside the system, such as those initiated or prompted by public policy. Autonomous adaptation options include introduction of new production technologies, embracing sustainable natural-resource management practices, increased diversity of the animal herd, improved livestock feeding and supplementation, and diversifying livelihood portfolios to include higher yielding, more stress-resistance crop and livestock varieties.

It is therefore crucial to keep the design and development of adaptation options flexible, enabling farmers to adjust to the local context and unknown future of climate variability. This will only be possible if supported by an effective institutional capacity and accommodating policy context. These planned adaptation options may include incentives for increased market participation or shifting production to areas that are

more favoured, livestock insurance, carbon credit schemes, or providing support services for livestock breeding and health. The responsive capacity of farmers and policy actors alike could benefit significantly from access to short- to medium-term weather forecasts. A substantial amount of research remains to be done to be able to assess the effectiveness, efficiency, equity and sustainability of the variety of, and the trade-offs among, available adaptation options. Adaptation and mitigation strategies are interdependent and, ideally, should be analysed simultaneously. For example, different adaptation strategies may lead to different emission levels of GHGs.

## 7. Mitigating greenhouse gases from livestock

Meeting the demand for livestock products in future carbon-constrained markets will require a mixture of adaptation and simple, effective and transparent mitigation strategies. Smith *et al.* (2007) identified three ways to contribute to reduction in GHG. Direct reductions of GHG, removing CO<sub>2</sub> from the environment, and offsetting emissions through indirect effects. Livestock can contribute to these in the following ways.

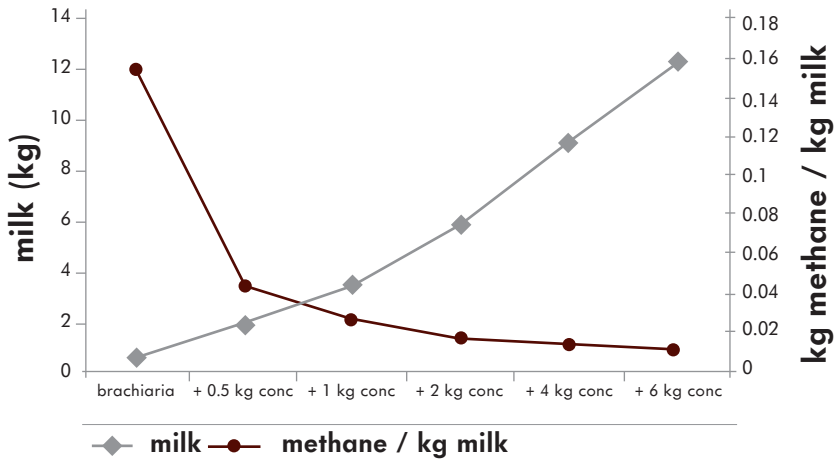
### *Reducing GHG emitted by livestock systems*

**Managing the demand for livestock products:** Managing the demand for livestock products in terms of reducing consumption of livestock products, in the developed world and sustainably intensifying systems in the developing world to produce more livestock products per unit of methane gas, can be part of the solution. However, this needs to be accompanied by adequate regulations, incentives, policies and possibly, carbon quotas (Herrero *et al.*, 2009).

**Intensification of animal diets:** Improving the quality of ruminants' diets can significantly reduce the amount of methane produced per unit of animal product produced (Monteny *et al.*, 2006). This increased efficiency would have enormous scope and could be achieved through improved land-use management with practices such as improved pasture management, including grazing rotations, fertiliser applications, development of fodder banks, improved pasture species and use of legumes, and through supplementation with crop by-products. Other options include manipulation of rumen microflora and the use of feed additives (Thornton *et al.*, 2009 and Smith *et al.*, 2007). Box 3 shows an example of diet intensification and how it can help increase milk production per animal, reduce methane production per litre of milk produced and help reduce animal numbers under carbon-constrained markets.

**Control of animal numbers and shifts in breeds:** Animal numbers is one of the biggest factors contributing directly to GHG emissions from livestock (Herrero *et al.*, 2009). In the developing world, replacing a large number of low-producing animals with

fewer but better-fed animals of higher potential would reduce total emissions while maintaining or increasing the supply of livestock products. This will require changing breeds or implementing crossbreeding schemes. These kinds of efficiency gains will be essential in carbon-constrained markets.



**Figure 5:** The effect of concentrate supplementation on milk production and the efficiency of methane production in a 500 kg cow consuming a basal diet of *Brachiaria spp.*

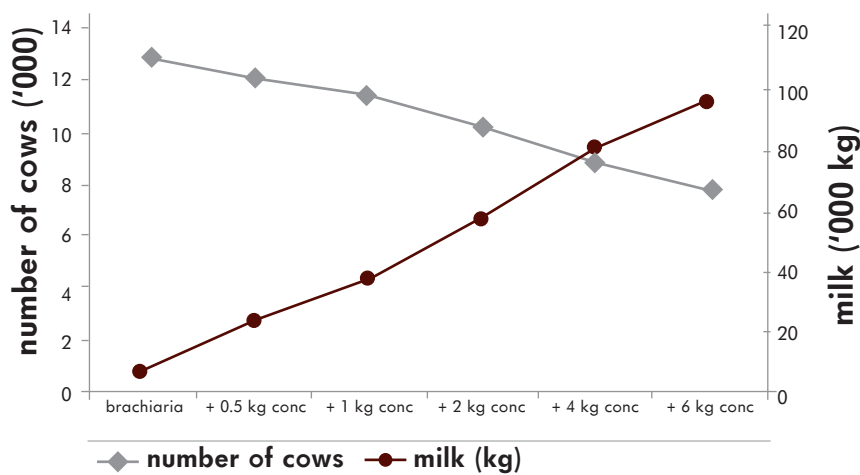
**Box 3:** Mitigating methane emissions of livestock: the role of diet intensification

Mitigation, proposed as a key strategy to reduce GHG emissions, is the subject of considerable international debate and negotiation (Kyoto, Bali) (IPCC, 2007). This includes strategies for mitigating methane from livestock industries. Improving the diets of ruminants and control of animal herd numbers could be an important mitigation strategy to be put in place, though few studies have tackled this complex problem at a global level (Herrero *et al.*, 2008). Their aim was to attempt to provide evidence of the biological basis for this strategy.

A validated dynamic model was used for predicting feed intake and nutrient supply in ruminants as the basis for calculating the methane produced from enteric fermentation. Details of the model can be found in Herrero *et al.* (2008). The model was based on a 500 kg cow consuming an *ad libitum* basal diet of poor quality *Brachiaria spp.* pastures (8 MJ ME/kg DM), as often found in the humid tropics of Latin America (Holmann *et al.*, 2004). Diet improvements were simulated by adding up to 6 kg of high quality (12 MJ ME/kg DM) grain concentrates to their diet.

The results indicated that the poor quality diet produced very little milk while producing a high amount of methane per kilogram of milk (Figure 4). Improving the diet quality not only increased milk production, it reduced the amount of methane produced per kilogramme of milk (Figure 5). The efficiency of methane production increased as the quality of the animals' diets improved.

Establishing emission targets for GHG can provide the guide needed for setting mitigation strategies (IPCC, 2007). For example, if a methane quota of 1 tonne is assumed, how much milk can be produced under the emissions target of 1 tonne, by changing the composition of the diet? Figure 6 illustrates the different combinations of diets for cows and numbers of animals required to achieve the 1 tonne methane emission target. The higher quality diets using more grain concentrates produce more milk and require fewer animals to produce the milk. Intensifying the diets may be a desirable strategy in places with little land and high opportunity costs for labour and land (Baltenweck *et al.*, 2003), while more extensive systems could also reach the same emissions targets (subject to pasture availability and its variability) with more animals and less productivity per animal.



**Figure 6:** Effects of diet quality on milk production and herd size to reach a methane emissions quota of 1 tonne (Thornton and Herrero, 2010)

These two concepts form the basis for designing methane mitigation strategies in ruminant-livestock systems, as they address the key trade-offs among emissions, livestock production and livestock numbers. For different locations, the impacts of a wider array of diet combinations using local feed resources such as crop by-

products, legumes and agroforestry practices, improved grasses and forages need to be tested. These would yield different amounts of milk and animal numbers at similar emission targets, thus identifying different ways of sustainably using local natural resources to contribute to increasing the productivity of livestock systems, while mitigating the effects of climate change. This framework can be expanded to include the economic efficiency and profitability of each of the diets, and therefore quantify the economics of reaching methane emission targets. This could be extremely important for commercial livestock production or where resources are scarce and their use needs to be carefully planned.

Other strategies could include shifts in breeds and reducing GHG from manure management through regulation, nutritional management and improved storage systems (Aarnink and Verstegen, 2007).

### *Livestock systems and carbon sequestration*

Significant amounts of soil carbon could be stored in rangelands or in silvo-pastoral systems through a range of management practices suited to local conditions. This not only improves carbon sequestration, but could turn into an important diversification option for sustaining livelihoods of smallholders and pastoralists through payments for ecosystem services. Table 1 shows the global potential for carbon sequestration from degraded rangelands is approximately 45 Tg C/yr, with the highest in Africa and Latin America (37 percent and 40 percent of potential global rangeland C sequestration, respectively) (Conant and Paustian, 2002). Average rates of C sequestration in the study conducted by Conant and Paustian, (2002) were 0.18 Mg C/ha/yr.

**Table 1:** *Potential for carbon sequestration (Tg C/yr) in global rangelands of different overgrazing severity, by continent (Conant and Paustian, 2002)*

	light	Moderate	Strong	extreme	Total
Africa	1.9	8.6	6.1	0.1	16.7
Australia/Pacific	4.5	-0.1	0.0		4.4
Eurasia	0.8	3.2		0.3	4.3
North America	0	1.6	0.6		2.2
South America	6.1	11.3	0.7		18.1
Total	13.3	24.4	7.4	0.4	45.7

While technical options for sequestering carbon from livestock systems in developing countries exist, there are various problems to be overcome. These are related, for example, to payments schemes, incentives, monitoring techniques for carbon stocks

and appropriate verification protocols. Livestock systems can also help offset GHG emissions by converting manures into energy sources (biogas) or using crops and residues either directly or after conversion to biofuels. However, biofuels are not zero-emission technologies, as there are indirect emissions embedded in the land-use changes required to produce them (Searchinger *et al.*, 2009).

## 8. Livestock and zoonosis

The majority of human infectious diseases (868 or 61 percent of the total) are technically zoonotic, meaning they are transmissible between animals and humans (Taylor *et al.*, 2001). While many of these are obscure or trivial, standard textbooks typically consider 100–300 zoonotic diseases of practical importance. However, for many of these diseases, animals do not play an important role in transmission or maintenance of the disease, for example, those saprophytic zoonotic diseases such as fungal zoonoses, and diseases in which the human-human transmission cycle predominates over the animal-human cycle (e.g. dengue).

However, even zoonotic diseases that are extremely unusual causes of human death (such as new variant Creutzfeldt Jakob disease or avian influenza) can be of great economic and social consequence. This is most often seen when the disease has serious consequences, when there is uncertainty surrounding its potential to spread and when there are failures in risk communication.

Without methods to assess the impact and relative importance of zoonotic diseases, bad and costly decisions will continue to be made. The most widely accepted measure for human health burden is the disability adjusted live year (DALY), which is a measure of years of human life lost or lived with disability due to a disease. The World Health Organization (WHO) estimates of the global burden of disease in terms of DALYs (WHO, 2008) include some infectious diseases in which animals clearly play no part in the transmission or maintenance (e.g. measles), others where animals have a minor role in transmission or maintenance (e.g. tetanus), and yet others where their role is important (e.g. sleeping sickness). Out of 20 diseases where causation is specified, 15 are zoonotic or have a zoonotic component.

The most important zoonotic diseases in terms of disease burden can be divided into two categories: food- and water-borne diseases and neglected tropical zoonoses.

**Food- and water-borne diseases** are those with pathogens for which livestock are reservoir hosts such as diarrhoeagenic *Escherichia coli*, *Campylobacter spp.*, *Salmonella spp.* and *Cryptosporidium parvum*. These are responsible for a substantial proportion of food-borne illness in both rich and poor countries. Parasitic food- and water-borne diseases such as cysticercosis are mainly confined to developing countries.

**Neglected tropical zoonoses** comprise a cluster of diseases that include trypanosomiasis, schistosomiasis and leishmaniasis, and together account for around 10 million DALYs a year. Livestock are less important in the epidemiology of these and, as the name suggests, almost the entire burden is borne by developing countries.

While it may appear that important zoonotic diseases are few, it is also argued that the current focus on “big burden” diseases has led to neglect of others whose importance is underestimated. This is the result of systematic under-reporting or because the blunt measure of life years misses other important aspects such as impact on vulnerable groups (Maudlin *et al.*, 2009). Zoonotic diseases are commonly neglected because they are difficult to diagnose and they fall between the medical and veterinary sectors (Schelling *et al.*, 2007). Furthermore, globally diseases such as leptospirosis (believed to be the world’s most common zoonoses), hydatid disease (resulting in annual losses of 4 billion US\$) or rabies (causing 55,000 human deaths a year) are not given the recognition they fully deserve.

Animal diseases are also important because of their potential to give rise to human diseases. Historically, many of the most important human infectious diseases, such as measles, influenza, and diphtheria, have transmitted to people from the animals they kept, the so-called lethal gift of livestock (Wolfe *et al.*, 2007). New disease emergence continues and seems to be accelerating. The examples of human immunodeficiency virus, sudden acute respiratory syndrome (SARS) and, more recently, swine influenza, show the enormous health, social and economic costs of diseases emerging from animals.

Of course, the human disease burden is only part of the cost of disease and may not even be the most relevant, especially in poor countries. Disease burden does not include the cost of illness (expense of treatment, lost productivity) or expenditure on preventative measures (mosquito nets, boiling water). In addition, many zoonotic diseases impose substantial burdens on animal production and productivity as well as wildlife and ecosystems. For example, the economic benefit of controlling brucellosis in the East African highlands resulted in an additional offtake of milk and meat of 334,000–615,000 tonnes/year and 163,000–271,000 tonnes/year respectively (Mangen *et al.*, 2002).

Yet on balance, the net effects of livestock on human health are positive. Animal source foods play an essential role in nutrition in developing countries, supporting child growth and cognitive development. Livestock also support millions of poor peoples’ livelihoods and generate income that, among other benefits, improves access to health services. Livestock and wildlife also contribute to ecosystem regulation of disease by preventing disease spill over to humans and can act as sentinels thus improving detection and management of human disease.



And while zoonotic diseases are responsible for a substantial health, economic and social burden as well as 75 percent of emerging human diseases, animal diseases is not inevitable. Much of the current burden and risk could be eliminated by better use of more appropriate disease control technologies and institutions, and with investments in innovations for zoonoses control.

## 9. Conclusion

There is a large body of evidence suggesting that livestock and environmental trade-offs, which are already substantial, will increase significantly in the future as a result of the increased demand for livestock products from the growing population. Some of the most important impacts are those associated with land-use change for feed production, both for ruminants and monogastrics, which have significant and simultaneous impacts on a range of environmental dimensions (land use, GHG, water cycles, nutrient balances and biodiversity).

At the same time, there seem to be significant opportunities in livestock systems for improving environmental management while also improving the livelihoods of poor people. Sustainable intensification of smallholder systems could offer promising alternatives to increase food production (McDermott *et al.*, 2010), while there is strong evidence that rangelands can sequester significant amounts of carbon and play an important role in improving the water productivity of whole ecosystems in certain places.

Any discussion or debate of livestock's impact on the environment needs to be geographically differentiated and include food security and equity issues. There is, for example, a need for a fundamental shift in how demand for livestock products is seen and how different production systems can respond to meet this demand. Demand for livestock products could be reduced in places where there is excessive consumption of animal products or in places where environmental impacts are currently or potentially severe. At the same time, there is a need to de-intensify certain systems through policies and payments for ecosystem services, while other systems, which might have been neglected in the past, can intensify via technologies that can improve efficiency gains to produce more products per unit of resource. We need to provide significant incentives so that the marginal rangeland areas, often rich in biodiversity, can be protected and farmers can benefit from them. Achieving this will require a subtle balancing act. Cross-cutting commitment will be required from the science community, policy makers and other stakeholders if livestock are going to continue having a significant role in the livelihoods of millions of people around the world.

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# 5

## The Role of Foods of Animal Origin in Human Nutrition and Health

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### Abstract

In poor developing communities, livestock serve many functions including supply of food, fibre and draught power, income generation and enhancement of social status. The relationship among animal-source foods and human nutrition and health is complex and involves both positive and negative trade-offs and outcomes. The positive outcomes are mostly through their addressing malnutrition by supplying the essential nutrients that are lacking in plant-source foods. Among these are micronutrients such as iron, zinc, vitamin B-12, riboflavin and conjugated linoleic acids. In addition, supplementing the diet of pregnant women and children with foods of animal origin has resulted in improved maternal, foetal and child health outcomes such as successful births, reduced maternal mortality, increased prenatal growth rates and improved cognitive functions. There are potential risks associated with (over) consumption of foods of animal origin such as increased risks of cardiovascular diseases, diabetes and obesity. However, at moderate levels of intake, foods of animal origin do not pose such threats and recent research indicates that they may actually be beneficial in reducing these diseases. Livestock's potential contribution to environmental pollution and to total greenhouse gas emissions is recognised, but it is limited in the production systems available to poor communities where the nutritional and health benefits that accrue from consumption of foods of animal origin greatly outweigh the danger posed by livestock. Increasing the production of foods of animal origin at household level and linking this increased production to nutrition and the health of mothers and children is thus recommended for developing communities.

**Keywords:** livestock, multifunctionality, malnutrition, micronutrients, developing countries

### 1. Introduction

Livestock are multifunctional in developing communities where they produce food including meat, milk and eggs, fibre, hides and feathers. Livestock are also responsible for other goods and services including draught power, manure, income, religious and cultural services, ecosystem services and social status, and they serve as financial instruments. This chapter focuses on the complex interactions among foods

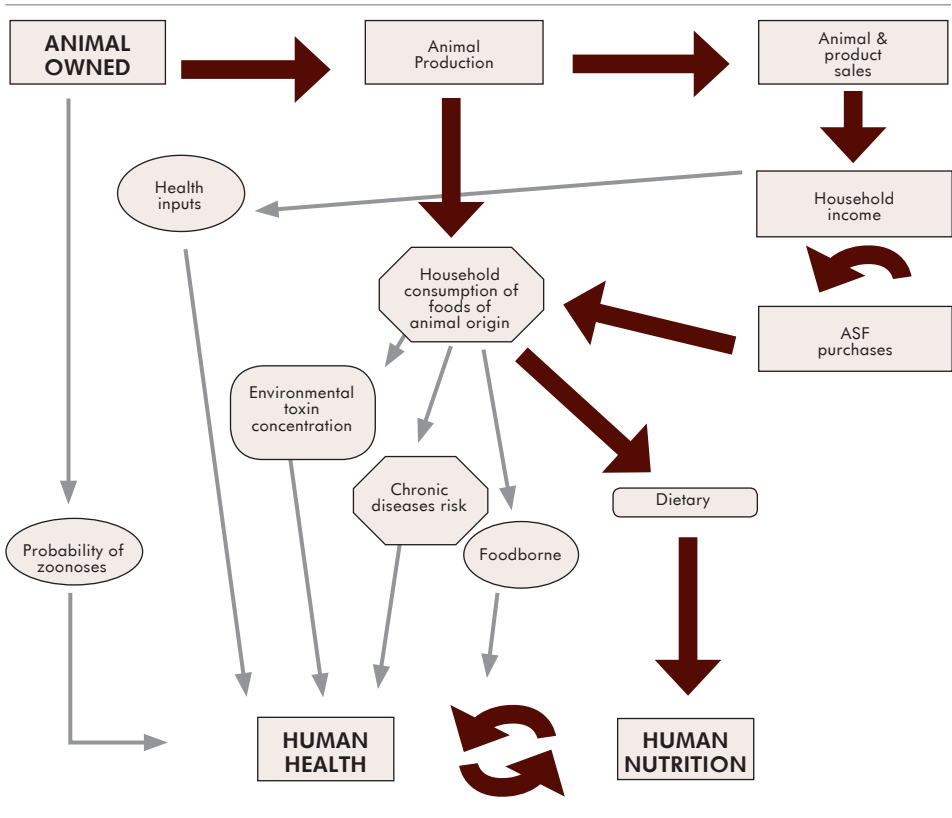


of domestic animal origin and the nutrition and health of developing communities who own livestock. The interactions, both positive and negative, are affected by externalities such as the policy environment and markets. The positive contribution of livestock to human nutrition and health further enhances the multifunctionality of livestock in the livelihoods of poor communities.

Randolph et al. (2007) elaborated on a broad conceptual framework for hypothetical causes and effects linkages between livestock keeping and human nutrition and health outcomes. The framework indicates that ownership of livestock has both positive and negative effects on human health and nutrition. The positive effects could be through increased consumption of foods of animal origin or through increased income, which may lead to increased purchases of foods of animal origin. However, increased consumption of foods of animal origin may increase risk of food-borne diseases or occurrence of chronic diseases, both of which would impact negatively on human nutrition. Livestock keeping may also increase the probability of zoonotic disease or indirectly affect human health through contamination of water bodies.

The importance of foods of animal origin relates to the linkages between nutrition and health. The World Health Organization (WHO, 1946) has defined health as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. Nutrition, a major component of health, is determined by both quantity and quality of food consumed by an individual. Hurni et al. (2009) defined a healthy diet as one that provides sufficient calories to meet an individual's energy needs as well as adequate protein, vitamins, minerals, essential fatty acids and trace elements to ensure growth and maintenance.

Foods of animal origin are rich in both macronutrients and micronutrients, and therefore an essential part of a healthy diet. Good nutrition is critical for development as it provides the basis for good physical and mental health. The consequences of malnutrition have multiplier effects as malnutrition affects not only physical growth but also reduces resistance to infection, decreases cognitive function and diminishes learning ability which, in turn, has deleterious effects on the productivity of societies and nations (Neumann *et al.*, 2002).



**Figure 1:** Theoretical causal linkages between animal ownership and health and nutrition outcomes among the poor (adapted from Randolph *et al.*, 2007)

## 2. Nutritional importance of foods of animal origin

Animal source foods are energy dense and excellent sources of protein, minerals, vitamins and essential fatty acids (Neumann, *et al.*, 2002; Leroy and Frongillo, 2007 and Givens and Shingfield, 2004). The protein in foods of animal origin contains essential amino acids that the human body cannot produce, some of which resembles that in the human body in terms of amino acid composition. Nutrient composition of selected foods of animal origin is shown in Table 1.

Iron, zinc and vitamin A are the main micronutrients available in meat while vitamin B-12, riboflavin, calcium and conjugated linoleic acid are available from milk. The bioavailability of these nutrients is high, compared to those in plants, because of the

presence of the haeme protein (Neumann *et al.*, 2002) and the absence of fibre and phytates in foods of animal origin.

**Iron** serves a number of roles in the human body, as a component of haemoglobin (the protein that carries oxygen), myoglobin (a protein found in muscle) and of some enzymes. Thus, iron deficiency reduces capacity for physical work, diminishes cognitive function in children and has been associated with anorexia (Li *et al.*, 1994).

**Table 1:** *Approximate nutrient composition of some animal source foods per 100 g (adapted from Neumann et al., 2002)*

Food	Energy (KJ)	Protein (g)	Fat (g)	Calcium (mg)	Iron (mg)	Zinc (mg)	Vit. A (RE)*	Vit. B-12 ( $\mu$ g)
Cows milk	301	3.3	4.0	76	0.04	0.31	28	0.29
Goats milk	289	2.9	3.0	90	0.04	0.24	46	0.05
Beef	1101	18.5	20.0	7	3.2	6.0	0	2.4
Chicken	674	31.0	6.0	13	1.3	1.8	42	0.2
Goat	1126	13.4	3.4	17	3.7	0	0	1.2
Rabbit	724	30.4	8.4	20	2.4	2.4	0	6.5
Fish	356	17.0	5.6	37	8.4	0.6	14	0.6
Offal	599	11.2	10.6	0	2.1	0	0	0
Liver	586	19.9	3.8	7	6.5	0	0	0
Eggs	628	12.1	10.0	50	1.54	1.1	192	1.0

\*RE - retinol equivalent

**Zinc** plays a significant role in gene expression, cell division and differentiation, and in DNA and RNA synthesis as it is a constituent of several enzymes involved in these processes. Zinc deficiency is of particular importance in maternal, foetal, infant and child health and survival (Neumann *et al.*, 2002).

**Vitamin B-12** is involved in the formation of normal blood and of neurological development and function (Allen *et al.*, 1995). It plays an essential role in the synthesis of DNA and RNA components (purines and pyrimidines), transfer of methyl groups, synthesis of proteins from amino acids and carbohydrates and fat metabolism. Vitamin B-12 deficiency results in reduced cognitive functions and is associated with anaemia.

**Vitamin A** is a fat-soluble vitamin that promotes good vision, growth and strengthens the immune system. Vitamin A deficiency results in stunted growth, impaired vision

and blindness, compromises the immune system and, in severe cases, may result in mortality.

**Conjugated linoleic acid (CLA)** is a generic term for a mixture of geometric and positional isomers of C18:2 that contain a conjugated double bond (Givens and Shingfield, 2004). These compounds have shown to have anti-carcinogenic effects (Aro *et al.*, 2000; Kritchevsky, 2000 and Roche *et al.*, 2001). They also have anti-diabetogenic, anti-atherogenic and anti-obesity effects as well as supporting immunomodulation and modulation of bone growth (Lock and Bauman, 2004).

### 3. The contribution of foods of animal origin to health

The major contribution of foods of animal origin to human health is through the alleviation of malnutrition caused by deficiencies in micronutrients that contribute to poor growth, impaired mental development and ill health, which, in aggregate, can contribute to poor economic growth of nations. The World Bank (2008) estimates that malnutrition leads to individual productivity losses equivalent to 10 percent of lifetime earnings, and gross domestic product (GDP) losses of 2–3 percent in the worst affected countries. Children and women of reproductive age are most vulnerable to malnutrition (Neumann *et al.*, 2002) and most reported studies have been done on these groups.

In most communities of the developing world, diets contain little, if any, animal-source foods and both macronutrients and micronutrients are usually inadequately balanced (Neumann *et al.*, 2003). Murphy and Allen (2003) reported on the inadequacies of diets consumed by school-going children who participated in a Human Nutrition Collaborative Research Programme in Egypt, Kenya and Mexico (Table 2). In all three countries, diets were grossly inadequate in several micronutrients, although they were mostly adequate in energy and protein.

The diets of Mexican children were particularly deficient in vitamin B-12, riboflavin and iron but more than adequate in calcium, while Kenyan children had diets seriously deficient in vitamin B-12, calcium, iron and zinc. These diets exposed the children to the risks associated with deficiencies of these micronutrients as discussed above. The inadequacies were ascribed to the children's low intakes of foods of animal origin, especially in Kenya and Mexico. In comparing plant-source foods with animal-source foods, Murphy and Allen (2003; Table 3) concluded that foods of animal origin could fill multiple micronutrient gaps found in diets based on plant-source foods, even in small amounts.

**Table 2:** Adequacy (%) of intake of nutrients by school-age children in Egypt, Kenya and Mexico (adapted from Murphy and Allen, 2003)

Nutrient	Egypt	Kenya	Mexico
Protein	100.0	100.0	100.0
Vitamin A	90.8	99.4	75.6
Vitamin B-12	76.4	13.1	61.7
Riboflavin	83.7	98.4	16.6
Calcium	30.7	8.8	100.0
Iron	29.6	68.6	12.7
Zinc	96.5	70.5	90.8

**Table 3:** Composition of selected plant source and animal source foods in relation to nutrient requirements of school-age children (adapted from Murphy and Allen, 2003)

Nutrient	Maize cooked	Kidney beans cooked	Milk whole, unfortified	Beef medium fat, cooked	Recommended intake of 7-yr-old weighing 20kg
Energy (KJ)	497	531	213	1124	6688
Protein (g)	2.7	8.7	3.3	24.9	17.3
Vitamin A ( $\mu\text{g}$ RAE*)	0	0	55	0	400
Vitamin B-12 ( $\mu\text{g}$ )	0	0	0.39	1.87	1.2
Riboflavin (mg)	0.07	0.06	0.16	0.15	0.6
Calcium (mg)	2	28	119	4	800
Available iron (mg)	0.12	0.15	0.01	0.32	1.86
Available zinc (mg)	0.12	0.11	0.18	2.05	1.44

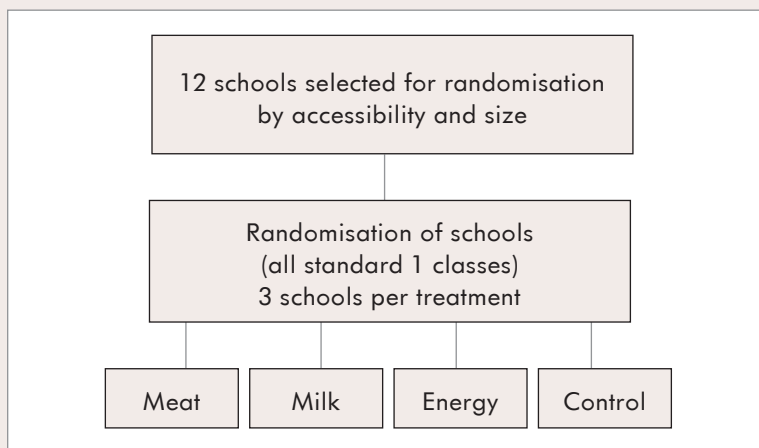
\*RAE - retinol activity equivalent

Siekman et al. (2003) found that increasing children's intake of foods of animal origin (meat or milk) improved their micronutrient status (Box 1). The intervention consisted of establishing four groups, one to receive a daily in-school meal of meat, (60-85 g/child), one to receive an in-school meal of milk (200-250 ml), and one to receive an in-school energy supplement (3-3.8 g oil) together with a local staple of

maize and beans. The fourth group received no supplemental food and acted as a control. The provision of meat or milk increased the concentration of vitamin B-12 in the children's plasma while provision of energy or no supplemental food resulted in a fall in plasma vitamin B-12. However, no differences were detected for other micronutrients among the groups and the authors suggested that this could have been due to high malarial infections in the area.

**Box 1:** Intervention project to study impact of foods of animal origin on micronutrient deficiencies in school children in Embu District, Kenya (Siekmann *et al.*, 2003)

The effect of consuming foods of animal origin was evaluated by randomly assigning 555 children in standard 1 from 12 schools as shown below for one school year.



Feeding intervention	133	144	147	130
Attrition	10	12	16	10
Sample analysed	123	132	131	120

The interventions initially consisted of 60 g of minced beef, 200 ml of whole cow's milk, 3 g of oil fed *githeri* (a local maize and beans meal) or no supplemental food (control). They were subsequently increased to 85 g of meat, 250 ml of milk and 3.8 g of oil. Blood and stool samples were collected for laboratory analyses. Household and family information, school examination scores, growth, physical activity and behaviours were also measured. The meals with meat or milk significantly increased plasma vitamin B-12 content but no differences were detected in other micronutrients. The meals supplemented with foods of animal origin also resulted in improved weight gain and cognitive function in the children.

The study showed the benefit of foods of animal origin, in terms of ameliorating the deficiency of vitamin B-12. Other studies have shown that vitamin B-12 deficiency is widespread in other developing communities where intake of foods of animal origin is low such as India (Refsum *et al.*, 2001), Guatemala (Casterline *et al.*, 1997) and Mexico (Allen *et al.*, 1995). This points to the potential for increasing the impact of livestock on human nutrition and health, thus enhancing their multifunctionality in the developing communities.

Neumann *et al.* (2002) reviewed the functional benefits of the consumption of animal-source foods in women and children who participated in the Human Nutrition Research Support Programme (NCRSP) in Kenya, Egypt and Mexico. Intake of foods of animal origin by pregnant women was associated with good infant growth beginning *in utero* and also affected postnatal increase in weight and length. These positive effects were related to improved levels of iron, zinc and vitamin B-12 in pregnant women who consumed adequate quantities of foods of animal origin.

The NCRSP studies, as well as studies conducted in China (Guldan *et al.*, 1993), Jamaica (Walker *et al.*, 1990) and Nicaragua (Seireg, *et al.*, 1992) found that consumption of animal milk by infants and children promoted increase in weight and height. In the NCRSP studies, linear growth or height in children from 6–9 years old were positively associated with intake of foods of animal origin and negatively associated with intake of plant source foods such as maize, millet or maize tortillas (Neumann *et al.*, 2002). Supply of calcium, phosphorus, vitamin B-12, CLAs and a protein of high biological value were identified as the major benefits of milk for growth. Compared to cow or human milk, goat milk has a high digestibility as well as certain therapeutic values in humans. Goat milk has been recommended as an ideal substitute for patients suffering from allergies to cow milk or other food sources.

Intake of foods of animal origin by pregnant mothers and young children has been associated with improved cognitive function (Sigman *et al.*, 1989; Rahmanifar *et al.*, 1993 and Neumann *et al.*, 2002). In addition, consumption of foods of animal origin predicted developmental outcomes, behaviour, verbal ability and involvement in classroom activities in school-age children (Neumann *et al.*, 2002). For example, iron deficiency anaemia has been associated with reduced mental and motor developmental indicators in children while zinc and vitamin B-12 also play a strong role in the structure and function of the brain (Neumann *et al.*, 2002). Additionally, foods of animal origin supplied CLAs and related compounds, which have been shown to improve immunity. All these micronutrients are highly available in foods of animal origin, which could explain the positive effects of consuming foods of animal origin on cognitive function.

## 4. Potential negative effects of foods of animal origin on human nutrition and health outcomes

The sections above have highlighted the positive effects of consuming foods of animal origin on human and nutrition outcomes. However, there are also potential risks that need to be considered, indicating the need to devise strategies for their mitigation.

**Food-borne diseases.** Because of their rich nutrient content, foods of animal origin tend to be susceptible to microbial contamination which can lead to food-borne diseases (CSPI, 2005). Microbial contaminants include bacteria, fungi, viruses or parasites that result in more than 3 million premature deaths worldwide each year (WHO, 2002). Improved access to foods of animal origin also requires parallel access to food safety education aimed at reducing incidences of food-borne diseases. Studies that have combined increased animal production with nutrition education have generally resulted in improved nutritional status of households (Leroy and Frongillo, 2007).

**Zoonotic diseases.** In recent years, there has been an increase in zoonotic diseases (i.e. diseases that are transmittable from animals to humans) such as Rift Valley fever, avian influenza, bovine tuberculosis, and foot and mouth disease. Keeping livestock may increase the risks of such outbreaks, yet improving access to foods of animal origin by vulnerable households requires increasing the number of animals or increasing production. This means that better methods of detection and control of zoonoses are required, including the participation of communities who own the animals together with veterinary and health professionals.

It also should be noted that the relationship between keeping livestock and an increased spread of zoonoses has not been established conclusively (Leroy and Frongillo, 2007) and more research is required in this area. Randolph et al. (2007) argue that zoonoses considered important by the poor receive less attention and resources than they deserve and, as such, the poor may face greater risks to their health than is generally recognised. Advocacy is needed for participatory surveillance and monitoring techniques that involve poor livestock owners, in order to better characterise those zoonoses that poor communities consider important.

**Chronic disease.** Foods of animal origin present a risk of chronic disease because of the purported association between consumption of the saturated fat present in foods of animal origin and the occurrence of cardiac vascular disease and development of type 2 diabetes (Nugent, 2004). This association is based on studies of diets with over consumption of foods of animal origin (Neumann *et al.*, 2002 and Leroy and Frongillo, 2007). However, in developing communities, consumption of foods of animal origin is low and, in reality, broad generalisations relating to fat consumption and its links to chronic diseases are inappropriate given recent findings about fat quality (Lunn and Buttris, 2008). The polyunsaturated fatty acids in foods of animal origin contain CLAs



and sphingolipids, which have essential roles in the human body (Lunn and Buttris, 2008). Humans and plants are unable to synthesise these polyunsaturated fatty acids and they need to be supplied in the diet by consumption of foods of animal origin.

Consequently, there have been several efforts to increase the content of these polyunsaturated in meat and milk. Lock and Bauman (2004) reported on strategies to increase milk fatty acids that are beneficial to human health through nutritional management of dairy cows. In a similar vein, Givens and Shingfield (2004) reported that amounts of CLA in both meat and milk can be enhanced through nutrition. Mir et al. (2003) reviewed dietary manipulations aimed at increasing CLA content in beef and concluded that fresh forage diets offered the best option. In most developing communities, ruminants are fed on fresh forage, at least during the wet season, and thus could have beneficial fatty acids profiles. Recent evidence suggests that the relationship between foods of animal origin and cancer is very tenuous at best (Hill, 2002 and Biesalski, 2002). Thus, the risk of chronic diseases because of low to moderate levels of foods of animal origin consumption in diets of developing communities is extremely limited.

**Water contamination.** While the risk of contamination of water resources by livestock waste is outside the scope of this paper, suffice to say that this risk can be mitigated through appropriate management of livestock waste, such as using biogas digesters and recycling manure on crops.

**GHG emissions.** Increasing livestock numbers has the potential to impact GHGs (carbon dioxide, methane and nitrous oxide). Already, livestock have been estimated to contribute about 18 percent of the global emission of GHG (Steinfeld *et al.*, 2006). However, in terms of livestock owned by the poor, the contribution would be small given the smaller number of livestock in poor areas compared to developed areas and the limited transportation of livestock over long distances in these areas.

The evidence above indicates that the risks to human health and the environment posed by ownership of livestock and consumption of foods of animal origin by poor communities are negligible compared to the individual and societal benefits that accrue as a result of combating nutritional deficiencies. Therefore, it is desirable to increase access to and consumption of foods of animal origin.

## 5. Improving access to and consumption of foods of animal origin

The annual growth of meat and milk production in developing countries has been projected at 2.4 percent and 2.7 percent respectively (Steinfeld, 2003). Most of this growth will be in white meat (pork and poultry), mostly in East and South Asia, and Latin America (Delgado, 2003) and will be based on industrial, vertically integrated,

large-scale livestock production (Steinfeld, 2003). Such increases are unlikely to benefit poor developing communities because of costs and poor market development. Increased animal production by smallholder farmers has been proposed as holding the greatest promise of improving the diet of poor rural communities (Neumann *et al.*, 2003). The assumption that increased animal productivity for a household translates into increased foods of animal origin consumption by that household is not strictly true. As indicated in Figure 1, the increased animal produce maybe sold instead of being consumed at the household level. The income from the sales may be used to purchase non-food items and other goods.

This point is further illustrated by a study that measured the impact of semi-scavenging poultry production on the consumption of foods of animal origin by women and girls in Bangladesh (Nielsen *et al.*, 2003; Box 2). Thirty-five households involved in a Participatory Livestock Development Project (PLDP) that supported the development of small-scale poultry enterprises and 35 households not involved in the PLDP were used to collect data. The PLDP household produced more than twice the number of eggs as non-PLDP households and sold more eggs. However, household egg consumption did not differ between the groups and neither did consumption of chicken. However, fish consumption in PLDP households increased significantly over non-PLDP households implying that some of the income from sales of chicken and eggs was used to purchase fish. The community preferred small fish as food over chicken and eggs, pointing to the inter-linkages between cultural norms and the consumption of foods of animal origin.

Leroy and Frongillo (2007) reviewed studies on the effect of increased animal production on human nutrition status of communities participating in the projects. The results were variable, but in general, showed improved dietary status as well as improved productivity, though the causality between the two was not certain. The authors found that the studies had design, evaluation and analysis defects that made it impossible to estimate the contribution of animal production to nutritional status of the groups researched. In one study that focussed on women and involved the supply of goats to improve vitamin A consumption, inclusion of nutrition education enhanced the consumption of goat milk by women and children in addition to increasing income. The results also emphasised the importance of multifaceted approaches that included nutrition education to ensure that household food allocation patterns prioritized the most vulnerable groups such as women, children and the infirmed.

**Box 2:** The impact of semi-scavenging poultry production on the consumption of foods of animal origin by women and girls in Bangladesh

The study was conducted by Nielsen *et al.* (2003) to investigate the Participatory Livestock Development Project (PLDP) impact on the food and nutrient intake of females in the PLDP-adopting households. Three villages that had adopted PLDP and three villages that had not were used for sampling. Thirty-five women and 35 girls (5–12 yrs old) were selected in each village. Quantitative data on food intakes were collected using a 24-hour recall method, while a structured questionnaire was used to collect data on household composition, socio-economic status, poultry production, resources, living conditions and food preferences. Results are summarised below.

**Intake of food**

Food group	PLDP-adopting households raw food/person/day	Non-PLDP-adopting households raw food/person/day	Significance
n	35	33	
Cereals	346±124	310±79	NS
Non-staple plant foods	210±146	288±189	NS
Oils and fats	7±6	8±5	NS
Animal-source foods	51±45	47±55	NS
Fish	39±33	28±41	0.06
Chicken	0	1±6	-
Eggs	1±5	2±6	NS
Milk	11±35	16±43	NS

Poultry and egg production was lower at 30 vs. 121 in the PLDP-adopting households than in the non-PLDP households and the PLDP-adopting households owned less (3 vs. 0) high-yielding poultry varieties. However, consumption of chicken and eggs did not differ between the two groups, indicating that intake of foods of animal origin and improved animal production may not be associated in a linear fashion. Fish was the preferred food of animal origin and it is possible that income from sale of poultry and eggs was used to buy fish.

## 6. Conclusion

Foods of animal origin are rich in energy, protein, calcium, iron, zinc, vitamin B-12, riboflavin, vitamin A and conjugated linoleic acids (CLAs) that are bioavailable. These nutrients are an essential part of a healthy diet and, in some cases, foods of animal origin are the only sources of these nutrients. Diets in most of the developing world are deficient in several of these nutrients, especially the micronutrients (calcium, iron, zinc, vitamin B-12, riboflavin, vitamin A and CLAs), mostly because diets have limited amounts of foods of animal origin. As a result, there is widespread malnutrition in these areas reflected by stunted growth, impaired cognitive function, susceptibility to disease and high mortality rates, especially in women and children. The effects of malnutrition are not only limited to individuals, they can negatively affect communities and nations through lowered productivity, thus perpetuating the poverty cycle.

This chapter reviewed studies that showed beneficial effects of including moderate amounts of foods of animal origin in plant-based diets. These studies showed improved plasma levels of vitamin B-12 but not the other micronutrients. However, there were substantial gains in human nutrition and health as indicated by improved maternal outcomes, improved growth in children and improved cognitive function, and motor skills in infants and children. Unfortunately, design defects in the studies prevented direct extrapolation to view the impact on health, indicating the need for more robust research with designs that allow separation of the interrelated social and health effects of nutrition.

Concerns have been raised as to the potential negative effects of consumption of foods of animal origin on human health. Yet, the concerns are based on studies of societies who over-consume these foods, where foods of animal origin have been linked to cardiovascular diseases, type 2 diabetes, cancer and obesity. However, in developing communities, consumption of foods of animal origin is negligible and a moderate increase would not have detrimental effects, but rather would be beneficial in supplying essential micronutrients not available in plant-source foods. Additionally, some of the association between foods of animal origin and chronic diseases has now been questioned as a result from new research conducted in this field. Concerns over the negative impact of livestock on the environment have been raised in the last decade or so, but the impact of livestock on poor communities is very limited at present because of lower animal populations and marketing systems that tend to be localised, meaning less transportation is involved and thus lower fuel emissions.

While micronutrients can be produced industrially and made available as supplements, the effectiveness of this route is limited compared to consumption of foods of animal origin that provide multiple micronutrients simultaneously and are tasty. Evidence certainly exists of the importance of advocating for increasing the production of

foods of animal origin at the household level and linking this increased production to the nutrition and health of mothers and children.

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# 6

## Interactions between Gender, Environment, Livelihoods, Food, Nutrition and Health

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### Abstract

The rural poor are continuously involved in a struggle to improve household livelihoods and food security. Livestock, through provision of animal food products such as meat, milk and eggs and its provision of draught power, fuel and hides, can contribute to both. This chapter synthesises and analyses cross cutting themes on gender, environment, livelihoods, food, nutrition and health. Central to the gender issue in rural communities is the challenge faced by women, who continue to be overlooked in livestock-related research and development interventions as development practitioners ignore the need for gender analysis and the need to develop women's institutions. At policy and design level, consideration needs to be taken to identify critical components in a systems context to ensure sustainability of future projects. Funding of research projects is planned for shorter time periods than funding for long-term development projects. Such challenges are explored in relation to policy development that looks into creating a balance between livestock production and the consequence of its negative impact on the environment. The measurements of the negative impacts of livestock are confounded by the lack of cross-country indicators that are comparable across a range of socio-economic situations. Studies to establish appropriate livestock production systems should be a priority in developing countries to mitigate the negative impacts of greenhouse gases on the environment. Overall, the impact of livestock on human health and nutrition has been ignored, yet it offers opportunities for adding value to livestock interventions.

**Keywords:** livestock, cross-cutting themes, socio-economic factors, biophysical resources, research and development, approaches.

### 1. Introduction

The livestock sector has experienced phenomenal growth in the last decade fuelled mainly by a global increase in demand for products of animal origin. This has been attributed mainly to population growth, urbanisation and income growth and has since been coined the 'livestock revolution' (Delgado *et al.*, 1999). In 1995, for the first time, the volume of meat produced in the developing countries exceeded that of



developed countries. Since then, the gap in milk output between developing countries and developed countries has been narrowing (FAO, 2005a).

The livestock revolution has implications for health, livelihoods and the environment. At international level, there has been variation in terms of determining the extent and nature of the livestock sectors growth and, invariably, the extent to which livestock can contribute to economic development and the achievement of the Millennium Development Goals (MDGs). For example, some developing countries, particularly those in sub-Saharan Africa, possess large feed resources, yet they have lagged behind in reaction to the livestock revolution that has characterised other developing regions (Mwangi and Omore, 2004). According to Chilonda and Otte (2003), keeping livestock makes contributions in a variety of ways, including:

- ▶ achievement of both national and household food security;
- ▶ reduction of poverty through generation of employment, income and savings; and
- ▶ contribution to economic development through trade in livestock, livestock products and the supplying of raw materials to industry.

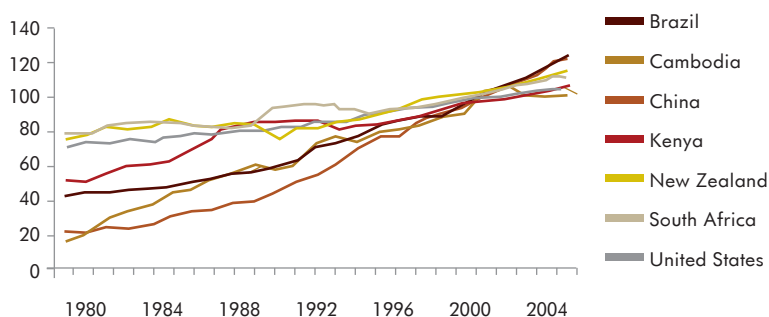
At the same time, it is also important to manage the environmental and public health implications of livestock production.

Chilonda and Otte (2006) recognised the relationship between the impact of livestock on the economy, the socio-dimension of the livestock resources and livestock's relationship with the biophysical resources. The paper also looked at indicators to monitor trends in livestock production at national, regional and international levels.

### *Livestock in the economy*

While agriculture is an important economic activity in most countries, it is known to dominate the economies of developing countries in terms of its contribution to the gross domestic product (GDP) and to supporting livelihoods. Common sources of economic data include the World Bank (2005) and national statistical reports. Livestock, as with other sectors, is intended to contribute to the economic development of a country. Through its role in national economic activity, the livestock sector interacts with other sectors of the economy such as crop and manufacturing sectors. At the national level, this illustrates the need to situate livestock in the context of the overall economy and in particular to agriculture, which can be done by estimating the share that agriculture and livestock contribute to the total GDP. At the global level, it is estimated that 70 percent of the rural poor's livelihoods is supported by the animal sector, representing approximately 20 percent of animal products traded worldwide (Ali, 2007).

Estimating the share of livestock GDP in agricultural GDP gives an indication of the relative importance of the livestock sector within the agricultural economy. Annual growth rates are useful indicators of trends. Overall livestock output and productivity can be measured using the Livestock Production Index as illustrated in Figure 1.



**Figure 1:** Evolution of the Livestock Production Index (1999-2001 = 100) in selected countries (1980–2004) (World Bank, 2005)

### *Socio-economic dimension of livestock resources*

According to Chilonda and Otte (2006), livestock production has a multifunctional purpose and is used to satisfy various needs in human society. Socio-economic indicators – in particular those that relate livestock to trends in human demographics and human welfare – provide information about the supply and consumption of food of animal origin.

Principal sources of socio-economic data include the World Bank (2005), FAOSTAT (FAO, 2005a), national statistical databases and reports. Relevant population segments of the data would include total population, agricultural population, economically active population in agriculture disaggregated by sex, livestock-keeping population, and urban population as consumers of livestock products. Possible indicators could include proportions of each population segment in the total population and their annual growth rates, densities on total and agricultural land, number of livestock per person and number of livestock units per household.

The total number of agricultural households and livestock-dependant households needs to be estimated as they provide information on not only the distribution of livestock ownership, but also on productivity of the sector. This may be measured as output per livestock worker or household. Swanepoel et al. (2009) argue that, due to the multifunctional nature of livestock, it is misleading to regard livestock as an isolated production activity normally associated with a conventional system. Livestock's role in minimising risk in household security is much more complex,

as livestock production decisions are integrated with other household production and consumption decisions (Vandamme *et al.*, 2010). The Sustainable Livelihood Framework (SLF), designed by Carney (1998), can be used as a conceptual model for explaining this complexity and to provide insight into how livestock affect a variety of household assets and, ultimately, the wellbeing of the poor (Randolph *et al.*, 2007).

Furthermore, measures of human welfare, such as poverty measures and the Human Development Index compiled by the United Nations Development Programme (UNDP), are becoming increasingly important indicators in determining the potential role livestock is currently fulfilling (UNDP, 2005). Countries that have a high incidence of rural poverty and a poor ranking on the Human Development Index may place more emphasis on the role of livestock in poverty alleviation, while a relatively wealthier urban population will offer a ready market for food of animal origin which can contribute to livestock sector growth. There is also a need to link livestock to overall rural development. Keeping livestock so as to assure both national and household food security needs is an important goal in livestock production, and hence consumption of livestock products needs to be monitored. Consumption of livestock products may be measured in terms of quantity of calories, proteins and fats derived from animal products consumed per day.

### *Livestock and biophysical resources*

Approximately two-thirds of the world's livestock are used in developing countries' farming systems where resources are often limited and scarce (Pell *et al.*, 2010). The livestock component in these systems plays an important role in organic- and mineral-nutrient cycling and thus helps maintain the resilience and productivity of these resources. This occurs mostly in complex crop-livestock systems (Stroebele *et al.*, 2010).

Seré and Steinfeld (1996) used the land-livestock ratio as one of the criteria for describing livestock production systems of the world. Availability of land and grazing resources often determines the type of livestock that can be kept, the way they are managed (i.e. predominant production systems) and the extent to which livestock production can expand further. Countries and regions that are abundant in land and possess both low human and livestock densities, as in most sub-Saharan countries, tend to have grassland-based systems. This is in comparison to locations where high human and livestock densities tend to push livestock systems towards intensification, such as the landless industrial systems of East and South Asia, which raise mainly monogastric animals. Indicators relating livestock and biophysical resources need to consider the different categories of land, such as total land, arable land, arable and permanent crops, permanent or non-permanent pastures, and non-arable pastures.

The proportion of each land type and its evolution over time in relation to total land is important, especially that of permanent pastures.

Densities of livestock populations on total land and agricultural land are indicators of the land resources available for livestock production and, when used along with human population pressures, they can be used to analyse the evolution of different livestock systems. For example, diminishing land resources due to increasing population pressure tend to drive livestock systems towards intensification (Winrock, 1992).

## 2. Research and development

Multifunctionality must be factored into the design of development projects that can make a difference. At institutional, policy and design levels, efforts must be made to identify critical components in a systems context to ensure sustainability of future projects (Pell *et al.*, 2010). Such a system-focused framework should identify relevant stakeholders and weak linkages that are part of the dynamic relationship between the public and private sectors. Responsible research designers should include strengthening of such relationships as part of their objectives, even though in reality, it is a policy issue. The challenge is for policies dealing with research funding to address the need to align research agendas and development projects. Research and development needs have been formulated on the basis of scientists and policy makers' understanding of the macro and micro environment without the communities in the driver's seat and, all too often, resulting in duplication of research on the same research topics, themes and programmes that reached the same conclusions.

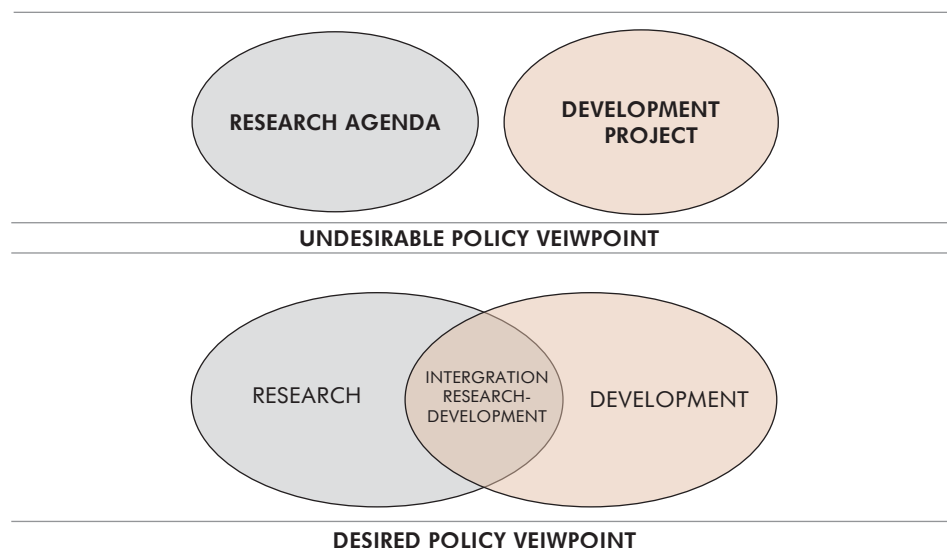
The use of information and communication technology (ICT) should be embedded in research funding to enable active exchange of information, even to communities that otherwise would not have access to it. Research must be undertaken in order to identify the knowledge needs and which methods are user-friendly to the different stakeholders. As a matter of policy, packaging and delivery of knowledge should be appropriately designed for each of the different partners, such as the private sector, farmers and researchers, according to their unique needs and contexts.

Sustainability of projects continues to be poor due to variation in objectives of different stakeholders such as researchers, funders, community members, and public and private sector organisations. The challenge of facilitating a shared common goal among partners is further complicated by the short-term funding of projects with long-term goals. Figure 2 illustrates undesirable and desirable policy paradigms.

**Undesirable policy paradigm** illustrates a situation in which research plans are based on what researchers "think communities need", but have no connections to

the planners of development projects. These two programmes have different funding sources with no linkages, collaboration or communication between them.

**Desirable policy paradigm** illustrates a situation in which research-funding mechanisms and processes are integrated with the developmental agenda of the sector, country or region. In this case, a proposed new policy could assist in channelling resources to community-based priorities rather than spreading funding thin over a short period of time.



**Figure 2:** Schematic representations of policy viewpoints

### 3. Gender

It is estimated that 600 million livestock owners in the world are women. Women contribute up to half of the world's food and perform two-thirds of the world's work, yet earn only a tenth of the world's income and own less than a hundredth of the world's property (ILRI, 2008). The said scenario paints a picture of a typical smallholder farmer in survival mode in a resource-poor environment. It also describes a livelihood situation that goes beyond the input-output models and exposes poor socio-economic and empowerment policies that have been neglected for decades. Although the situation has been improving over the last 20 to 30 years due to the intervention of NGOs, women continue to be overlooked in livestock-related research and development interventions. There is still a strong tendency for project planners

and implementers to assume that the major actors in livestock production are men, particularly when large ruminants such as cattle or camels are involved (Waters-Bayer and Letty, 2010).

These projects may unknowingly strengthen the position of men over women. For example, they may i) deprive women of traditional realms of responsibility, social recognition and income in the livestock sector, ii) prevent women from benefiting equitably from various development initiatives, iii) ignore the possibility of involving women in livestock activities that have been the traditional realm of men and iv) constrain women from fulfilling their full potential to contribute to development (Waters-Bayer and Letty, 2010).

In the case of livestock-related project development, there seems to be an acceptable level of access by women to small-stock enterprises based on goats and poultry. The said entry point assists women's groups that aspire to move to larger stock such as cattle, thereby further attempting to empower woman. The main challenges include access to finance, sustainable institutional arrangements and cultural barriers that limit assertive ownership by women. This highlights the fact that traditional customs (beliefs, traditions, ideology) should be understood and integrated into research and development projects if rural enterprises are to be sustainable. In most developing countries in Africa, bureaucracy and corruption remain challenges that demand political solutions.

The foremost lesson that should be learned and implemented by researchers is that gender analysis is a must, and cannot be confined to a once-off exercise, because situations change over time. Furthermore, recording processes and data in a gender-differentiated way is not sufficient to monitor the impact of livestock interventions on women. Other lessons for researchers include the need to:

- ▶ focus on those women who need the most support to attain equality with men;
- ▶ strengthen local women's organisations;
- ▶ improve women's access to education and training;
- ▶ recognise dynamism and openings for positive change in resource-poor households; and
- ▶ seek gender equality in livestock services and organisations.

#### **4. Livelihood and environment**

One focus of the MDG challenge (MDG 7) concerns ensuring that livestock can contribute to social and economic progress in ways that do not have adverse impacts on the environment. There are research gaps in how the complexity of development on the environment is dealt with. Researchers have to understand the context under

which the biological assets are used and also the tradeoffs between the need for increased production and impact on the environment. Conflicts exist between the actual biophysical environment and the delivery and support systems, input and output markets, research and extension, policies and institutions.

The threats of climate variability and change have led researchers to emphasise the negative effects on domesticated animals. This is due to the fact that the farm animal sector is the single largest anthropogenic user of land. However, it also provides food for urban and rural consumers and is an important source of income, employment and traction in developing countries (Herrero *et al.*, 2008a). Livestock have an unintended negative consequence in that they actually contribute to environmental problems such as global warming and climate change. The other school of thought is that if animals were not part of the ecosystem that utilises natural pastures, would there be a better way to recycle these resources? It is important to recognise that there are regions of the world where the positive roles of livestock outweigh environmental problems.

Researchers and development experts should focus on understanding the livestock systems in their local contexts, with the hope of identifying alternative livelihood options for livestock where they exist. The measurements of the negative impacts of livestock are confounded by lack of cross-country indicators that are comparable under different socio-economic situations (Chilonda and Otte, 2006). Studies of this nature are crucial in designing research and development agendas that can provide food and livelihood options while maintaining the ecosystem's resources around the globe (Herrero *et al.*, 2008b).

The need to deal with the current and potential multiple impacts associated with that of changing climates has become so strong that symposiums have been organised to deal with this threat to rural livelihoods in the developing world, such as "Implications of climate change for sustainable agricultural production systems in ACP countries" held in Ouagadougou, Burkina Faso, in October 2008 (Sweetmore, 2008). From a policy perspective, there is need for more funding to study the impact of animal production on global warming, especially in developing countries. In addition, investments are needed in areas such as developing and transferring technologies that can convert animal manure into biogas and for designing feeding systems that can reduce methane gas emissions. Furthermore, incentives in the form of tax relief or grants will be needed to encourage farmers to implement these systems that will enhance their operations and, at the same time, avoid environmental pollution from animal waste.

## 5. Food, nutrition and health

Food, nutrition and health have proven more difficult to manage in developing countries than in developed countries. In these resource-poor countries, food is needed to provide essential nutrition to marginalised populations to address micronutrients such as vitamins, minerals, protein and energy needs (Oelofse *et al.*, 2008). Poor populations in these countries often suffer from micronutrient deficiencies due to diets that are based on cereals. About 820 million people were identified as undernourished in the period 2001 to 2003, representing 17 percent of the developing world's population (Randolph *et al.*, 2007). As animal-based food sources tend to have sufficient levels of protein and essential micronutrients, they can make critical contributions to the balanced diets of the vulnerable groups of the rural poor, mainly children, pregnant and lactating women. Efforts to empower women livestock owners therefore should consider their decision-making rights in terms of producing livestock products for income generation or food security.

Livestock-based development projects that support more market-oriented management systems that require the purchase of expensive inputs tend to have production that is sold to cover the input costs rather than for consumption. Integrating livestock development projects with nutrition and health goals could go a long way to ensuring that the disposable income created by these systems is used to purchase nutritionally acceptable household food that is equitably accessible to all members of the family. In poor countries, food security has been the main agenda while the issue of food safety has been dealt with behind the scenes. Comprehensive food-security models should include elements of food safety, especially for the rural poor who are the most vulnerable, such as children, those who are immune-suppressed or the malnourished. Among the food safety issues in developing countries is the fact that environmental conditions – high temperatures, rainfall and humidity – can lead to high pathogen loads and food-borne diseases. In addition there is a lack of food preservation infrastructure, inadequate food safety systems and poor response capacity (Randolph *et al.*, 2007). Food-borne diseases also create a bigger marketing challenge for smallholders who would like to access markets in developed countries, but cannot due to their inability to meet the importing countries' safety standards.

Development of food safety policies should consider issues of poverty reduction, equity and gender empowerment, lest the poor continue to be penalised. If poor farmers cannot meet a market's high food safety standards, they often move to informal markets, creating a bigger problem to monitor. Indigenous knowledge and practices must be taken into consideration in setting food safety standards in levels across the value chain.



## 6. Approaches, methods and tools

Appropriate approaches to livestock development are those that are holistic and recognise that technical solutions and material/financial support alone are not sufficient to close the gap between demand and supply of services. Appropriate approaches tend to be participatory and set up a learning cycle composed of phases within a whole action learning process. The phases may include, for example, a situational analysis, initial change, searching for new or alternative ways, planning and strengthening local organisational capacity, experimentation while implementing a plan of action, sharing of experiences, reflection on lessons learned, and re-planning. Each phase consists of a number of aspects to be facilitated, but this needs to be understood as a continuous process and local organisational change is the backbone that cuts across all the phases. The establishment of communication among local organisations allows for the development of a common vision for change and consolidates efforts to pursue change with the support of service providers. This builds community linkages with outside stakeholders.

The challenge to the practitioner is to identify innovative and economically attractive technical solutions consistent with people-centred development. In the context of developing countries, most households are headed by females and live below the poverty line. For them, market-oriented agriculture plays a minor role. Participatory development approaches (PDA) facilitate the re-establishment of indigenous values and knowledge, and empower local community structures and organisations to articulate their felt needs, with respect to service providers and stakeholders. An additional challenge on PDA's institutionalisation process relates to efforts to combine traditionally top-down service delivery with processes of community empowerment and self-organisation, in turn leading to more demand-led delivery responses.

PDAs also make extensive use of farmer-to-farmer extension and technology adoption methodologies, as farmers normally accept the advice of neighbouring or fellow farmers more readily than advice from an outside person. However, there is no blueprint solution, as each community has a different history and organisational capacity. Latest methodologies include diagnostic-based approaches to agricultural research for development, which also focus on interdisciplinary research and training coupled with other participatory tools. Technically based methods such as life-cycle analysis linked with integrated approaches to understand food-livelihood-health linkages can also be implemented.

The Geographical Information System spatial analysis has been used to address system diversity and variability in an integrated manner in development-related projects.

## 7. Conclusion

Establishing a sustainable role for livestock in developing communities demands a paradigm shift by both researchers and development practitioners. For livestock to play a significant role in eradicating poverty and enhancing the nutrition and health of marginalised rural households, there must be reciprocal action learning by researchers and smallholder farmers. The challenge to the practitioner is to identify and provide innovative economically attractive technical solutions consistent with people-centred development. In the context of developing countries, the majority of households are headed by females, live below the poverty line and, for them, market-oriented agriculture plays a minor role. For progress to be realised, there is a need to develop funding policies that support long-term research aligned with long-term development projects that are mostly in developing countries. Risk and vulnerability challenges associated with climate change will continue to compel scholars, researchers, donors and decision makers to think globally and inter-disciplinarily across sectors, in order to establish appropriate livestock production systems in balance with the environment. For poor and marginalised women livestock owners to be empowered, institutional capacity building in the form of self-help groups, cooperatives and training should be implemented as entrepreneurial vehicles to accelerate rural development.

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# 7

## Livestock against Risk and Vulnerability:

### *Multifunctionality of Livestock Keeping in Burundi*

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### **Abstract**

Although poor households in developing areas are generally seen as highly vulnerable, they actually do have coping mechanisms through which they deal with risks. In essence, they cope by adapting their income- and food-generating activities. The focus of this chapter – livestock keeping as a livelihood strategy in a risky environment – explores whether resource-poor households use livestock to overcome risks. A study of the reasons for livestock keeping and the multifunctionality of livestock within the sustainable livelihoods framework identified the use of livestock as insurance against risk and as the base from which to diversify economic interests. The study obtained information on 288 households in Burundi, including demographic, socio-economic, food security and agricultural characteristics. Recognising that food security is probably the most important and valid measure of livelihood outcome in resource-poor areas, the level of food insecurity was analysed by asking questions regarding availability, accessibility and diet quality. The second part of the analysis studied characteristics of livestock keepers and how livestock contribute to their household risk-coping abilities. The majority of households are food insecure and involved in wage labour. The more food-secure households are involved in livestock keeping and more likely to be involved in food and cash crop markets. Although average animal production is very low, involvement in livestock keeping is significantly linked to better food security. Livestock was used to overcome vulnerability through income from animal products and distress sales, provide opportunities to obtain credit and facilitate investment by serving as insurance. These results support the hypothesis that livestock can play a role as insurance and increase the risk-bearing capacity of resource-poor households, especially for risky investments that have higher returns.

**Key words:** risk, vulnerability, food security, insurance, investments, resource-poor households, Burundi

## 1. Introduction

It is generally recognised that poor households in developing areas are highly vulnerable to risk. Risk is the exposure to events with uncertain and potentially unfavourable consequences (Hardaker *et al.*, 1997). The two main negative events identified are shocks and stresses. Shocks are large, unpredictable, irregular disturbances, while stresses are smaller, predictable, regular and sometimes continuous disturbances (Pearce *et al.*, 1989). A household is said to be vulnerable to risk when it is prone to food insecurity and experiences a high degree of exposure to shocks and stresses (Chambers, 1989 and Davies, 1996). This refers both to external threats to livelihood security and internal coping capabilities determined by assets, food stress, support from kin or community amongst others (Ellis, 2000). Faced with external threats, a household will adapt its income and food-generating activities in the best possible way to minimise risk and achieve food security. The focus of this chapter is to explore how important it is for households in resource-poor areas to keep livestock in order to overcome vulnerability and surmount risk.

Measuring and conceptualising vulnerability and resilience to risk is complex. On the one hand, the large variety of risk factors makes it difficult to isolate specific causes. The ability to cope also depends on which livelihood strategies are practiced. With regards to the former, different risk factors result in different types of risk: i) environmental factors such as droughts or floods; ii) socio-economic factors such as gender discrimination or a lack of efficient resource management; iii) natural and man-made hazards such as conflict, insect plagues, malfunctioning markets and high prices; and iv) political factors such as civil unrest and policies that affect entitlements and access to resources (Collier and Gunning, 1999). This chapter does not consider these types of risk, but instead focuses on livestock keeping as a livelihood strategy in a risky environment.

Ellis (2000) makes a clear distinction between *ex ante* and *ex post* risk management strategies. *Ex ante* strategies or adaptive strategies are long-term adaptations aimed at improving livelihood security. *Ex post* strategies or coping strategies describe households' attempts to manage limited resources to ensure survival and protect assets in the hope of recovery after a shock or threat (Ellis, 2000). Consumption smoothing is a very important *ex post* coping strategy, and refers to a uniform way of consumption between income generating periods to prevent lack of money towards the end of non-income generating periods. An important instrument for consumption smoothing is the distress selling of assets in times of crisis. The main assets used for distress sales are livestock and food crops (Ellis, 2000). For livestock to assume a role in consumption smoothing, Dercon (1998) identified some necessary economic and geographical conditions that must be in place: i) livestock markets should be well developed, ii) prices should be relatively stable and reasonable, and iii) there should

be risk management strategies for disease management or moving cattle in case of a life-threatening drought.

This chapter presents a case study undertaken in a northern province of Burundi to i) identify the contributions of livestock keeping to rural livelihoods and ii) determine the role of livestock keeping in risk-management strategies. Results are based on data from 288 households interviewed about their farming practices in 2007.

## 2. Literature overview

An estimated two-thirds of resource-poor rural households worldwide keep some type of livestock (LID, 1999). Six different reasons for livestock keeping can be distinguished: i) food production; ii) income generation; iii) provision of manure; iv) draught power; v) financial instruments; and vi) enhancing social status (Moll, 2005 and Randolph *et al.*, 2007). The first four result in the direct-use value of livestock (Shackleton *et al.*, 2001) while the last two are more related to development settings and their cultural, social and economic context and create indirect-use value (Shackleton *et al.*, 2001). Livestock serve as financial instruments in rural settings because of the persistent absence of credit and financial markets in rural areas of developing countries. According to Moll (2005), investment in livestock is seen as creating a savings account or insurance, which can provide an instrument of liquidity and consumption smoothing in times of need. The sixth reason refers to widely-found social implications of livestock keeping. In fact, livestock keeping does not only induce cultural and social advantages, in many cases it also translates into access to or authority over a broader base of resources which provide opportunities to obtain higher income (Randolph *et al.*, 2007).

To understand and identify the contributions of livestock to the general well-being of rural households, the conceptual framework of livelihoods can be used (Randolph *et al.*, 2007). Chambers and Conway (1992) defined livelihoods as the capabilities, assets and activities required for a means of living. According to Ellis (2000) the most important feature of this popular livelihood definition is that it directs attention to the link between assets and the options people possess in practice to pursue alternative activities that can generate the income level required for survival. Assets are the starting point for livelihood analysis, the basic building blocks upon which households are able to generate their means of survival. Scoones (1998) distinguished five types of capital households may possess in the sustainable livelihood framework, namely; natural capital, human capital, physical capital, financial capital and social capital.

**Natural capital** comprises the land, water and biological resources that are utilised by people to generate means of survival.

**Physical capital** refers to infrastructure such as roads, electricity and water supply, irrigation canals, machines.

**Human capital** comprises the labour available to the household: their education, skills and health.

**Financial capital** refers to any stock of money to which the household has access. Generally these can be savings or access to credit in the form of loans.

**Social capital** attempts to capture community and wider social claims which contribute to individuals' and households' means of survival.

Randolph *et al.* (2007) identified specific contributions of livestock to each type of capital. Animal manure can increase natural capital by increasing soil fertility. It also indicates a linkage between herd size and physical capital, because an increase in herd size results in an increase in physical capital. Animal products and proteins are important contributors to human nutrition and health status and therefore provide a means to empower human capital. Animal production is a means of income generation and therefore increases financial capital. The clear linkage between livestock keeping and social status indicates the positive implications livestock keeping has on social capital.

A DFID study by Heffernan and Misturelli (2000) in Kenya provided evidence of the major importance of livestock keeping in household economic security. Using a ranking exercise, they found that rural households identify livestock keeping as their most important income source. Kristjanson *et al.* (2004) found that livestock played a key role in pathways both into and out of poverty. Dercon (1998) found that in Sukumaland, Tanzania, households that owned cattle had significantly higher income than those households that did not own cattle. Assuming that keeping cattle has highly positive effects on livelihood outcomes, one might wonder why not all households are involved in cattle keeping. Dercon (1998) stated that some households were excluded from the economic activity of cattle keeping due to low asset and resource endowments. This suggests the presence of entry barriers for the involvement in cattle keeping.

Reardon *et al.* (1992) showed that larger livestock holdings in Burkina Faso were linked to greater diversification, which resulted in risk reduction strategies and identified three different activities leading to risk reduction:

- i Livestock can be used as collateral for loans to start non-farm enterprises. Ellis and Freeman (2004) described livestock as a substitutable asset that can be sold in order to invest in land or small businesses and vice versa. Non-farm income can be used to build up herds and obtain the necessary inputs.
- ii Income can be gained from selling animals and by-products.



- iii Households with larger livestock holdings seem to be less risk averse and thus perhaps more willing to invest and diversify outside agriculture in off-farm activities.

Ellis (2000) found that households would only engage in economic activities with high perceived risk when they could compensate for this risk by having contingency income sources or fallback positions of social support in place, in case of failure. Dercon (1996) showed that in Tanzania, households with relatively low livestock holdings allocated significantly more of their land to sweet potatoes – which are considered a low risk and low return crop – than households with large livestock holdings. These findings suggest the possibility that livestock holdings influence the household's farm-management decisions.

These studies lead to the conclusion that livestock can be used to overcome vulnerability both directly through income from animal products and distress sale and indirectly through providing opportunities to obtain credit and facilitating investment by serving as insurance and thereby increasing risk-bearing capacity.

### **3. Case study: Livestock keeping among poor households in Ngozi Province, Burundi.**

#### *General information of Burundi*

Burundi is among the poorest countries in Africa. Its annual gross national income (GNI) per capita (PPP) is only US\$320, five times less than the average sub-Saharan African GNI. Burundi was ranked 167 out of 177 countries in the last United Nations Development Program's (UNDP) Human Development Index (HDI), which measures human development by combining life expectancy at birth, education level and standard of living. Burundi has a population of 8 million and average population density of 273 persons/km<sup>2</sup>. Agriculture is by far its most important economic activity, with 90 percent of the population involved in agricultural activities. The most important staple crops are beans, sweet potato, cassava and banana, with coffee as its only important cash crop for export. Despite high population growth, Burundi was food self-sufficient until the beginning of its 1993 civil war (Cochet, 2004). Currently, the political environment in Burundi is relatively stable but widespread insecurity and uncertainty still prevails.

Rural households in Burundi are exposed to high levels of different risk factors. Climatic risks related to a fluctuation in rainfall and temperature result in crop yield uncertainties. Economic risks and political conflicts cause widespread price uncertainty due to market instability and unreliable institutions and infrastructure. Increasing population pressure and land scarcity create great uncertainty on yields

and hence on income derived from the agricultural sector. In this context of high risk and uncertainty, rural households develop coping mechanisms and risk management strategies to ensure a sustainable income or, in the worst case scenario, to survive.

### *Data collection*

The data used in this case study was gathered during August and September of 2007 in Ngozi province of northern Burundi. This province is characterised by a high population density (475 persons/km<sup>2</sup>) resulting in land scarcity and high levels of food insecurity. Information obtained on 288 households included demographic, socio-economic, food security and agricultural characteristics.

### *Methodology*

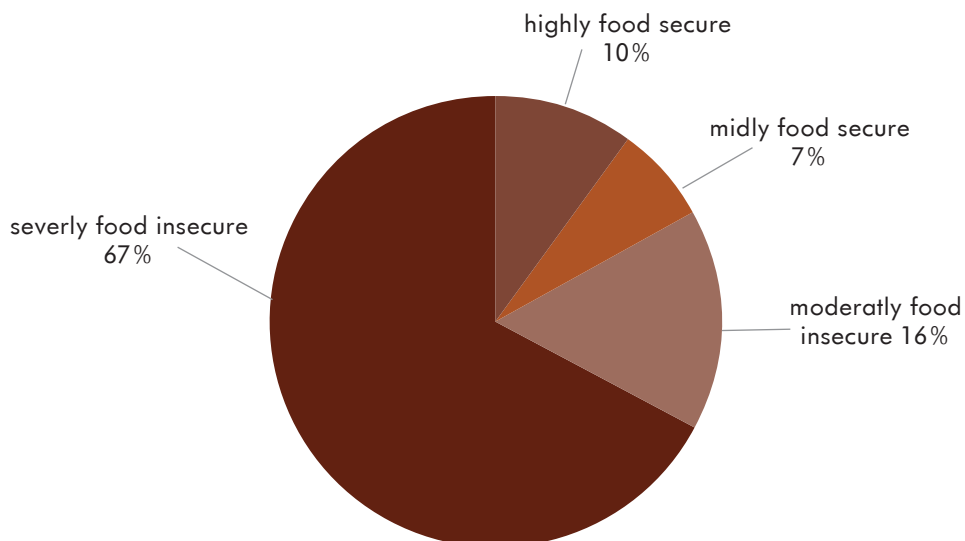
The data is used to identify how livestock contributes to rural livelihoods and what characterises livestock keepers in the sample. It is worth noting that an estimated 90 percent of the households in Burundi depend on agriculture for their survival. Food security, probably the most important and valid measure of livelihood outcome in resource-poor areas, can be assessed using various indicators such as daily caloric intake. However, this study uses a more subjective measure, namely the Household Food Insecurity Access Scale (HFIAS) developed by USAID (Coates *et al.*, 2007). Using this method, the answers to a specific set of questions on availability, access and diet quality, result in a score for each household indicating the level of food insecurity. The score ranges from 0 (household is food secure) to 27 (household is highly food insecure). The HFIAS score can be divided further into four different categories ranging from category one for food-secure households to category four for highly food-insecure households. The relative importance of livestock is analysed for each of these categories.

The second part of the analysis studies different characteristics of livestock keepers and how livestock contributes to the household's risk-coping abilities.

### *Results*

#### Contribution of livestock to food security

In order to analyse food security for livelihood outcome and sustainability, households with different food security levels and livelihood activities were compared to reveal how differences in the uptake of economic activities resulted in a better or worse food security status. The original distribution of households for Ngozi in four different food security categories (highly food secure, mildly food secure, moderately food insecure, and severely food insecure) is shown in Figure 1.



**Figure 1:** Food security status of households in Ngozi in 2007 (N=288)

For further analysis, the two food secure categories were merged to create a larger category for statistical reasons, resulting in three different categories; i) food secure households; ii) moderately food insecure households; and iii) severely food insecure households. For these three categories, the share of households involved in different livelihood activities was compared with a Pearson Chi-squared test. The results are presented in Table 1.

**Table 1:** Livelihood activities of households (hh) with different food security status in Ngozi, 2007 (N=288)

Share of households (%) involved in	Food secure hh (N=47, 16.5%)	Moderately food insecure hh (N=47, 16.5%)	Highly food insecure hh (N=194, 67%)	Test (Chi-squared)
Food crop sales	91.5	91.5	74.4	11.19**
Cash crop sales	91.5	61.7	69.6	11.85**
Wage Labour	12.8	29.8	41.8	14.65**
Trade	46.8	46.8	30.4	7.41**
Livestock	66.0	42.6	31.4	19.28**
Poultry keeping	17.0	27.7	18.0	2.45
Goat keeping	51.1	38.3	35.1	4.11
Cattle keeping	40.4	25.5	12.4	20.78**

Households with a food-secure status were more likely to be involved in food crop and cash crop sales, and livestock keeping. A significantly larger share of households with high food-insecurity levels were involved in wage labour. Being involved in livestock keeping in general, and specifically cattle keeping, was significantly linked to a better food-security level which suggested that cattle keeping and livestock keeping in general had a positive effect on household food security levels.

### Contributions of livestock to livelihood strategies

Table 2 shows the distribution and characteristics of livestock keeping in Ngozi. Goats were the most popular livestock species while an equal share of households were involved in cattle and poultry keeping. Other livestock species were less common.

**Table 2:** *Characteristics of livestock keeping in Ngozi, 2007 (N=288)*

	Number of households (N)	Share of households (%)	Maximal	Mean number of animals (SD)
Cattle	56	19	13	2.38 (1.93)
Goats	110	38	40	3.48 (4.13)
Poultry	56	19	46	6.84 (6.87)
Pigs	27	9	9	1.56 (1.78)
Sheep	22	7.5	5	2.59 (1.29)

Table 3 shows the households that kept cattle or poultry, the share of households that actually obtained animal products from their livestock and the quantities obtained. Approximately one-third of the households keeping cattle or poultry actually obtained milk or eggs from their animals. The average animal production was low, which implied a low production value. These findings suggested that the sales of animal products such as milk or eggs were probably not the main reason for livestock keeping.

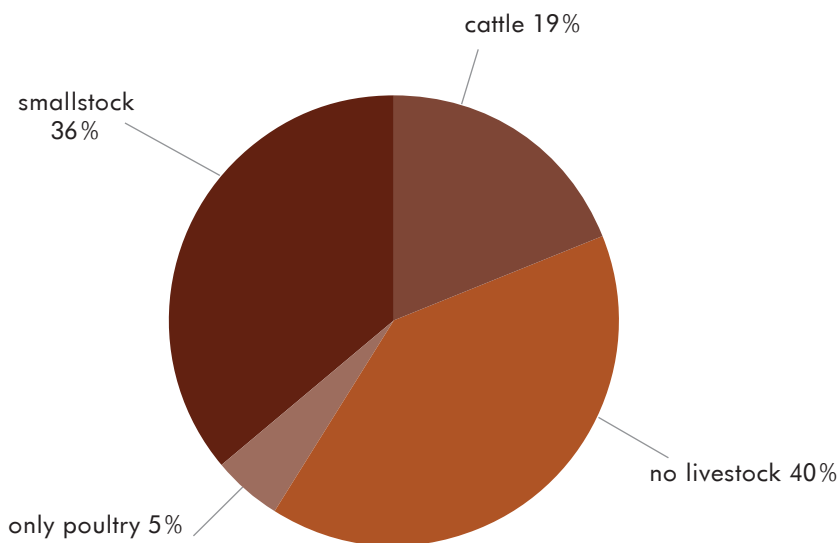
**Table 3:** *Animal production in Ngozi, 2007*

	Share of households (%)	Minimal	Maximal	Mean (SD)
Milk production (l/week)	25.5	1	42	14.47 (12.75)
Egg production (eggs/week)	35.7	3	20	9.30 (5.03)

Livestock were partially integrated in the farming system through the specific use of manure as fertiliser for the purpose of nutrient cycling. A similar study in the

same study area, performed in 1996, found an increase in the use of manure over the previous ten years. This implied a certain, albeit more indirect, importance of animal products in rural livelihoods.

Figure 2 gives an overview of the distribution of the most valuable livestock assets owned by households. Different livestock keeping strategies were distinguished: i) households keeping cattle and possibly also smallstock (goats, sheep and pigs) and poultry; ii) households keeping smallstock and possibly poultry; iii) households keeping poultry; and iv) households without livestock. More than half of the households in the sample kept some type of animal, mostly smallstock. This was partly explained by a government project that introduced goats. One-fifth of the households kept cattle. Since only very few households were solely involved in poultry keeping, they were merged with households involved in smallstock keeping for further analysis. This resulted in three livestock keeping strategies: i) no livestock; ii) keeping only smallstock, i.e. poultry, goats, sheep or pigs; and iii) keeping cattle and possibly other livestock species.



**Figure 2:** *Distribution of different livestock keeping strategies of households in Ngozi, 2007 (N=288)*

As stated, livestock can be used to overcome vulnerability both directly, through income from animal products and distress sale, and indirectly by providing opportunities to obtain credit and facilitating investment by serving as insurance and thereby increasing their risk-bearing capacity. The low productivity and production levels of livestock in Ngozi indicated that income from animal products as an outcome

of livestock keeping would not be a major contributor to households' risk-coping mechanisms. Although distress sales had potential to be another possible coping strategy, a lack of information on the functioning of local livestock markets and access to those markets prevented drawing clear conclusions on the contribution of distress sales to coping strategies and insurance possibilities in Ngozi.

According to Table 4, only 12.5 percent of all respondents had access to credit. A Pearson Chi-square test, used to determine whether there was significant difference in access to credit for households involved in different livestock keeping strategies, allowed a comparison of the share of households that had access to credit for each livestock keeping strategy. It found that households owning cattle had significantly higher access to credit.

**Table 4:** *Access to credit for households involved in different livestock keeping strategies in Ngozi, 2007*

	Share of all households having access to credit (%)
General dataset (N=288)	12.5
Hh not involved in livestock keeping	7.1
Hh keeping only smallstock	11.8
Hh keeping cattle	25
Chi-Square test: 11.09**	

The last indirect contribution that livestock keeping might have had to risk and uncertainty management was providing a type of insurance that would increase risk-bearing capacity. Households owning livestock assets might have been more willing to invest in more risky farm and non-farm activities because they had livestock assets to fall back on in case the investment went wrong. This hypothesis was examined by comparing farm management decisions and activity choices for households involved in different livestock keeping strategies.

#### ► Farm management decisions

For rural resource-poor households, farm-management decisions are crucial. These households try to allocate the limited resources they have as efficiently as possible in order to increase income security, food security and risk-coping ability. The different farm-management decisions studied included cropping choices, input investments and the level of investment in conservation measures. For comparing cropping choices, less common products such as pineapple and passion fruit as fruit crops, and tomatoes, cabbages and onions as vegetable crops were also included in order to ascertain whether investments in these crops could be linked to differences

in livestock-asset holdings. The field-fragment share for food crops or cash crops indicated the percentage of field fragments cultivated with either food crops or cash crops. A higher share of field fragments cultivated with cash crops could indicate a higher preference to invest in cash crops. Table 5 compares the uptake of different management decisions for the different livestock keeping categories. Different tests were used to check whether there was a significant difference between households belonging to different livestock keeping categories.

**Table 5:** *Farm management decisions of households with different livestock keeping strategies in Ngozi, 2007 (Standard deviation between brackets for continuous variables)*

	Households not keeping livestock (N=113; 39%)	Households keeping only smallstock (poultry, goats, sheep, pigs) (N=119; 41%)	Households keeping cattle (N=56; 20%)	Test
<b>Cropping choice decisions</b>				
Number of different crops	5.52 (1.81)	5.97 (1.70)	6.25 (1.81)	F-stat: 3.64**
Share of households involved in vegetable cropping (%)	24.8	35.3	41.1	Chi-Squared: 0.07
Share of households involved in fruit cropping (%)	9.7	10.9	12.5	Chi-Squared: 0.30
Share of households involved in rice cropping (%)	7.1	7.6	23.2	Chi-Squared: 12.22**
Field fragment share food crops	0.71 (0.18)	0.65 (0.18)	0.69 (0.21)	F-stat: 2.43
Field fragment share cash crops	0.20 (0.16)	0.21 (0.14)	0.18 (0.16)	F-stat: 0.65
<i>Input decisions</i>				
Share of households using fertiliser (%)	42.5	52.9	48.2	Chi-squared: 2.55
Share of income invested in farm (%)	16.17 (13.38)	25.67 (18.15)	30.39 (20.68)	F-stat: 15.86**
Expenditure on inputs (\$/ha)	64 (118)	61 (77)	57 (77)	F-stat: 0.12
<b>Conservation measures</b>				
Share of households applying anti-erosion measures (%)	26.5	47.1	44.6	Chi-squared: 11.39**

The data provided some evidence of linkages between livestock holdings, and cropping and investment decisions. Households without livestock grew significantly fewer crops, were less involved in vegetable and fruit cropping (although not significantly) and were less involved in rice cropping. They invested a significantly lower share of their income in farming activities, although actual expenditures on inputs per landholding did not seem to differ significantly. In addition, a significantly larger part of livestock keepers invested in anti-erosion hedges, making them less vulnerable to erosion. These findings indicated that livestock holdings were related to farm management decisions and that the presence of livestock asset holdings might provide an incentive to diversify crop choices and invest in rarer crops and specific conservation measures.

### ► Activity choices

Table 6 shows the share of households from different livestock keeping categories involved in different livelihood activities. The study found significant differences in activity choices of households involved in different livestock keeping strategies.

**Table 6:** *Involvement in livelihood activities of households with different livestock keeping strategies in Ngozi, 2007*

Share of households involved in	Households not keeping livestock (N=113, 39%)	Households keeping only smallstock (poultry, goats, sheep, pigs, (N=119, 41%)	Households keeping cattle (N=56, 20%)	Test (Chi-squared)
Food crop sales (1=yes)	75.2	80.7	89.3	4.69
Cash crop sales (1=yes)	63.7	79	73.2	6.75**
Wage labour (1=yes)	45.1	28.6	28.6	8.27**
Trade (1=yes)	24.8	40.3	48.2	10.79**
Share of income from off-farm (%)	43.85	29.26	26.93	F-stat: 8.49**

A larger share of households involved in livestock keeping were involved in cash cropping while a larger share of households not involved in livestock keeping were involved in wage labour. Almost half of the households involved in cattle keeping were also involved in trading, while less than one-quarter of households not involved in livestock keeping were performing trading activities. However, comparing the share of income derived from the off-farm sector indicated that off-farm income was most important for households that did not have any livestock. Households not



involved in livestock keeping derived a larger share of their income from off-farm activities which indicated some kind of substitution between livestock and off-farm income.

## 4. Conclusion

Uncertainty is part of everyday life for most rural households in resource-poor areas. To deal with this risk and uncertainty, rural households develop different risk-coping strategies, adapt their farm management practices and invest in social ties and tangible and secure assets, such as livestock. This study focused on livestock keeping in a densely populated province of Burundi.

Literature describes the direct and indirect ways livestock keeping decreases vulnerability of rural households and controls risks. This can occur directly through the income gained from sales of animal products but also the distress sales of animals. Looking at the low animal production levels, however, indicated that this could not be the most important contribution of livestock to livelihoods of households in Ngozi. Limited information on livestock markets inhibited drawing a conclusion on the importance of distress sales of livestock as a risk-reduction strategy.

However, the obtained data did indicate that the indirect contribution of livestock keeping could be described either as facilitating access to credit or serving as insurance that, in turn, could provide incentives to engage in higher risk and higher return activities. In general, access to credit in Ngozi was very poor, as only 12.5 percent of households had access to credit. Results suggested that livestock keeping, especially cattle keeping, facilitated access to credit.

Studying the linkages among different livestock keeping strategies and on- and off-farm management decisions found that households with livestock were keener on risky investments such as vegetable, fruit and rice cropping and had a higher likelihood of investing in anti-erosion hedges to decrease erosion risk. Differences related to off-farm activity choices suggested that households involved in livestock keeping were also more involved in trading.

These results support the hypothesis of livestock playing the role of insurance and increasing the risk-bearing capacity of resource-poor households. Owning livestock gives households a sense of security and breathing space to invest in more risky crops and activities that have higher returns. It allows the conclusion that livestock are important contributors to households' capability to cope with risk and overcome vulnerability because they provide a reliable means of insurance in high risk, resource-poor areas such as Ngozi.

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# 8

## Sustainable Livestock Intensification

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### Abstract

Livestock intensification is a response to increased demand for livestock products, especially milk and meat. Although intensification offers opportunities for better income, it may deny smallholders the benefits of the multifunctionality of livestock, particularly the intangible benefits derived when products become increasingly commoditised. The increase in livestock populations has meant consequent impacts on the environment due to management changes such as increased use of commercial feeds and poor waste management practices. Although traditional livestock systems have provided a livelihood mainstay, particularly for farmers in developing countries, they now face challenges from a degraded natural resource base, negative impacts of climate change such as prolonged droughts, and an unresponsive policy environment. Livestock intensification is bringing about structural changes in livestock systems, particularly within the poultry and swine subsectors which provide huge returns per unit input and offer farmers economies of scale. This practice is edging closer to urban centres where there are large markets supported by better infrastructure. However, there are also current environmental, disease and welfare concerns when animal rearing occurs in small spaces with little waste-absorptive capacity. The right pathway for intensification in these situations seems dependent on sound policy and legislative frameworks aimed to mitigate impacts on the environment and welfare, while ensuring enterprise profitability. This chapter follows the livestock intensification theme and evaluates various practices influencing its sustainability and multifunctionality from the perspective of practitioners in both the developing and developed worlds.

**Keywords:** livestock intensification, livestock revolution, environmental impact, animal protein consumption, driving forces

## 1. Introduction

The 1992 United Nations Earth Summit held in Rio de Janeiro sought to lay a foundation for sustainable development in the world economy. The esteemed Brundtland Report credited with raising the debate five years earlier, defined sustainability in simple terms as the ability to meet the needs of the present generation without compromising the ability of future generations to meet their own needs (WCED, 1987). Two decades after the Brundtland Report was issued, sustainability had proven a hard concept to pin down, vague as a guide to the future, and interpreted to mean “all things to all people” (Tietenberg, 2005). However, sustainability has become more clearly assessed and understood in terms of environmental, economic and social dimensions with quantitative indicators acceptable to the stakeholders (Mollenhorst, 2005).

Intensification of livestock systems is the process of modifying production practices to increase output per animal, per unit of land and per unit of labour (Nicholson *et al.*, 1995). For instance, in ruminant livestock production, production output is measured in terms of the amount of milk or beef per unit of land. In its broadest sense, intensification can range from minor modifications to the complete restructuring of existing systems. It therefore identifies more closely with the objectives of productivity in a given system.

This chapter assesses the status of livestock intensification in developing countries, especially with regard to smallholder farmers who experience resource constraints such as decreasing land sizes, low financial inputs, low access to information and markets, and insufficient infrastructure to develop their animal enterprises. In spite of these challenges, improved productivity, profitability and sustainability of smallholder livestock farming is viewed as the main pathway out of poverty and for stimulating agricultural development (World Bank, 2007).

Furthermore, this chapter evaluates the multifunctionality of livestock systems and the role of intensification in the developing world, namely Africa, Latin America and Asia. The concept of multifunctionality recognizes agriculture as a multi-output activity producing not only commodities (food, feed, fibres, agro fuels, medicinal products and ornamentals), but also non-commodity outputs such as environmental services, landscape amenities and cultural heritages (IAASTD, 2008). To understand underlying issues better, the chapter introduces key intertwined themes:

- ▶ changes to the existing livestock systems and what intensification may imply;
- ▶ management of the transition to livestock intensification and related system dynamics; and
- ▶ analysis of agricultural economic systems to ascertain if they will automatically produce sustainable livestock intensification systems or if policy changes will be required and, if this is the case, what policy changes will be needed.

Structural changes in global agriculture will cause the livestock sector to change from a multifunctional to a commodity subsector. In this light, the following sections detail an overview of trends in livestock development in the quest for sustainable intensification.

## 2. Role of livestock in developing countries

The livestock sector is projected to become the world's most important agricultural subsector in terms of value-added products and land use. Livestock products account for about one-fifth of the global trade of agricultural products (Ali, 2007). In developing countries, demand for livestock products such as beef, milk and hides continues to expand due to increased household income, urbanisation and population increase. Each year in developing countries, the human population grows by 72 million, which adds to the demand for food products. There are, however, wide differences in population growth between East Asia, which has reported a decreased rate of 1.6 percent in population growth per annum, while sub-Saharan Africa has had increases of 2.8 percent per annum. In addition, the changing population structure has seen a fast increase in urbanisation and, as has been shown, urban dwellers adopt new eating habits, consuming higher amounts of animal proteins and eating a higher proportion of food away from home (Steinfeld *et al.*, 2006).

### *Animal-protein consumption*

According to Delgado (2003), consumption of meat in developing countries increased by a factor of five from the early 1970s to mid-1990s. In East and Southeast Asia, where population, income and urbanisation grew rapidly from the early 1980s to the late 1990s, meat consumption grew between 4 and 8 percent per year. In India, which is the world's largest milk producer, milk consumption doubled from the early 1980s to the late 1990s, now accounting for over 13 percent of the world's total milk produced and over 30 percent of the milk consumed in developing countries (Ali, 2007).

Rapid urbanisation in Latin America has led to a higher average level of milk consumption at 112 kg per capita, compared to 43 kg per capita in the developing world as a whole (Delgado, 2003). This compares well with per capita meat consumption of 80 kg for developing countries and 130 kg per year in high income countries (Steinfeld *et al.*, 2006). The increasingly urban and more affluent population in the developing world will demand a richer, more diverse diet, with more meat and milk products. As a result, global meat demand is projected to grow from 209 million tonnes in 1997 to 327 million tonnes in 2020, and global milk consumption from 422 million tonnes to 648 million tonnes over the same period. This has appropriately been called the "livestock revolution" (Delgado *et al.*, 1999). Table 1 provides an

overview of the important dietary transition that has occurred in the average diet in different parts of the world.

**Table 1:** *Protein supply from livestock & all sources in 1980 and 2002 (FAO, 2003)*

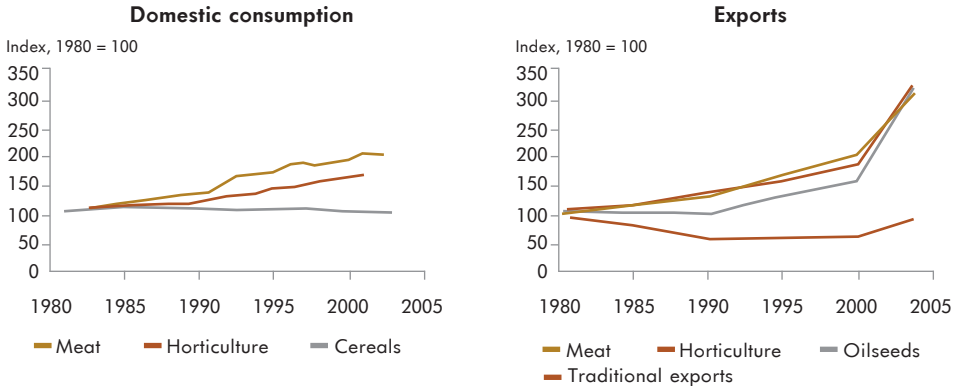
Region	Total protein from livestock		Total protein	
	1980	2002	1980	2002
Sub-Saharan Africa	10.4	9.3	53.9	55.1
Near East	18.2	18.1	76.3	80.5
Latin America	27.5	34.1	69.8	77.0
Developing Asia	7.0	16.2	53.4	68.9
Industrialised countries	50.8	56.1	95.8	106.4
World	20.0	24.3	66.9	75.3

Industrialised countries derive over 40 percent of dietary protein from livestock, excluding fish and seafood, and saw little change in these amounts between 1980 and 2002. However, in developing countries, changes were quite evident in those same years. They were most dramatic in Asia where protein supply from livestock increased by 131 percent followed by Latin America where per capita animal protein intake rose by nearly a third. In contrast, livestock consumption in sub-Saharan Africa declined, perhaps reflecting economic stagnation and a decline in available incomes (Steinfeld *et al.*, 2006).

Developing countries realised an average annual growth of 3.8 percent (1.8 percent per capita) from 1991 to 2001, up from 2.9 percent in the preceding ten years, while developing countries in East Asia experienced a very strong annual economic growth of 7.4 percent (6.2 percent per capita between 1991 to 2001) with China leading as the world's fastest growing economy (Steinfeld *et al.*, 2006). Consumption of livestock products is closely related to per capita income. According to the World Development Report (World Bank, 2008), domestic consumption and exports of high value products such as meat, horticulture and cereals are growing rapidly (World Bank, 2007). Figure 1 depicts the trends in the last two-and-a-half decades.

It is apparent that the developing world will be the most important supplier to this growing market. Production of meat and milk is expected to increase by about 3 percent per year in the developing world, compared to about 0.5 percent in industrial countries (de Haan *et al.*, 2001). For instance, India reported an increased annual milk production of 88.1 million tonnes from 2003–2004. In value terms,

Indian exports of livestock products increased from US\$90.8 million in 1980–1982 to US\$469.6 million in 2002–2004.



Source: <http://faostat.fao.org>, accessed June 2007, and <http://comtrade.un.org>.

**Figure 1:** Domestic consumption and exports of high value products in developing countries are growing rapidly.

The exports of meat and meat products, dairy products and eggs registered a remarkable increase during this period. These accounted for 72.8 percent, 13.4 percent and 10.4 percent respectively of total livestock exports from 2002–2004 (Ali, 2007).

It is anticipated that industrial poultry production will be the fastest growing sector with an expected increase in output of about 80 percent until 2020, while other livestock commodities are anticipated to grow at about 50 percent in the same period compared to the production recorded in 1997 (de Haan *et al.*, 2001). Poultry, an inexpensive meat in times of economic recession, has a more efficient conversion than either pigs or beef cattle, and remains relatively cheap when feed prices are high. Consumption is therefore increasing compared to a decrease in other, more expensive meats. Within poultry, consumers in the developing world prefer less expensive cuts, therefore there is a tendency to replace breast meat with wings (Rabobank, 2008).

### 3. Livestock production systems

Livestock agricultural systems are categorised according to agro-ecological circumstances and the demand for livestock commodities. Steinfeld *et al.* (2006) observed that these systems are largely shaped by biophysical and socio-cultural factors. The livestock element is often interwoven with crop production, such as in the



rice/buffalo and cereal/cattle systems of Asia. In other cases, livestock uses semi-nomadic pastoral systems.

Extensive pastoral production utilises up to 25 percent of the world's land area and produces 10 percent of the meat used for human consumption, while supporting some 20 million pastoral households. Pastoral production is split between the extensive, enclosed systems typical of North America, Australia and parts of South America, and the traditional production, open-access systems of Africa, the Andes, Asia and Siberia (Blench, 2001).

Many livestock systems are under pressure to adjust, due to socio-economic conditions as witnessed by the emergence of large poultry and pig production units. In Latin America, alternative cattle systems range from specialised intensive technologies (e.g. dairying) from affluent countries in temperate regions to traditional dual-purpose (milk and beef) technologies from resource-poor countries in subtropical regions. These options represent extremes in a continuum of intensification alternatives. The diversity of climatic zones – ranging from cool highlands to warm lowlands, with substantial variation in rainfall – adds to the complexity. Intensive systems are better suited to highland agro-ecozones and dual purpose is typically suited to lowland areas (Nicholson *et al.*, 1995).

### *Types of livestock systems*

Steinfeld *et al.* (2006) identified five classification criteria to define key livestock systems, namely:

- ▶ integration with crops (includes traction, manure and residual feed);
- ▶ relation to land;
- ▶ agro-ecological zone;
- ▶ intensity of production; and
- ▶ type of product.

Based on these criteria, Seré and Steinfeld (1996) defined a widely used global livestock production classification system. In referring to a livestock production system as a subset of farming systems, they identified 11 broad categories of systems based on the first three classification criteria. Two main groups of livestock production systems were identified from all the categories – those based solely on animal production and those that mix cropping and livestock.

In the production systems based solely on animal production, 90 percent of dry matter fed to animals comes from rangelands, pastures, annual forages and purchased feeds, with less than 10 percent coming from non-livestock farming activities. In mixed-farming systems, or where 10 percent of the total value of production comes

from non-livestock farming activities more than 10 percent of the dry matter fed to animals comes from crop by-products such as stubble. Mixed systems are mostly rainfed and are widespread in semi-arid and subhumid areas of the tropic and temperate zones. Other systems include the following.

- ▶ **Landless livestock systems (LLs)** are a subset of the pure livestock systems in which less than 10 percent of the dry matter fed to animals is farm produced and in which annual average stocking rates are above ten livestock units per hectare of land.
- ▶ **Grassland-based systems (LGs)** have more than 10 percent of the dry matter fed to animals produced from farm and average stocking rates are less than ten livestock units per hectare of agricultural land. A distinction is made between temperate zones and tropical highland, humid/sub-humid tropics and subtropics, and arid/semi-arid tropics and subtropics.
- ▶ **Rainfed mixed-farming systems (MRs)** are a subset of the mixed systems in which more than 90 percent of the value of non-livestock farm production comes from rainfed land use. These systems can be subdivided into the same agro-ecological sub classes as given above.
- ▶ **Irrigated mixed-farming systems (MI)** are a subset of the mixed systems in which more than 10 percent of the value of non-livestock farm production comes from irrigated land use. It also includes the same subclasses. The systems are found throughout the world in relatively small size. Exceptions are the eastern parts of China, northern India and Pakistan where they extend over large areas.

The worlds 1.5 billion bovine and 1.7 billion ovine are well distributed across the land-based systems, but average densities increase sharply from grazing systems to mixed-irrigated systems. Mixed-irrigated systems have greater livestock supporting capacities per unit area. Some 70 percent of ruminants are found in grazing systems and over 80 percent of large ruminants in grazing systems are located in developing regions (Steinfeld *et al.*, 2006). Table 2 shows the ruminant populations and animal production in the different production system groups, both globally and for the developing regions.

**Table 2:** *Global livestock population in different production systems (Averages 2001 to 2003) (Steinfeld et al.2006)*

Type of animal/ animal product	Livestock population (10 <sup>6</sup> heads) and production (10 <sup>6</sup> tonnes)			
	Grazing	Rainfed mixed	Irrigated mixed	Industrial
<i>Animal</i>				
Cattle and buffaloes	406	641	450	29
Sheep and goats	590	632	546	9
<i>Animal product</i>				
Total beef	14.6	29.3	12.9	3.9
Total mutton	3.8	4.0	4.0	0.1
Total pork	0.8	12.5	29.1	52.8
Total poultry meat	1.2	8.0	11.7	52.8
Total milk	71.5	319.2	203.7	-
Total eggs	0.5	5.6	17.1	35.7

*(Based on FAOSTAT data and calculations by J Groenewold classification and characterisation of animal systems; unpublished FAO report, 2005)*

As population density increases and less land becomes available, there is a general trend for crop and livestock activities to integrate. For instance in Asia, both ruminants and non-ruminants are integrated into the systems where annual crops and perennial tree crops are grown. More than 90 percent of the total population of large and small ruminants are kept on mixed farms in the region. Some 69 percent of cattle, 64 percent of goats and 46 percent of sheep are raised on farms of 5 ha or less (Devendra and Thomas, 2002). Box 1 provides levels of production for both ruminants and monogastrics under different systems and by region. It is noteworthy that the most economically important livestock systems in Asia, Latin America and West Asia–North Africa are mixed systems, which provide for 75 percent of all livestock reared in these regions.

Livestock production systems in marginal lands that were previously pastoralist areas are increasingly changing to focus on sedentary farming and as reserves of biodiversity. Their very inaccessibility has permitted the survival of species eliminated in high-density agricultural areas (Blench, 2001). Consequently, there is pressure on governments to declare large regions as protected areas, both because of pressure from the conservation lobby and the potential income from tourism (Wilke, personal

communication 2010). Uncertainties about pastoral tenure and common property rights have made it difficult for pastoralists to lodge effective land claims.

**Box 1:** Ruminant and monogastric production in different livestock systems

Ruminant productivity varies considerably within each livestock production system. It is lower in grazing and mixed systems of developing countries than in developed countries. Worldwide, average annual beef production averages 36 kg/head, but the average for developing countries is only 29 kg/head. The difference between developed and developing regions is even more marked in mixed rainfed systems which have the largest variation of production intensity and are the largest producers of ruminant products. Even though developing regions host the vast majority of the mixed rainfed ruminant population, they account for far less than half of the systems' production worldwide. Beef productivity of mixed rainfed systems is, on average, 26 kg/head per year as opposed to 46 kg/head at world level, and their milk production represents 22 percent of the world total. Across all systems, developing regions account for half of the world's beef production, some 70 percent of mutton production and about 40 percent of milk production.

In the monogastric sector, more than half of the world's pork and over 70 percent of poultry production originates from industrial systems. About half of this production originates from developing countries. There is substantial monogastric production from irrigated mixed systems in developing regions accounting for the majority of the world's pork, poultry and egg production. Huge differences are found among the developing regions. Although production is substantial in Latin America, its total production is less than one tenth that of Asia, and the production in Africa and the Near East is almost non-existent. The industrial countries, together with Asia, account for 95 percent of the world's industrial production. (Steinfeld et al., 2006)

Mixed-farming systems provide farmers with opportunities to diversify risk from single crop production systems, to use labour more efficiently, to have a source of cash for purchasing farm inputs, and to add value to crops or their by-products (Devendra and Thomas, 2002). Combining crops and livestock also has many environmental benefits, including maintaining soil fertility by recycling nutrients, and providing entry points for practices that promote sustainability, such as the introduction of improved forage legumes. In intensive mixed farming systems around the central highlands of Kenya, Franzel and Wambugu (2007) report the benefits of incorporating high protein agroforestry fodder species such as *Calliandra calothyrsus* and *Luceana trichandra* into smallholder entities. These species help substitute farmer spending on commercial feeds while substantially boosting milk production in zero-grazing systems. Using 6 kg of fresh *Calliandra* per day substitutes 2 kg of purchased dairy meal, resulting in savings of about US\$130 per cow per year. A smallholder with

about one ha requires about 500 *Calliandra* shrubs to sustain one dairy cow per year. Mekoya et al. (2008) reported similar potential of multipurpose fodder trees for sheep production in Ethiopia.

**Box 2:** Integration of oil palm-ruminant systems

Devendra (2009) identified the opportunities of integrating oil palm into ruminant systems for intensification. Oil palm plantations offer feed sources such as oil palm fronds, oil palm trunks, oil palm kernel cake and palm oil mill effluent. These feeds, combined with leguminous trees, provide a balanced diet at relatively low cost. Vast areas in Southeast Asia are available for mixed production of palm oil and milk and meat. There is evidence of increased productivity, increased yield of fresh fruit, increased income, saving of weeding costs and an internal rate of return of approximately 19 percent. However, feeding strategies may require using oil palm kernel cake in ruminant feeding in local production systems instead of exporting the oil palm kernel cake, and paying more attention to growing multi-purpose trees as an additional protein rich feed. Little information is available about the carbon sequestration of integrated systems and greenhouse gas production. The plantation management needs to interact with local communities, representing the livestock owners, to create a win-win situation. Institutional arrangements can be made through participatory programmes and government policies that support credit availability, encourage joint use of oil palm plantation land with ruminants, create awareness of the advantages on both sides, and support research and training.

Mixed-farming systems are known to maintain soil biodiversity, minimize soil erosion, conserve water, provide suitable habitats for birds, and make the best use of crop residues that might otherwise be burnt and lead to carbon dioxide emissions (de Haan *et al.*, 1997). The closed and intensive nature of mixed-farming systems makes them less damaging and more beneficial to the natural resource base. Devendra and Thomas (2002) suggest that mixed-farming systems provide the best opportunities for exploitation of the multipurpose role of livestock. Key among these is improved nutrient cycling from fodder, feed inputs for animals, and obtaining animal manure for supporting intensive cropping systems. Cattle manure application is reportedly high in intensive livestock systems of central and western Kenya, Tanga and Kilimanjaro in Tanzania, Gokwe, Chiota and Chiduku in Zimbabwe, while there is limited use of both fertiliser and manure in extensive systems of Ntonda and Chisepo in Malawi (Thorne *et al.*, 2003 and Waithaka *et al.*, 2007). However, there are concerns about farmers' manure management, as ineffective collection, composting and application have negative effects. Labour shortages, taboos, work discomforts and long-term efforts to improve soil fertility pose further bottlenecks (Batz *et al.*, 1999).

It is clear that smallholder mixed farming systems are more productive and competitive than market returns, based on tangible production, as suggested by policy makers. Indeed, in the event of a fall in milk and beef prices, smallholders continue to engage in production due to in kind income and the intangible benefits derived from livestock keeping (Moll *et al.*, 2007).

Animal production dynamics can be determined by one or a combination of forces, depending on the livestock production system and production site. This interplay of constraints and opportunities can lead to their intensification or even to extensification, insofar as the appropriate technologies are both available and cost effective. According to Fearnside (1999) before 2000, Brazilian policy efforts to encourage livestock – as a means of discouraging deforestation in Amazonia – focused on pasture fertilisation, use of improved pasture, genetic improvement of cattle herds and better regulation of stocking densities. However, this actually resulted in extensification as farmers speculated on the value of land, livestock and tenure securities given the high rate of inflation. Siegmund-Schultze *et al.* (2007) showed that livestock in the eastern Amazon was attractive as a low input system and that farmers would only change to more sustainable practices if stable credit programmes replaced the financing function of cattle. After 2000, increased soybean and maize prices also made it attractive to use virgin *cerrado* (tropical savannah ecological region of Brazil) and tropical forest for these crops.

Nicholson *et al.* (1995) observed that extensive cattle systems pervade Latin America because extensive production systems serve the objectives of individual investors and farmers, despite their lower rates of outputs as compared with intensive specialised systems. Cattle production, though viewed as a stable store of wealth, is also a means for farmers to gain other resources accompanied with land ownership, such as government subsidies, subsurface mineral rights and speculative increases in land value. For small producers, extensive cattle systems require relatively lower amounts of capital and labour to provide highly marketable products, improve the cash flow of the farm household and serve as a store of wealth that protects against inflation (Schelhas, 1994). Since extensive systems fulfil many roles other than meeting demand for livestock products, it is important that strategies to intensify cattle systems recognise these roles and work to enhance productivity as well as social security through improved policies.

Livestock production is expected to shift from temperate and dry regions to more humid and warmer regions (de Haan *et al.*, 2001). A clear, worldwide shift from the temperate regions has already occurred. For example, in the USA, production has moved from the northern states to the southern states and, in the South American tropics, from temperate highlands to subhumid savannas. In Brazil, the share of cattle in the subhumid *cerrados* has risen from 14 percent of the national population in

the 1940s to 29 percent in the 1990s. A similar trend is occurring in Africa, with strong increases of livestock numbers in the subhumid savannas. Delgado et al. (2008) predict that poultry will be the main source of growth, with other sectors growing at a lower level. Poultry have a better feed conversion ratio than pigs and ruminant animals, and their production technology is more universal. For these and other reasons, worldwide poultry production will increase by almost 80 percent over the period 1997–2020, whereas dairy, beef, and pork production are projected to increase by 40–50 percent over the same period.

#### 4. Transitions in livestock systems

Globally, the livestock subsector is undergoing enormous structural changes to meet the increasing world animal product demands. In developed countries, the rate of growth of commercial systems has outstripped smallholder farming. Similarly, a shift to large-scale commercial and away from smallholder farming in developing countries is now imminent. Indeed, livestock production in Asia and Latin America has been transiting away from a multipurpose activity of producing food, savings, traction power, hides and manure, observed over the last 25 years. With this transition, family labour and farm-produced feed on smallholder crop farms is moving towards a more specialised enterprise that uses hired labour, borrowed capital, western technology and purchased inputs in systems producing more uniform quality food items, similar to industrial modes of organisation (Seré and Steinfeld, 1996 and Delgado *et al.*, 1999).

In Brazil, it has become the norm for large commercial dairy farms to buy out smallholders who, in turn, are forced to operate in difficult environments (Nicholson *et al.*, 1995 and Fearnside, 1999). In India, where land holding is more skewed towards medium- and large-scale farmers, rearing of small ruminants, pigs and poultry is emerging as an option for poor households to earn their livelihood on a sustainable basis (Ali, 2007). Within India's value chain, the introduction of the *Kuroiler* – a dual-purpose hardy bird suited for poor rural people – has proven a remarkable development (Ahuja *et al.*, 2008). It has been developed as part of a system that supports the value chain from the parent farm to village markets. Evaluations have found that the government could improve the *Kuroiler's* impact by providing appropriate health and extension services for the *Kuroiler* value chain. The result of these evaluations could be applied to many situations in developing countries, where a large number of smallholders are livestock producers who need appropriate technologies and often lack alternative employment and livelihood options.

### *Livestock industrialisation*

The more commercial and intensive livestock systems based on commercial feeds taking root in the developing world prefer poultry and swine, which are increasingly being produced in landless systems. This so called “livestock industrialisation” (Delgado *et al.*, 2008), with its shift to more grain-based production, has raised concerns over its effect on global and national food security. For instance, Steinfeld *et al.* (2006) indicate that the total global production of 54 million tonnes of human edible animal protein requires an estimated 74 million tonnes of human edible plant protein, at a conversion of 1:1.4. The Council for Agricultural Science and Technology (CAST, 1999) calculated that the average grain consumption per 1 kg of beef in the OECD countries is 2.6 kg of edible plant food per 1 kg of live weight gain. In developing countries, only 0.3 kg of edible plant food is used to produce 1 kg of live weight gain.

Though using human edible food for animal production has been of concern to mostly industrial world production systems, the livestock revolution is now causing these models to expand rapidly in the developing world. This means that choice of animal species and systems will be important because different systems have different feed and energy efficiencies, with an increasing efficiency from milk, via broilers, eggs, pork to feedlot cattle. Table 3 provides some ranges of total feed conversions and amount of edible grain used per kilogram of animal product produced.

**Table 3** *Feed conversion for main species and world regions (CAST 1999; de Haan et al., 2001)*

Species	Feed conversion		Edible grain per kg of product	
	Kilograms feed per kg live weight gain	Kilograms feed per kg product	Industrial world	Developing world
Aquaculture	1.2-1.6	1.5-2.0	n.a.	n.a.
Poultry meat	1.8-2.4	2.1-3.0	2.2	1.6
Pork	3.2-4.0	4.0-5.5	3.7	1.8
Beef	7	10	2.6	0.3

n.a. – not applicable

A steady shift to grain-based pig and poultry production could increase grain prices and thus reverse the balance from grain feeding to grass-based systems, or lower consumption levels. The eventual resource constraints such as water and



land, and significant increases in energy costs are not clear. Additionally, intensive systems require more energy per kilogram of meat than the more extensive land-based systems, mainly because of the high energy and water requirements for feed production.

Increases in the price of energy would tend to shift the balance back to grass-based systems. A major breakthrough in the production of high-quality fodder in the tropics or improved digestibility of the current high-fibre tropical forages could radically shift the balance from pigs and poultry to cattle and small ruminants and from industrial production to grazing systems. It would also shift production to subhumid tropical areas, as they have the potential for high levels of biomass production. From a global perspective, it would appear that increases in poultry production would put the least pressure on global food security, but part of the feed used in these systems competes directly with human cereal consumption.

The large number of cattle worldwide (estimated at almost 1.5 billion) is responsible for about 45 percent of agricultural land use, with each animal requiring between 0.5 and 5 ha of land to feed on. This large livestock population has a huge impact on natural resource use and the environment (Devendra and Thomas, 2002 and World Bank, 2005). For instance, the rapid deforestation of large expanses of the tropical rainforest, such as in Amazonia, due to the extension of large-scale ranches (Nicholson *et al.*, 1995 and Fearnside, 1999). The desertification and land degradation of sub-arid tropical regions, particularly in the Sahel, both north and south of the Sahara, has also become problematic. Sanchez *et al.* (1997) estimated annual losses of 4.4 million tonnes of nitrogen (N), 0.5 million tonnes of phosphorous (P) and 3 million tonnes of potassium (K) in 37 countries in sub-Saharan Africa. This is exacerbated because smallholders have shortages of land and capital to adopt economically sustainable land management practices.

The more intensive livestock systems are increasingly edging closer to urban centres where markets are large and there are economies of scale, a trend that has raised environmental and health concerns in developing countries. It is feared that increased concentration of livestock might lead to an increase in the emergence of new disease patterns and more incidences of food-borne diseases. Environmental pollution could worsen, as has happened in France, the Netherlands, the USA and the eastern seaboard of China where surface water and aquifers have been polluted due to the excessive intensification in densely populated areas (Devendra and Thomas, 2002). Furthermore, it has been suggested that over-consumption of animal products by the middle-income class in the developing world might lead to diet-related chronic disease patterns similar to those in the industrial world (de Haan *et al.*, 2001).

In summary, rapid industrialisation of livestock systems is driven by factors such as consumer demand, declining real prices for feed grains (which are now linked to energy prices through the biofuel expansion), improved feed-to-meat conversion efficiencies, better animal health and reproduction rates, relatively cheap transportation costs and trade liberalisation (World Bank, 2005). Another economic perspective suggests that stricter environmental regulations, consumer concerns about health and animal welfare, increases in the price of grain, water, energy, and transport, land scarcities and major breakthroughs in the use of tropical fodder will shift the balance back to red meat production. What is clear from available evidence is that the livestock sector is undergoing dramatic structural and geographic changes in the way livestock products are produced, marketed and consumed (de Haan *et al.*, 2001; World Bank, 2005 and Delgado, *et al.*, 2008).

## 5. Sustainable livestock intensification

Intensification of agriculture is a process which decreases production costs per unit of agricultural product produced. Production costs are the function of costs of labour, land and capital. Capital-intensive agriculture develops where availability of cheap labour and, most of all, land, is limited, as in, for example, Belgium and the Netherlands. While countries with limited capital and land, such as India and China, have developed labour-intensive agriculture, countries with limited capital and labour, such as Argentina, have developed agricultural systems that require extensive tracts of land.

In extensive systems, increasing the number of animals reared without improving system performance places pressure on the available resources, often resulting in land and pasture degradation. For example, in southern Africa, poor range management involving overgrazing practices are to blame for increased soil erosion and increased amount of poor pasture and invasive plant species on the natural pasture. Often, degraded cropland is converted into pastures. Pasture productivity has lagged far behind that of cultivated areas, although detailed estimates are difficult to make. These trends demand new policy and well-defined roles for public and private institutions to manage system dynamics and ensure equitable use of available resources without compromising the needs for future generations. Obviously, different forms of production will have different impacts on the environment, and social structure of rural areas. When population density increases and less land becomes available, the general trend is for crop and livestock activities to integrate and later to specialise in separate intensive and large-scale crop and livestock farms.

Intensification of livestock production is taking place mostly with regard to inputs. There is a shift towards more grain-based production and away from traditional livestock production systems based on locally available feed resources, such as natural

pasture, local fodder, crop residues and unconsumed household food (FAO, 2005). Pressure to intensify livestock production systems has resulted in direct competition between crops for human and animal feed and biofuels (see Table 2). For instance in 2004, 690 million tonnes of cereals (34 percent of the global cereal harvest) and another 18 million tonnes of oilseeds (mainly soya) were fed to livestock. In addition, 295 million tonnes of protein-rich processing by-products were used as feed (mainly bran, oilcakes and fish meal). In this context, intensification draws on technological improvements – in areas such as genetics, health, feed and farm management – that contribute to increased natural resource use efficiency and output per animal.

A dramatic shift towards the production of monogastric animals, such as chickens and pigs, which use concentrated feeds more efficiently than cattle or sheep, has occurred in the last decade. Chickens and pigs also have short life cycles that accelerate genetic improvements. For instance, between 1980 and 2004, pig meat, chicken meat and milk offtake per unit of stock increased by 61 percent, 32 percent and 21 percent respectively (FAO, 2005). According to Naylor *et al.* (2005), the average time needed to produce a broiler in the USA was cut from 72 days in 1960 to 48 days in 1995, and the slaughter weight rose from 1.8 to 2.2 kg. Meanwhile, feed conversion ratios (FCRs) of kilogram of feed per kilogram of meat produced were reduced by 15 percent for broilers and by over 30 percent for layers.

Overall, annual growth in pig and poultry production in developing countries was twice the world average in the 1990s. By 2001, three countries – China, Thailand, and Vietnam – accounted for more than half of the pigs and a third of the chickens produced worldwide (Delgado *et al.*, 2008). Brazil is also a major producer of chickens and pigs and is expected to become the world's leading meat exporter (FAO, 2005).

Determining the most appropriate ways to increase production is critical in intensive systems. Feed accounts for about 50–60 percent of total production costs in ruminant-feeding systems, and 65–80 percent in industrial or intensive systems. Smallholder farmers are more wary of large production costs, especially feed costs, and industrial production systems depend heavily on external inputs (Devendra and Sevilla, 2002). The increased cereal requirements needed to meet increased feed demand of the pig and poultry population over the next two decades will require an additional 65 million hectares to be placed under cultivation, an area more than the size of France (World Bank, 2005).

Rudimentary indicators that define livestock systems' levels of intensification and specialisation or diversification will need to estimate the share and trend of agricultural land engaged in livestock breeding or cereal (wheat and maize)

production. This means assessing the number of livestock units (stocking density) per hectare of utilised agricultural land and milk or cereal production trends per hectare.

The intensification and concentration of the livestock industry over the last decades is threatening to crowd out the poor. Successfully protecting the smallholders therefore, depends to a large extent on the level and success of pro-poor policies, institutions and technologies focused on poverty alleviation (de Haan *et al.*, 2001). Mitigating the negative effects and enhancing the positive effects of livestock intensification, and to enhance sustainability, the following factors have become crucial: environmental impact, markets, food safety and institutional arrangements.

### *Environmental impact*

Agriculture currently contributes 60 and 50 percent of global anthropogenic emissions of methane gas and nitrogen oxide, respectively. Since the 1960's the natural resource base on which agriculture depends has declined faster than at any time in history due to increased global demand for agricultural products and degradation of the natural resource base. Additionally, 75 percent of the genetic base of agricultural crops has been lost. Increases in population and changes in diet are projected to increase water consumption in food and fibre production by 70–90 percent. If demands for biomass energy increase, this may aggravate the problem and further exacerbate the stress on developing country producers. Degradation of ecosystem functions, such as nutrient and water cycling, constrains production and may limit the ability of agricultural systems to adapt to climatic and other changes in many regions. Sustainable agricultural practices are part of the solution to current environmental changes. Examples include improved carbon storage in soil and biomass, reduced emissions of methane gas and nitrous oxide from rice paddies and livestock systems, and decreased use of inorganic fertilisers (IAASTD, 2008).

Livestock activities emit considerable amounts of carbon, methane and nitrous oxide gases from respiratory and digestion processes and manure, although totals vary depending on how the activities are managed. Carbon balances for land used for pasture or feed crops are also affected, especially if forests are cleared for pasture (FAO, 2006). Excessive nitrogen, phosphate and heavy metal levels in the effluent of intensive livestock farms cause environmental pollution and loss of biodiversity. While exact data on the total global environmental impact are not available, some illustrative facts estimate that more than 130,000 km<sup>2</sup> of arable land in China and 30,000 km<sup>2</sup> in Thailand (together an area about four times the size of the Netherlands) have an annual livestock nutrient waste production of phosphate of at least 20 kg per hectare per year. This is in excess of the absorptive capacity of the surrounding ecosystem. The extent of nitrate-nutrient loading is probably even more severe

(World Bank, 2005). Box 3 provides key sources of environmental pressure and some recommendations on policy.

On the other hand, because intensive production systems produce less carbon dioxide per kilogram product than low-production systems, industrial systems might also have a positive effect by reducing the pressure on fragile ecosystems and their unique biodiversity, and reducing greenhouse gas emissions (de Haan *et al.*, 1997). However, the comparative advantages of economies of scale of industrial pig and poultry production might disappear if the “polluter pays” principle is invoked in the developing world and the environmental costs of excess nutrient emissions are made inclusive.

Recent outbreaks of pandemics such as classical swine fever, avian influenza and foot-and-mouth disease have focused consumer attention on the negative side effects of intensive production. The widespread use of antibiotics has led to antibiotic resistance to methicillin-resistant *Staphylococcus aureus* (MRSA) for example, and *E.coli* and *Campylobacter* have become the source of frequent intestinal infections in humans.

**Box 3:** Sources of livestock system pressure on the environment and recommended remedial policies

According to the World Bank (2001), pressure on the environment is manifested in several ways.

- ▶ **Waste production.** Nutrient surpluses from production using feed concentrates, seen earlier mostly in the eastern USA and northwestern Europe, are now also common in areas of East Asia and Latin America. Extremely high (more than 800 kg per hectare) nitrogen surpluses around urban areas of eastern China have been reported. A rough estimate indicates that about 100,000 km<sup>2</sup> in the developing world are already threatened by severe nutrient loading, which would cause eutrophication of waterways and subsequent damage to aquatic ecosystems.
- ▶ **Gas emission.** Animal waste produces methane and nitrous oxide gases – one of the most aggressive greenhouse gases – and ammonia, which in turn cause acid rain and the destruction of marginal landscapes and habitats.

- ▶ **Feed grain demand.** Significant demand for feed grains increases the need for cultivation. More cultivation causes additional erosion, loss of plant and animal biodiversity, and puts an additional strain on the world's scarce water resources. Delgado et al. (1999) estimate that under the normal demand scenario, the additional feed grain requirements are about 240 million tonnes, which, with an average yield of 6 tonnes per hectare, would require 40 million hectares of additional arable land to be placed under cultivation.
- ▶ **Requirement for genetically uniform stock.** The industrial system and the consumer require uniformity, which contributes to an erosion of domestic animal diversity as local breeds are crowded out by industrially popular breeds. The consequent narrowing of the genetic base also increases vulnerability to epidemics.

Several current technologies could mitigate these negative effects. A policy framework to induce those technologies should contain the following.

- ▶ **Internalise environmental costs in the price of the product.** Although more information needs to be collected on the environmental costs of industrial production units, some figures from Australia and Singapore point to a 10–15 percent direct surcharge to mitigate water and soil pollution and abate gaseous emissions (de Haan *et al.*, 1997). The key issue will be governments' willingness to impose these surcharges on predominantly urban consumers.
- ▶ **Search for the tools (e.g. zoning, taxation) that will provide a better geographic distribution of intensive production.** The key challenge of intensive production is to bring waste production in line with the absorptive capacity of the surrounding land. In particular, pig manure has high water content, and neither drying nor transporting it over long distances is economically attractive. A combination of zoning regulations and fiscal incentives, now being tested successfully in East Asia could be a solution.
- ▶ **Promote the use of technologies that increase the efficiency of feed conversion, reducing inputs and nutrient emissions.** A large number of technologies currently exist that could improve the digestibility of key nutrients, thereby reducing nitrogen and phosphates emissions. The adoption of such technologies should be encouraged.
- ▶ **Support ecological farming practices.** Mainstream sound ecological farming practices, such as integration of crops and livestock and development of markets for organic products, has potential where it is ecologically efficient on the relevant environmental parameters.

(de Haan et al., 2001)

Finally, it is evident that most environmental damage by livestock is a consequence of how livestock are managed. With good management, livestock can enhance sustainable agriculture and with bad management, it can harm the environment. Policies should define emergent livestock production practices and their impact on the environment.

## Markets

The ongoing livestock revolution is market driven, unlike the green revolution which was supply driven. Market drivers include increasing human population, rising incomes, urbanisation and increased consumer consumption of animal products and proteins. To a certain extent, liberalised markets have meant that livestock producers and other industry actors have been increasingly able to respond to consumer demands (Waldron *et al.*, 2007). Most food is being consumed locally and, with higher energy prices, local consumption will be preferred wherever possible.

Most of the growth in livestock product demand will be in the developing world because meat and milk have high income elasticity for those with lower incomes. For example, Schroeder *et al.* (1995) found that in countries with per capita annual incomes of between US\$1000 and US\$10,000, income elasticity for meat varied between 1 and 3 depending on the type of meat. Above US\$10,000, income elasticity levels are up to 1. For these reasons, per capita meat consumption in the developing world has been projected to increase from 25 kg to 35 kg from 1997 to 2020, compared with an increase of 75 kg to 84 kg in the industrial world (World Bank, 2001).

Consequently, increased livestock product demand can offer opportunities for the poor, as livestock production is among the few commodities that smallholder farmers produce widely (Moll *et al.*, 2007). The production of meat in the developing world was projected to increase from 110 million tonnes in 1997 to 206 million tonnes in 2020, and milk from about 208 million tonnes in 1997 to 386 million tonnes in 2020 (Delgado *et al.*, 2008).

Though globalisation might increase trade, infrastructure (port facilities, road networks and communication technology) constraints, and higher transportation costs in the developing world pose serious challenges. On the other hand, stricter animal welfare and environmental regulations in the industrial world may support a shift toward increased production in the developing world. Recently, it has been observed that smallholders in developed countries have been forced to exit livestock farming, mainly because smallholder operations cannot compete with the larger operations that benefit from both technical and allocative economies of scale embodied in genetic improvement of animals and feeds or improved organisation. This is especially true for the poultry and pig industries, where profitable adoption

simply requires larger farm sizes (Delgado *et al.*, 2008). Furthermore, industrial poultry and pork operations seem uniformly characterised by a rapid transfer of breeding and feeding innovations. There is also a tendency for large firms to control production and marketing as they are increasingly linked to major retail chains. They tend to be concentrated in geographical areas where input costs are relatively low, infrastructure and access to markets are well developed and, in many cases, environmental regulations are lenient.

Therefore, strategies to support developing countries production should consider subsidies wherever effective, and renew efforts to reduce trade-distorting subsidies in developed countries and regional barriers such as (informal) tax levies at road checkpoints or borders, so that fair competition is established in the global and regional markets. There is also a need to streamline and reinforce legitimate anti-dumping measures and provide temporary protection and improved international market access through equitable contractual arrangements. Proven policy interventions that benefit smallholders include: expanding access to microfinance, keeping inflation rates low, identifying reliable banks, financing value chains, developing local markets, supporting farmer associations and cooperatives, and supporting fair trade and product diversification. The trade policy environment should be supported by reducing or eliminating escalating tariffs on agricultural products in developed and developing countries, along with strengthening of national institutions and infrastructure, including improved local and regional market linkages. These factors will be the key determinants of whether policy approaches will produce pro-poor results at grassroots level.

### *Food Safety*

Food safety is emerging as the most prominent source of conflict in international markets. Developing countries are required to upgrade their food quality control capacities if they want to maintain access to international markets. Fears that increased intensification is leading to the emergence of new diseases is worsening the situation. For instance, *bovine spongiform encephalopathy*, caused by recycling animal slaughter waste, is a direct result of the increasing scarcity of feed resources and the cost of waste treatment. The re-emergence of classical swine fever and foot-and-mouth disease, which has led to massive destruction of animals, is directly related to animal densities that increase the effects of infection. Another example is the *Nipah* virus, which caused a new form of viral *encephalitis* in Malaysia and led to the destruction of more than 1 million pigs (World Bank, 2005). Emphasis is on export development demands, good sanitary practices, standards and compliance with health and food safety obligations. It is, however, often forgotten that food production is largely for local use and has to be acceptable for local/domestic consumers. For



instance, Kenyans like fresh milk to be boiled for their *chai* (tea), so there is no need to pasteurise milk and raise costs. It is clear that driving up cost of production for small export markets is not fair to local consumers and may drive small farmers out of business. Through research by Kurwijila et al. (2006) in Tanzania, local functioning of milk markets in East Africa was improved by training raw milk sellers. Rather than pushing them out of business with unwanted pasteurised milk, they contribute to a growing market of raw milk buyers.

Control measures of zoonotic diseases require rapid identification and communication of disease outbreaks, financial compensation, and training and strengthening of coordination between veterinary and public health infrastructure. Identifying emerging infectious diseases and responding effectively to them requires enhancing epidemiologic and laboratory capacity and providing training opportunities (IAASTD, 2008). Focusing on interventions at a single point along the food chain may not provide the most efficient and effective control. Therefore, for a stronger focus on food safety and health issues, programmes must at least concentrate on the following areas;

- ▶ **policies and institutions** related to the level of involvement in food safety for domestic consumption and export, control of diseases during trade, emerging diseases and their effect on human health and, consequently, strengthening links with the health sector;
- ▶ **appropriate legislation** is needed, that factors in local food preparation practices and trends, the role of the public sector in food safety, and partnerships with the private sector and consumers; and
- ▶ **infrastructure, human and institutional capacity building** in general, but particularly in sustainable animal health and production, best practices in managing the food chain from farm to fork, and informed participation in organisations for setting international standards, so that the voices of the developing countries are heard.

### *Institutional Arrangements*

The role of livestock as an income generating activity depends on the success of markets, policies, institutions and technologies that are available. In the absence of strong local and national institutions that support development and sustainability goals, the transfer of productivity-enhancing technologies does not significantly benefit resource-poor, risk-exposed producers. The global linear transfer of research and technology results in imbalanced competition among farming systems that have been supported by public economic investments for decades over systems that have never received comparable public investments. On the other hand, natural resource

management policies are needed to address how access and ownership is shared among the communities from which these resources originate.

To ensure that technology supports livestock development and sustainability goals, strong policy and institutional arrangements are required to balance private and communal rights with regards to knowledge and resources. The individual small farmer will only achieve these goals if strong farmer associations and cooperatives can succeed in the newly emerging livestock value chains. Hazell et al. (2007) and Delgado et al. (2008) provide ample evidence of the institutional needs for a future of relatively small but productive and sustainable livestock farms.

## 6. Conclusion

Livestock farming in the developing world is undergoing tremendous structural change attributed to increased global demand for animal products. The role of livestock is quickly changing from multifunctional systems to a commodity-driven sector. Developing parts of the world will be the suppliers of livestock products for their own markets due their own steadily increasing domestic demand, rapid urbanisation, improved incomes and diet changes.

Intensification of livestock systems, also known as *livestock industrialisation*, is primarily taking root in the poultry and swine industries, although it is also taking place in dairy, followed by beef. Poultry and swine are particularly appealing to farmers due to their economies of scale. They are more efficient feed converters than cattle, have a short reproductive cycle that accelerates genetic improvements, and thus, productivity and returns can be realised within a short time. The trend in developing countries is to set these enterprises near urban centres where there is a ready market for inputs and outputs and accessible transport, and operational costs are generally low. There are, however, environmental and health concerns over these industrial systems similar to those in developed countries, especially where uniform products are demanded, particularly for the export market. The shift to monogastric intensification in developing countries has been attributed to lenient environmental regulations.

Cattle, swine and poultry production systems are changing and in many cases, this means intensification which is most often based on external input systems involving feed grains. This trend has raised concerns that it could compromise national and global food security as more crop protein is fed to animals. Smallholder operations in developed countries are already facing challenges to remain competitive with their large-scale counterparts who wield economies of scale owing to the size of their operations and their better access to capital. Livestock intensification is a result of technology advances and greater use of crop inputs in crop production in the areas

of plant breeding, irrigation and water management, application of fertilisers and mechanisation.

As a result, smallholder farmers are wary of large production costs, especially for feed, and industrial production systems that depend heavily on external inputs. Although globalisation might increase trade, infrastructure (port facilities, road and communication networks) constraints and higher transportation costs in the developing world pose serious challenges. Traditional production systems based on pasture and local forages are experiencing challenges due to degradation of the natural resource base and declining land sizes. As population density increases and less land becomes available, there is a general trend for crop and livestock activities to integrate.

The livestock sector is undergoing dramatic changes in the way livestock products are produced, marketed and consumed. Establishing sustainable intensification will depend largely on the level and success of pro-poor policies, institutions and technologies for poverty alleviation. It is critical to determine the most appropriate ways to increase production at local, regional and international levels. In order to mitigate the negative and enhance the positive effects of livestock intensification on the environment, livestock development emphasis needs to be product driven, but it also needs to give more recognition to its multifunctional roles. Intensification as a response to increasing consumer demand has to address three major issues, environment which includes climate change and water productivity, energy needs and poverty alleviation.

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# 9

## Value Chains and Innovation

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### Abstract

Market opportunities are increasing at a rapid pace for livestock products, fuelled by rising incomes, globalisation and urbanisation, particularly in the developing world. At the same time, these opportunities bring increased complexity in the supply channels that market, distribute, organise and govern high-value products. This begs the questions on the ability of smallholder producers to contribute to this complex process. This chapter utilises the rubric of value chain analysis to unpack the different dimensions behind smallholder participation in emerging and growing livestock markets. Concepts and drivers behind value chain analysis and development are discussed and further elaborated in the context of three case studies from Africa. Issues of input supply and animal health emerge prominently from the analysis as areas needing specific attention within the value chain. Governance and organisational aspects are not only crucial in driving value chain-level interventions, they also provide equitable opportunities for smallholders to engage and benefit from market participation.

**Keywords:** value chain, opportunities

### 1. Livestock sector market opportunities and challenges in developing countries

Growing populations, urbanisation and economic growth in developing countries are contributing to growing demand for livestock and livestock products (Delgado *et al.*, 1999 and Hall *et al.*, 2004). This livestock revolution is part of a broader revolution in the increased consumption of higher value agricultural commodities including fish, fruits and vegetables. The size and nature of the demand varies by region and country. In more urbanised areas of Latin America, Asia and even some parts of Africa, much of the demand has a strong urban-consumer-led focus with the demand for more stringent food quality and safety standards led by retail chains (Regmi and Gelhar, 2005; Boselie *et al.*, 2003 and Weatherspoon and Reardon, 2003). In areas



of Africa and Asia with less urban demand, local and often informal markets are growing and evolving, with formalised markets entering and growing as well, albeit at a slower pace.

The market opportunities for the poor vary by region and livestock sector. In general, smallholders are relatively more competitive in ruminant than monogastric production (McDermott *et al.*, 2010 and Herrero *et al.*, 2010). However, there are a number of challenges that need to be overcome in order to enhance the market success of smallholder production. On the input side, technical inputs such as feeds are scarce, relatively expensive and of poor quality, and the knowledge and expertise needed is not readily accessible. On the output side, organisational farm-to-market links are weak as are the overall infrastructure investment, enabling the policy and regulatory environment to support smallholder market access (McDermott *et al.*, 2010).

Opportunities vary greatly across different settings in developing countries. In poorer countries, local and informal markets offer the primary initial growth potential. Even in local markets, the complexity of livestock value chains provide varied opportunities for value addition by the poor, not just as farmers, but as input suppliers, livestock producers, labourers and employees, market agents and retailers (Kaitibie *et al.*, 2008).

In this context, post-production systems are often neglected areas of livestock value chains. Given the multifunctionality of livestock, post-production systems are varied and include, for example, processing of manure for fuel and collection, and processing and producing of secondary products from hides and skins. Post-production systems can be an important component of value addition, and the opportunities they present should be considered in different livestock value chains.

This chapter focuses on the value chain approach in assessing how to improve market opportunities with livestock for poor people in developing countries. Livestock value chains are defined by looking at all the actors involved in the chain from production to consumption, including input suppliers, labourers, livestock producers and all agents along the value chain from producers to consumers having been well defined (GTZ, 2007).

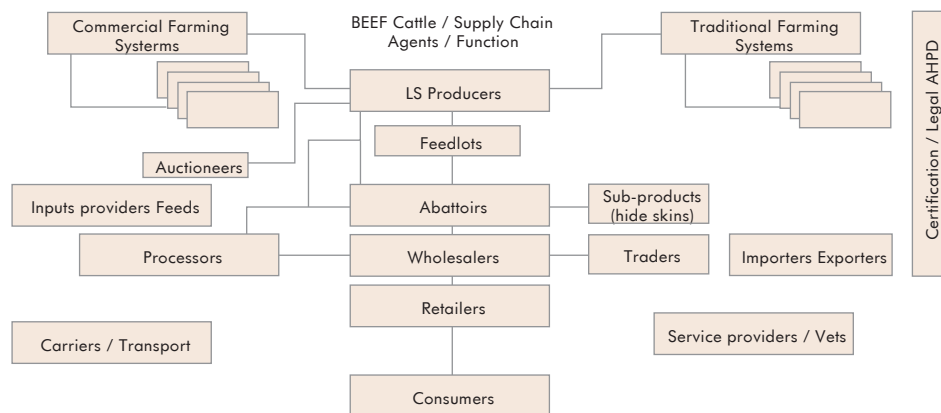
The analysis of value chains builds on more classical supply chain management and subsector approaches. An advantage of value chain analysis is the characterisation of the institutional and organisational nuances that exist behind increasingly complex agricultural and livestock value chains, and the emphasis on the coordination of chain actors. Consequently, they are a useful way of holistically assessing the potential market opportunities that exist for smallholders, as well as highlighting the various technical, economic and institutional constraints that public policy may need to address.

## 2. Value chains in livestock development

The value chain concept has been applied in both the crop and livestock sectors as an approach for assessing potential interventions from a development perspective (Rich and Perry, 2010 and Rich *et al.*, 2010). The value chain concept goes beyond supply chain analysis to make a more critical assessment of performance and competitive advantage in a dynamic context, particularly in terms of opportunities of the organisation. This is also true for their ability to innovate in response to supply and demand changes (Kaplinsky and Morris, 2001).

This is particularly important because the livestock development context for different livestock commodities in different regions is variable and dynamic. If sound investment choices are to be made and implemented successfully, a systematic approach to evaluating the aforementioned is critical. At the same time, most contemporary value chain studies of the livestock sector still focus on qualitative characterisations of chain actors, functions, and relationships rather than focusing on the chain as a dynamic platform for quantitative analysis, although methods to remedy this have been proposed (Rich *et al.*, 2010).

Value chains can be viewed as a network of different functions or stages from production to consumption, including all ancillary support services. They can thus include input supply, production, assembly, transport, storage, processing, wholesaling, retailing and utilisation, with exportation included as a major stage for products destined for international markets. Embedded within these linkages are the coordination and governance mechanisms that establish rules for transactions, as well as the institutions that mediate those relationships. For a specific value chain, it is important to include the stages that make a significant functional contribution and have critical linkages to other stages for the effective operation of the value chain. Developing an overall diagram of a value chain is especially helpful. Figure 1 provides one such example of a generic value chain for beef in Southern Africa (SADC-PRINT, 2006).



**Figure 1:** A detailed generic value chain for beef (SADC-PRINT, 2006)

In applying the value chain approach for agricultural commodities in developing countries, the principles outlined by the Institute for Development Studies (Kaplinsky and Morris, 2001) focused on four key areas:

- ▶ **actors** at different stages of the value chain – including roles and performance;
- ▶ **governance** of the value chain – in terms of who drives and coordinates production and quality standards;
- ▶ **opportunities** for improving and upgrading the system – through its specific components; and
- ▶ **distribution** of benefits to the different actors.

The governance of livestock value chains can vary greatly. Both public and private actors play key roles through measures such as public regulation, and institutions such as farmer organisations and cooperatives. As value chains become more complex and demands for diverse sources of production increase, there is an increasingly sophisticated interface between and within the public and private sectors. This can include attempts to integrate smaller actors into more formal chains through arrangements such as contract farming, outgrower schemes or linking smallholder organisations to larger commercial chains.

Similarly, overall value chain governance has been influenced by general trends in agrifood systems in which food retail and distribution entities have become more consolidated and taken an assertive role in driving the standards that are transmitted down the value chain (Regmi and Gelhar, 2005). Clearly, the public sector has a strong role in regulating quality and safety, in providing and enabling an environment that can support the efficient exchange of knowledge, goods and services and in

issues associated with social equity and environmental sustainability. These can then be matched and linked with the private sector, which has advantages in areas such as efficient allocation of goods and services, and have adaptive responses to market demands.

One of the key attractions of using a value chain framework in a livestock development context is that coordination is critical for improving the effectiveness and efficiency of the flow of knowledge, goods and services in the value chain. Enhancing coordination among investment incentives, input supply, grades and standards, agro-processing, production technologies and innovations in the organisation of producers can lead to important increases in value to the different actors in the value chain (these will be explained further through case studies in a later section of this chapter).

Practical manuals are available that can be applied to the development of livestock value chains at meso and micro levels. Kaplinsky and Morris (2001) first elucidated many of the general principles of value chain analysis in their value chain “Handbook”. A number of development-oriented value chain guides have been developed in recent years to assist in practical value chain development at a micro level. These include GTZ Value Links Manual (2007), KIT *et al.* (2006), M4P (2008), and Riisgaard *et al.* (2008). In the context of livestock, Humphrey and Napier (2005) provided guidance on applications of value chain analysis in a livestock setting, while Kobayashi (2006) illustrated the utility of the value chain approach in the area of animal health.

### **3. Livestock value chains – opportunities and threats for the poor in different regions of the developing world**

Opportunities for livestock development that can benefit poor people vary widely across the different regions of the developing world. As noted in Delgado *et al.* (1999) on the seminal work of the “livestock revolution,” where demand for livestock products is growing rapidly, particularly in urban areas of the developing world including Latin America and the growing economies of Asia.

Much of this demand growth is fuelled by urbanisation, rising incomes and diversification of diets away from grains and towards more sophisticated sources of protein. McDermott *et al.* (2010) note discernable shifts in livestock product demand as per capita incomes rise, with higher levels of daily per capita income (US\$5) associated with shifts towards consuming higher quality rather than quantity. Consequently, these demand shifts create possibilities for suppliers in the developing world.

At the same time, the potential for smallholders and the poor to engage in such value chains depends largely on the specific context of the market, product and place in question. McDermott *et al.* (2010) cite a number of studies pointing to the efficiency of

smallholders in informal, low-input settings. In such instances, smallholders are often more efficient by virtue of being able to leverage household labour and low-cost inputs in production. This, coupled with high levels of consumer demand for informal sector products, helps to explain the success of smallholder dairy producers in India vis-à-vis more commercialised entities. The ability of smallholders to engage in higher-value market opportunities and other value chains varies greatly and depends on the organisational model utilised.

The dairy sector is one value chain in which smallholders have been very competitive across the developing world, including South Asia, East Africa and Latin America. Operation Flood, in which dairy value chains were developed in India, is perhaps the most famous value chain development example (Cunningham, 2009). More importantly, beyond the development of the dairy sector, broader social benefits have been realised through the organisations developed, especially through gender development and education.

Consumer demands are evolving and smallholder dairy systems will need to adapt. In input supply, the supply of improved animals is invariably low, whether for improved indigenous animals, crossbreds or introduced breeds. In South Asia and much of sub-Saharan Africa, low quality crop residues form the bulk of the ration while in Latin America, grasses and forages are more important. Strategies to improve the nutritional quality of roughages through linkages to strategic supplementation and improved ration formulation are needed. Combining genetic and feed improvement has led to productivity gains of up to 300 percent in smallholder systems in sub-Saharan Africa (McDermott *et al.*, 2010).

Linking improved input supply to knowledge, financial and market services is critical. Integrating these services into the initial assembly and distribution services part of the value chain has been important in the development of the smallholder dairy sector in South Asia, East Africa and Latin America. Risk-based quality and safety assurances initially are quite basic in local systems, but as they evolve as supply chains they become more complex and eventually need to be built into the market services.

The organisational models under which these services have been provided have varied from cooperatives through to contract farming arrangements with large multinational companies (McDermott *et al.*, 2010). However, as Lynam (2008) notes, innovations within value chains are often disproportionately skewed towards more formalised, vertically integrated value and supply chains, suggesting that effective coordination and organisation within the value chain are crucial for success and for smallholders to be incorporated effectively within this type of organisation.

The experience with smallholders as part of contract farming programmes varies considerably. A recent analysis by Bijman (2008) suggests contract farming is more

likely to be utilised in the milk and poultry sector, as such products can receive price premiums for quality in the market, have a high level of perishability and require more in the way of technical assistance (e.g. through a contractor) in production techniques.

At the same time, Bijman (2008) suggests that smallholders are more likely to benefit from contract farming when:

- ▶ markets are oriented towards sellers;
- ▶ enabling policies from governments exist;
- ▶ power asymmetries between actors are minimised;
- ▶ crops are standardised; and
- ▶ collective action and NGO support can be mobilised.

The empirical evidence from cases of livestock development in India suggests some benefits from participation in livestock value chains such as dairy (BIRTHAL *et al.*, 2005) and poultry (RAMASWAMI *et al.*, 2006).

Not all value chains in livestock may be equally suitable for smallholder access. Rich (2009) and Rich and Perry (2010) noted many of the challenges faced by African producers in export markets for meat products, specifically beef. Africa currently contributes 1–2 percent of global exports of meat products and is a growing net importer of many meat products, such as poultry and beef. Where exports exist, such as from southern Africa into European markets, it is often because of preferential tariff access. Often smallholders have limited participation in such schemes.

In Namibia, for instance, most exports of beef are derived from larger scale producers south of the veterinary cordon fence (VCF) or “red line” which physically separates Namibia into foot and mouth disease (FMD) FMD-free and FMD-endemic areas. Smallholders are largely concentrated north of the red line, with market access opportunities much more constrained by international trade rules which assign disease risk for all livestock products based on the region of origin of animals and not the disease risk implicit in the product derived from them (Rich and Perry, 2010).

Disease risk is an important market access driver of many livestock value chains, especially when they graduate from local and regional to international export markets. Commodity-based trade (Thomson *et al.*, 2008) is an important, novel approach to mitigating disease-shock threats and increasing market access, although its acceptance among global trading partners remains extremely limited.

Moreover, African producers face increasing pressure from low-cost competitors in South America and India that have economies of scale, low-cost production systems and highly sophisticated supply chains for the distribution of a diversity of different

products. Some of these low-cost systems can be smallholder driven, as in the case of India, where low-input production systems and cultural factors that mitigate against beef consumption provide large surpluses of meat that can be exported abroad. On the other hand, as formal markets in urban areas of Africa rise in importance, smallholder domestic producers in Africa face the daunting task of competing with cheap and ever increasing imports from such sources.

The complexities and idiosyncrasies of livestock value chains make it challenging to generalise and distil some of the key success factors that drive smallholder participation. However, as shown in this section, organisational and governance aspects of the chain are crucial to both organise value chain actors and deliver innovations necessary for value chain success, which themselves are modulated by the product mix in question.

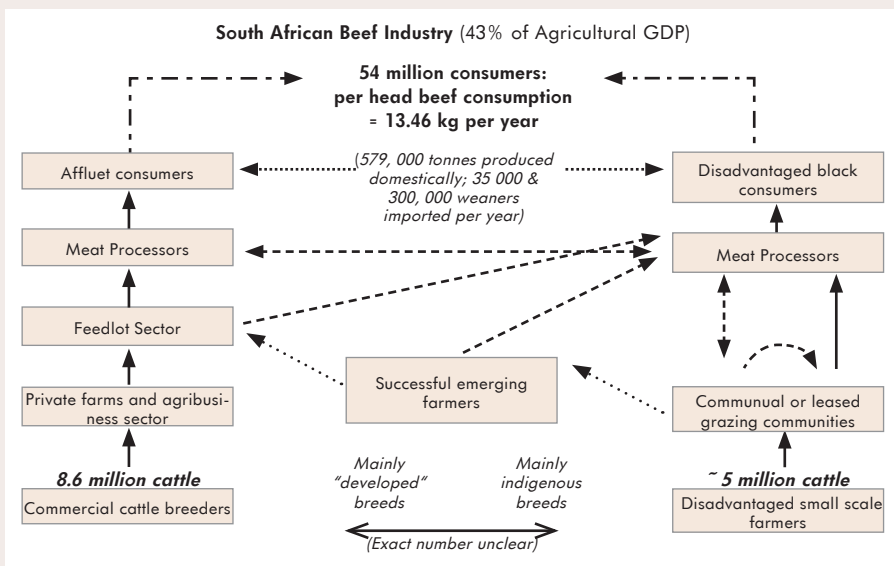
The next section introduces three case studies of developing livestock value chains in sub-Saharan Africa. These include the example of the South Africa beef value chain of emerging farmers, which has both strong domestic demand and a strong commercial sector. This contrasts with the second example from Ethiopia, where domestic demand is less dynamic and the government is attempting to develop an export-beef value chain.

The third example, also from Ethiopia, highlights smallholder dairy value chain development. This is an emerging market that is similar to other poorer sub-Saharan African countries and poorer regions of South Asia, but contrasts with the much larger smallholder dairy systems in much of South Africa and Kenya that are well described elsewhere. Table 1 summarises many of the important value chain components and characterises each chain through the lens of Kaplinsky and Morris (2001), while highlighting the priority areas for improvement based on the typology found in Lynam (2008).

## 4. Livestock value chain development in sub-Saharan Africa: three case studies

### Box 1: South Africa beef value chain: linking emerging farmers to markets

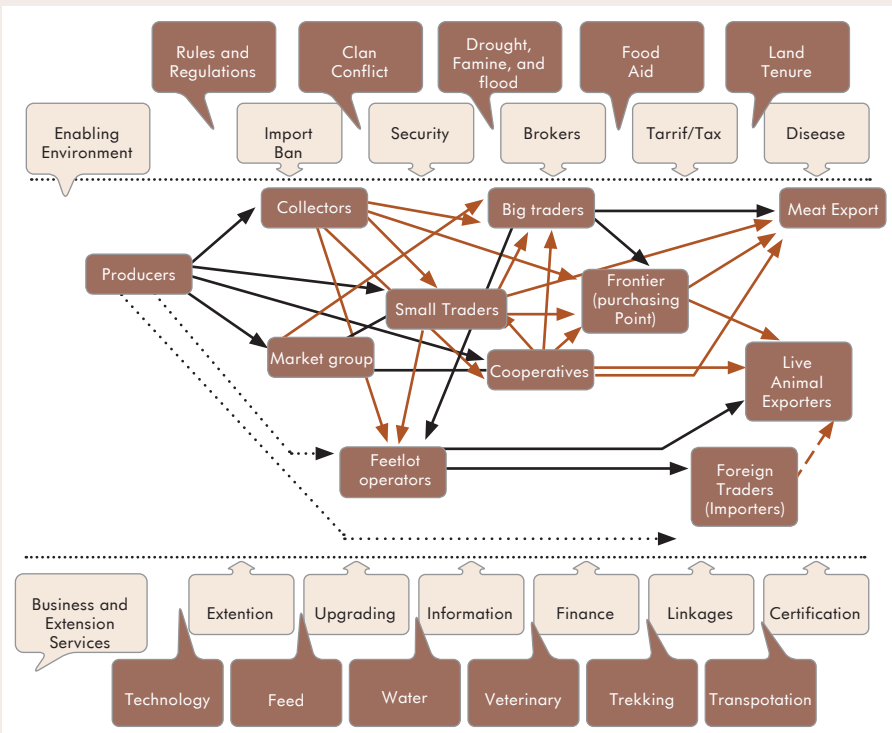
Since 1994, South Africa has focused on linking small-scale communal farmers (3 and 4 cattle per group) and groups of emerging farmers (10 and 1,000 cattle) to commercial retail markets, in which they have had little previous success. Supermarkets require animals that are earlier maturing, more efficient converters of high quality feed and possess superior carcass attributes. South Africa's advanced commercial beef production sector can meet these demands. To improve profitability for small-scale and emerging farmers, efforts have focused on developing a commercial value chain, where feed efficiency, growth and superior carcass attributes can be assessed and improved through formal performance management.





**Box 2: Ethiopia beef – efforts to improve domestic and export value chains**

Ethiopia currently has one of the largest cattle herds in Africa, with over 40 million head. Much of the industry is mixed, pastoral based and not commercially oriented. Indeed, Negassa and Jabbar (2008) reported that net commercial off-takes of cattle were less than 10 percent among smallholders and pastoralists. The Ethiopian government has ambitions to increase the volume of high-value exports of livestock products, particularly beef. The initial 2008 export target was 30,000 tonnes which has not been achieved, and projects have been established to investigate constraints. For example, existence of trade barriers due to transboundary diseases was identified as a constraint and led to the development of an export certification programme in Ethiopia aimed at increasing the volume of beef exports in target markets in the Middle East. The proposed certification system seeks to leverage current live animal value chains with both existing and new downstream actors involved in high-value exports. The current situation, illustrated below, is based on the research of Legesse (2008).



Most supplies of cattle come from a combination of pastoralist or smallholder farmers. Sales of animals are often infrequent, with nearly half of pastoral producers neither buying nor selling in commercial markets on a regular basis (Negassa and Jabbar, 2008). Marketed animals are sold to a diversity of small collectors and commercial traders who distribute to both domestic and foreign markets, often through a host of other market intermediaries. Some sales are made directly to feedlot owners, who fatten animals until they reach an appropriate weight for export sales. These animals are then sold live to Egypt or the Arabian Peninsula or to abattoirs that sell meat locally in high-value markets or to destinations in Africa and the Middle East.

**Box 3:** Ethiopia smallholder dairy development in peri-urban zones

Ethiopia has an increasing demand for dairy products due to a growing population and urbanisation, but per capita demand lags behind other East African countries (particularly Kenya) for a variety of cultural and wealth issues. Nonetheless, the environment is highly favourable for smallholder dairy production in much of the Ethiopian highlands and there is a strong demand in and around the rapidly growing capital, Addis Ababa, and some other large towns. In 2010, demand for milk in Addis Ababa was estimated at 155 million litres.

Peri-urban and urban dairying is expanding to meet these demands. Improved roads are expanding but transportation constraints limit significant increases in market-oriented dairy production to milk sheds within 50–100 km of the city. Traditionally, the public sector has provided the limited input supply and services, but cooperatives and private sector providers are increasing in market-oriented zones. Over the past 20 years, the Ada'a cooperative, just east of Addis Ababa, has expanded its membership and services. With growing demand more recently, private input supply and service providers for breeding and feeding have begun to operate and private dairy companies are buying milk from the cooperative, other market agents and even farmers directly.

These three case studies are dissected and discussed in Table 1.

**Table 1:** Comparison of value chain components, linkages and areas for future development among three different African value chains

Components, Actors	South Africa – beef (Emerging farmers)	Ethiopia – beef	Ethiopia – smallholder dairy
Description of value chain components (including key issues and actors)			
Input supply/ service provision	Linking input supply and services to output market services. Breeding and feeding inputs need to be adapted to and evolve with organisational capacity.	Limited to veterinary services with NGOs providing business development services. Some interface between input suppliers and feedlots. Proposed certification system uses trained staff in purchases of healthy animals.	Primary responsibility for input supply and service with government. More market-oriented producers get private feed, breeding and animal health services. The cooperative provides feed and animal health services to members.
Production	Focus on improving productivity and production targeting linked to markets through a continuous improvement and innovation system. Production inputs and practices need to be adapted to local conditions.	Pastoral, semi-pastoral, and sedentary farming systems; some existence of cooperatives to link producers to buyers.	The urban / peri-urban system has an average herd size of 5 with 2 crossbred cattle. Main constraints are lack of improved breeds and feed. Improving these under local conditions increases production from 2 to 10 litres per day.
Assembly and distribution	Major effort to develop and organise producers within commercial model (Beef Profit Partnership) with clear performance targets.	Numerous atomistic distribution channels via collectors, petty traders, brokers, large traders and feedlot operators. Some tensions reported between sellers and abattoirs in procurement. Proposed certification system conceives of own distribution network to ensure biosecure transport.	Cooperative milk collection increased tenfold to 2.6 million litres between 2000 and 2005, half of which is sold directly and half to dairy industry. Involvement of private businesses in assembly and distribution showed significant increase.
Processing	Currently weak links to get emerging farmers into commercial processing chains for domestic markets.	Domestic-marketed beef, slaughtered locally; export beef by larger export slaughterhouses.	Cooperative introducing value added processing to increase member value and also selling to dairy pasteurisation plants. Private processing businesses emerging.

Components, Actors	South Africa – beef (Emerging farmers)	Ethiopia – beef	Ethiopia – smallholder dairy
Description of value chain components (including key issues and actors)			
Marketing and retail	Commercial sector receives much higher prices due to organisation. Strong influence of large retail sector with some local adjustment.	Mainly through traditional channels. Sizable volumes of informal live animal exports via Somalia. Small volumes of beef exports to Egypt and Central Africa (<10 000 tonnes)	Market differentiated between informal and formal. There is still a strong preference for unpasteurised milk from most consumers.
<b>Actor linkages, governance and benefits (Kaplinksky and Morris, 2001)</b>			
Actors and their relationships	Currently weak market power for communal and emerging farmers reflected in low pricing. Governance and organisation need to be strengthened to improve prices and stimulate investment and performance innovation.	Linkages and governance mechanisms overwhelmingly arms length and ad hoc, though often facilitated through clan relationships.	Linkages and governance mechanisms have been weak and ad hoc. Emerging cooperatives and processing sectors are stimulating a gradual strengthening of linkages.
Capacity and skill development	Simultaneous effort on capacity on input and production side and for improving marketing. Both individual farmer and organisational strengthening.	Minimal upgrading in the chain. Proposed certification system would develop higher-value product and improved biosecurity processes to add value.	Major priorities are around improved production practices, hygiene procedures and stronger input and output market organisation.
Distribution of benefits	Benefits can be improved and are dispersed and reliance on market agents lowers producer share.	Dispersed throughout complex web of value chain network.	Households can capture benefits due to strong demand but require better organisation for effective response to demand.
Priority areas for future improvement (Lynam, 2008)			
Investment opportunities and incentives	Simultaneous effort on input and production side and market side through organisations that can link emerging farmers to commercial markets.	Potential opportunities in export-oriented slaughter if costs of certification chain (particularly feed) can be reduced.	Steady increase in demand provides strong incentives for different market actors. Opportunity for market pulls to improve investment from household to larger levels.

Components, Actors	South Africa – beef (Emerging farmers)	Ethiopia – beef	Ethiopia – smallholder dairy
Description of value chain components (including key issues and actors)		More direct interfaces required.	
Input supply and service provision	Organisations needed to improve efficiency and effectiveness of input supply and services and link to other services.		Currently, largely through a public technology transfer model but more responsive public, private and farmer organisation mechanisms are needed for improved breeds and feed.
Production technology	Competitiveness issues associated with breeding and feeding inputs relative to commercial producers.	Improvements required in disease management, feed availability and animal productivity.	Better organisational arrangements for breeding and feed inputs linked to knowledge needs.
Organisation of producers	A key issue is increasing the linkages between farmers, input suppliers and marketing chains.	Better coordination needed between producers and other parts of the chain.	Producers are small, so extra efforts through innovations in knowledge management and organisational arrangements are critical.
Grading and standards	Understand beef market and potential for meeting different demands in different domestic markets from rural to urban.	Role of alternative international trading standards in future (e.g. commodity-based trade)	Basic hygiene procedures with better enforcement required for informal markets. Smallholders will require support to meet higher formal market standards.
Processing and marketing	Future efforts to link emerging farmers to value added feedlotting and processing. Potential for directly linking emerging farmers to retailers.	Improved technology, especially for high-value export products; more integrated marketing infrastructure.	Hygienic standards in handling and marketing in the informal market; increased processing capacities to address seasonal low milk demand due to religious reasons

Although in very different production and market systems, these case studies reveal a number of critical crosscutting issues for broad application. In Africa, the need to improve input supply and production efficiency is a major issue in livestock value chains involving smallholders. In all three case studies, breeding and feeding inputs were a critical constraint. Animal genetic improvement – a challenge in smallholder and emerging farmer contexts – requires innovative organisational arrangements that consider both the value chain and production contexts (Payne and Hodges, 1997).

For feed supply, quality and price relationships are always key issues and require sourcing the main diet components as cheaply as possible, either through high-yielding grasses or with by-products from cropping systems or agro-industries. The next level of complexity is in balancing rations and adding supplements to improve performance. Given the increasing competition for tropical biomass among food, feed and fuels, dynamic price shifts in feedstuffs need to be monitored carefully as feed costs are often the most critical competitiveness issue. This was a crucial issue in the Ethiopia beef case, where simulation analysis revealed that using best-cost rations instead of traditional feed sources could reduce costs by US\$600 per tonne on a boneless meat basis, making market access into higher value markets more viable (Rich *et al.*, 2009).

Animal health is also a critical production constraint. In extensive systems, such as the two beef value chains, infectious diseases are a critical constraint that relies on public-sector vaccination and disease control programmes. As production becomes more intensified, production-related diseases, such as pneumonia and mastitis, become more important and are best provided for through private sector means linked to other inputs. Similarly, disease risk is critical in each of the cases. Improvements in organising production and marketing in value chains can allow for differentiated response to quality standards based on risk.

Commodity-based trade approaches (Thomson *et al.*, 2008) are promising, but are not yet applied to govern trade in livestock products. This regulatory innovation would allow smallholders to evolve and adapt over time with quality standards in a manner consistent with minimising disease risk. For example, in the Ethiopian beef case, an innovative system of phased export with an initial period of quarantine, vaccination and disease control measures followed by observation in an export zone feedlot before slaughter, has provided an agreed method of certifying meat as disease free for Middle Eastern markets.

In all the value chain cases, governance and organisation along the value chain are critical in allowing poor producers to benefit from participation in higher-value markets (Gereffi *et al.*, 2005). Producer organisations were critical in changing this relationship for emerging farmers in the South African case. Conversely, in the

Ethiopian beef case, power asymmetries exist throughout the chain. In the absence of formalised coordination mechanisms, other than those derived from relational, trust or clan linkages, the ability to leverage the value chain to improve the benefits of value chain participation for pastoralist producers and other smallholders is limited (Legesse, 2008).

Organisational improvements can also be critical to improving value chain performance and driving through private-sector-led innovations. In the South African case, a critical feature was introducing a business approach in which key goals were identified and monitored through quantitative performance targets (Clark *et al.*, 2008 $a,b$  and Timms and Clark, 2008). Capacities and soft skills to implement these business approaches were critical to success (Burrow *et al.*, 2008). In the less developed value chains of Ethiopia, it is still critical to evaluate performance, but planning and monitoring needs to combine quantitative with qualitative measures. Furthermore, organisational arrangements are critical in improving performances related to improved marketing and responses to changing consumer demands for quality and safety.

## 5. Conclusion

Value chains provide an excellent framework for assessing opportunities for poor people in livestock markets. They allow focus on the individual components of production and marketing chains that need to be improved, as well as the benefits of different institutional arrangements, needed public investment and enabling policies and regulations. In most developing countries livestock value chains, it is critical to improve input supplies and services as well as output market linkages.

Value chain methods also provide a framework for instituting and assessing continuous improvement programmes that provide performance targets, and emphasise the need for developing skills and experience, so that different actors improve their capacities to innovate, adapt and respond to changing circumstances and opportunities.

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# 10

## Implications and Innovative Strategies for Enhancing the Future Contribution of Livestock

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### Abstract

The multifunctional capacities of animals are of four categories. They (i) provide a means of diversifying the use of resources and reducing socio-economic risks, (ii) promote linkages with other systems' components, (iii) generate value-added products such as milk and meat, and provide attendant services such as draught power, and (iv) contribute to sustainable agricultural production. This context underscores an urgent need for innovative strategies that will enhance the future contribution from livestock to sustainable food security, stable livelihood systems and environmental integrity. This urgency is justified by the disquieting parallel scenario of decreased interest and investments in agriculture and a lagging livestock subsector whose prevailing supplies of animal proteins are inadequate to meet the current and projected human requirements up to 2050. However, these scenarios also indicate there are major opportunities for the owners and producers of livestock to intensify productivity in the developing world. To date, a revitalised agenda for development is wanting, given that livestock constitutes about 30 percent of the agricultural gross domestic product (GDP) in the developing world. It is also one of the fastest growing sub-sectors in agriculture, and involves 2.6 billion smallholder farmers who produce the majority of food as well as all other products and services in agriculture, mainly on small farms. To increase productivity and promote agricultural growth in the developing world, assertive strategies and concerted pathways must encompass sustainable development and poverty reduction, production systems, gender equality and empowerment, risk and vulnerability, value chains and innovation, small farm systems, climate change and animal health. The challenge is to identify and implement innovative strategies that are consistent with the demonstrable capacity of animal production, and recognise its value as an industry that can make an enormous contribution to sustaining human welfare in the future.

**Keywords:** multifunctionality, production systems, products and services, poverty, vulnerability, gender and empowerment, strategies.

## 1. Introduction

This concluding chapter builds on the proceedings of the *Satellite Symposium on the Role of Livestock in Developing Communities: Enhancing Multifunctionality*, which was within the 10th World Conference on Animal Production. It highlights the strategies that need to be pursued in determining the way forward in achieving an increase in productivity from livestock by:

- ▶ providing a review of existing knowledge of the livestock sub-sector and increasing understanding of the implications;
- ▶ raising awareness of the urgent need to address current, continuing and emerging problems in the context of the efficient use of natural resources; and
- ▶ responding to the compelling quest to maximise the multifunctional contribution of livestock to sustainable food security, stable livelihood systems and environmental integrity.

The focus on multifunctionality and its contribution needs to be viewed against the background of three principal and overarching factors:

- ▶ livestock constitutes about 30 percent of the agricultural gross domestic product (GDP) in the developing world, about 40 percent of the global GDP, and is one of the fastest growing sub-sectors in agriculture (World Bank, 2009);
- ▶ about 2.6 billion smallholder farmers with farms less than 2 ha produce the majority of the world's food as well as all other agricultural products and services throughout the world (more than 70 percent of the world's hungry live in rural areas. IAASTD, 2008); and
- ▶ the significantly decreased interest and investments in agriculture, together with a lagging livestock sub-sector means there are major opportunities for the developing world's owners and producers of livestock to intensify productivity.

In broad terms, these major concerns indicate the need to focus on the following goals for the livestock sub-sector:

- ▶ define ways to increase awareness and provide informed views on the extent of the global importance of livestock for human welfare;
- ▶ promote improved understanding of the value of the numerous contributions that livestock afford;
- ▶ identify the major constraints limiting production;
- ▶ benefit from lessons learned from past practical experiences;
- ▶ identify the major challenges and opportunities for development; and
- ▶ define strategies, global policy development issues and future directions that can support increasing livestock's contribution to the greatest possible extent.

The intent of this chapter is to distil and highlight the key issues, and help define the way forward. This was facilitated by the preceding nine chapters in this book that synthesised state-of-the-art information from published and other available sources, the symposium proceedings, wide-ranging session discussions, and consensus by eminent scientists and practitioners from all regions of the world. The preceding chapters include 1) Multifunctionality of livestock in developing communities, 2) Livestock development projects that make a difference: What works, what doesn't and why, 3) Promoting gender equality and empowering women through livestock, 4) The way forward on livestock and the environment, 5) The role of foods of animal origin in human nutrition and health, 6) Interactions between gender, environment, livelihoods, food, nutrition and health, 7) Livestock against risk and vulnerability: Multifunctionality of livestock keeping in Burundi, 8) Sustainable livestock intensification, and 9) Value chains and innovation. Readers are encouraged to visit each of these chapters for more detailed discussions on individual subjects, as well as to follow up on pertinent references. The sections below provide a review of the findings for developing innovative strategies for future direction. Chapter 1 provides an introduction and context, while Chapter 2 sets the scene with reference to a conceptual framework.

## 2. The overwhelming context

The justification for increased contribution from livestock in the future is associated with several startling facts:

- ▶ Agriculture's share of GDP is declining in many countries and, as a result, the role and contribution of livestock is also affected and decreasing.
- ▶ The first Millennium Development Goal (MDG 1: halve hunger and poverty by 2015) is on course to fail. A World Bank study indicates that 100 million additional people have been pushed back into poverty in the last year.
- ▶ Poverty will be exacerbated by the exploding food crises and the rising cost of production inputs. Effects of globalisation will tend to exert increased pressure on smallholder systems and the livelihoods of poor livestock keepers due to competitiveness and transaction costs, particularly in Asia and Africa.
- ▶ Reduced agricultural productivity will exacerbate food and nutritional insecurity.
- ▶ Climate change will affect biodiversity and animal performance. IFAD (2009) has reported that climate change is expected to put 49 million additional people at risk of hunger by 2020 and 132 million by 2050.
- ▶ A 2.5°C increase in global temperature above pre-industrialised levels will see major losses of biodiversity, putting about 20–30 percent of the plant and animal species assessed at high risk of extinction (IPCC, 2007).

- ▶ Climate change will affect plant growth, the quantity and quality of crop residues and, therefore, animal performance.
- ▶ The meat and milk consumption levels projected for 2020 are far in excess of anticipated supplies. The supply of both meat and milk will have to double by 2050 (Steinfeld *et al.*, 2006) to meet human requirements, which are projected to be 44 kg and 78 kg respectively in developing countries, and 94 kg and 216 kg respectively in developed countries (Rosegrant *et al.*, 2009).
- ▶ Shortfalls in dietary animal protein supplies are far more serious than shortfalls in supplies of energy from cereals.

These daunting facts paint a picture of extremely difficult times ahead with major challenges for the future of animal production. Many of the issues are interrelated, the interaction of which will have a further dampening effect on animal production. The declining share of agriculture in the GDP is largely due to low productivity, resulting in low growth and lower incomes for people dependent on agriculture. In East Asia and the Pacific for example, agricultural growth dropped from 4 percent in the 1980s to a mere 0.1 percent in 2002–2003 (ESCAP, 2008).

The poverty problem is increasing, especially in developing communities. In 2000, the global community set about halving the number of hungry people in the world by 2015 as its first MDG. It now appears that this is unlikely to be achieved. In fact, according to the UK Department for International Development (DFID, 2008), extreme poverty and vulnerability have increased, initially because of the food crisis of 2008 that was aggravated by high energy prices, and now because of the global financial crisis. As a result, with food prices remaining high but incomes falling, the number of people who cannot access food increased by 100 million in the last year (DFID, 2008). A large proportion of the world's poor are livestock keepers who survive because of their livestock's contribution to their socio-economic wellbeing. Improved livestock production and agricultural growth is thus an important means to reduce hunger and poverty.

Climate change will have major impacts on livestock production and, hence, also on livestock owners. Although both risks and vulnerability are increasing due to the climate, the latter is of much greater concern. The result is a loss in biodiversity and a higher risk of extinction is predicted. Furthermore, climate change influences livestock feeding systems and performance by increased availability of more fibrous feeds such as straws and stovers. In rangeland situations, there is likely to be increased browse allowing for a greater concentration of small ruminants which can also result in subsequent overgrazing and environmental damage.

Although livestock are known to reduce risk and enable survival of the poor, the various constraints and interactions with the environment pose new and unexpected

challenges for the owners and producers of livestock. Realising the projected requirements of animal protein supplies to meet human requirements up to 2050 will be a noteworthy challenge (Steinfeld *et al.*, 2006). This raises the question as to whether or how they can be met in the face of the many and increasing number of constraints to livestock production. More importantly, it questions the efficiency of current animal production systems, the capacity of individual components of the livestock industry and the urgent need for more innovative pathways to address this issue.

### 3. Multifunctionality of livestock

It is especially imperative to keep the four broad multifunctional capacities of livestock in perspective (Devendra, 1993), namely:

- ▶ providing a means of diversifying the use of resources and reducing socio-economic risks;
- ▶ promoting linkages with components of other systems such as land, water and crops;
- ▶ generating value-added products, such as utilization of fibrous crop residues, production of meat and milk, and providing attendant services such as draught power; and
- ▶ contributing to sustainable agricultural production.

The multifunctionality of livestock can be described in terms of their contribution to products and services, food and nutrition, and security and survival. These are explained in more detail below.

#### *Products and services*

The roles and contributions of livestock are varied, complex and closely associated with farm families, interactions with crops, social values and prevailing agricultural systems (Stroebel *et al.*, 2008). The range of both products and services is considerable throughout the developing countries, as illustrated in Table 1, Chapter 2. Livestock enable savings; provide security; allow resource-poor households and women, who typically cannot own land, to accumulate assets and to finance planned expenditures as well as unplanned events such as illness; provide value through products such as meat, milk, eggs, manure and draught power, improve household nutrition; and help maintain social capital and status within communities. Livestock function as insurance policies and bank accounts in many parts of the developing world. Although there has been awareness in the research community for many decades of the multifaceted roles played by livestock, much of the current research still focuses on disciplines and

individual elements, such as feed efficiency or a particular disease or breed, rather than taking a holistic – or multifunctional – view.

### *Food and nutrition*

The importance of diets that provide the essential nutrients for good nutrition, including a proper amount of animal protein, is well known. Previously, the focus was on the potential of single nutrients to improve nutritional status and health. More recently, the concept of whole food and its collective contribution to nutrition and good health of communities in the developing world has become increasingly important. Providing for improved health and wellbeing is challenging and varies from country to country. However, the primary task is to meet nutritional needs by providing the type of basic but essential foodstuff to marginalised populations that address micronutrient imbalances (calcium, iron, zinc, and vitamins A, B6 and B12), as well as dietary proteins and energy. Diets lacking foods that provide proper nutrition can have health repercussions including obesity, hypertension and increase vulnerability of households to other secondary infections and diseases.

### *Security and survival*

The contribution of livestock to household security and survival is underestimated. In mixed farming systems, livestock ownership provides basic insurance against crop failure, and positive crop-livestock-soil interactions provide socio-economic benefits and stability within farm households. The ownership of livestock, together with livestock products such as meat, milk and eggs, enhances food and nutritional security.

It is in the harsh semi-arid and arid environments, where crop growth is limited, that livestock make the most significant contribution to survival. During droughts, camels, cattle and small ruminants come into their own and ensure human survival. Goats are especially well adapted to very arid conditions, making their increased value and contribution to the survival of poor livestock keepers extremely significant.

## **4. Issues and strategies**

Several chapters of this book focused on identifying and discussing the major issues and strategies that have significant roles in developing and enhancing the future contribution of livestock. This section synthesises those issues and their contributions.



### *Sustainable development and poverty reduction*

Strategies to enhance the multifunctionality and contribution of livestock must recognise that the associated research and development (R&D) needs are complex in that they must address and factor in a range of issues such as variations in the biophysical environment, interactions among system components and the threats of climate change. The list is extensive and understanding the needs and prioritising the efforts is essential. While these issues are agroecological zone (AEZ) specific, the importance of starting with community-based technology innovations and scaling up to realise impacts at the eco-regional level cannot be overemphasised.

R&D efforts aimed at sustainable poverty reduction benefit greatly from the methodologies used and the lessons learned from past activities. Results are more likely to be cost effective and successful if there is wider implementation and recognition of the conceptual framework involving the set of six important principles proposed by Pell et al. in Chapter 2. Building on the framework, it is also important to look at other prerequisites that could contribute to bringing about tangible impacts, such as diverse partners, choice of institutions, public-private partnerships, wider links to markets, learning platforms, systems approaches and longer time horizons.

The increased demand for livestock products needs to be translated into incentives and increased benefits for farmers. This will require better understanding of the mechanisms and processes used by livestock producers and household economies to adopt new technologies, of linkages to opportunities and market outlets, and of ways to reduce transaction costs and increase understanding of consumer requirements. These aspects should be an integral component of concerted development strategies.

Community participation in R&D is critical. Several key interrelated issues are relevant to sustainable development including, *inter alia*, the need for more community-based multidisciplinary R&D that identifies locally specific problems, priorities and needs, farmer-researcher-extension agent partnerships, the establishment of avenues for dialogue to take place, integration of efforts by different stakeholders and short-term funding. There are many examples of successful development projects that have applied these principles and processes, and have proven to be applicable in most parts of the developing world.

Associated with the above also requires an improved understanding of the biophysical environment, households, farmers and the available assets and production resources. These elements influence how the assets and production resources are used, decision-making processes, the methods used to deal with complex farming systems and the interactions of the system's components. These requirements enable an assessment of the efficiency of production, socio-economic impact and extent of sustainability.

## Production systems

Improved production systems need to be developed that maximise the use of available resources and are an overriding determinant for enhanced productivity from livestock. The mainly private sector-run intensive non-ruminant industries will continue to supply the bulk of the meat and egg to the world's markets. Major opportunities exist to expand ruminant production in target AEZs throughout the developing countries in appropriate production systems.

The prevailing ruminant production systems are unlikely to change, although there will be shifts between systems such as changes from agropastoral systems to mixed crop-animal systems in Africa, and from crop-animal systems to zero-grazing systems in Asia and Latin America. In the process, different levels of intensification within and between production systems are inevitable and need to be vigorously promoted to increase productivity. The principal strategy should be to maximize the use of available feed resources so that individual production systems can respond to increased outputs of quality animal products in ways that are consistent with market dictations and consumer requirements.

Among the ruminant production systems, integrated ruminant-tree crop systems (e.g. coconuts and oil palm) or silvopastoral systems have been underestimated and merit more development attention. This system enables, *inter alia*, stratification of production through, for example, national breeding programmes, increasing feed production and stock numbers to support and intensify production systems, and *in situ* use of crop residues and by-product feeds from the parent crop. Devendra (2009) has recently highlighted this strategy and the opportunities for intensification that are associated with increasing productivity and sustainability in oil palm. Such systems provide good linkages between production and post-production as well as environmental sustainability.

Intensification of production systems is inevitable. This is particularly reflected in the non-ruminant poultry and pig sectors and, to a much lesser extent, in dairying. With ruminants, intensification will involve a shift from the more extensive systems to systems whereby the intensive use of the available feed resources will be an important prerequisite. In the future, the process of these shifts and the sustainability of the systems will be challenging.

Intensification will be in direct response to population increase and the need for more animal proteins. As Van der Zijpp et al. pointed out in Chapter 8, this also involves structural changes that have the potential to affect the environment and human health. This, as they rightly emphasised, makes it essential to establish a policy framework that address legislative issues for promoting orderly development.

In this context, it is pertinent to point out the following suggestions of the World Bank (2005) report that covers these issues:

- ▶ Integrate livestock-environment interactions into environmental impact assessments and national environmental action plans.
- ▶ Continue developing innovative approaches to managing the interactions between livestock production and the environment in the “hot spots”. Such approaches include drought preparedness in addressing desertification of arid rangelands, benefit-sharing systems for livestock-wildlife systems, payment for ecological services in improving degraded pastures so that deforestation is reduced in the humid tropics, and area-wide integration of industrial units into croplands and pastures in order to limit nutrient loading and groundwater pollution.
- ▶ Promote sound ecological farming practices such as the integration of crops and livestock, and development of markets for organic products where it is ecologically efficient within the relevant environmental parameters.

Animal production systems are dynamic and constantly respond to biophysical factors and other externalities, in addition to the various interactions of soil, crops and animals with the environment. There are major R&D issues to be addressed concerning the sustainability of these systems, with particular reference to farming systems perspectives. Associated with the future of these systems, Table 1 provides a summary of the broader livestock systems, the priority production systems in ruminants across regions and the major emerging issues within these systems.

**Table 1:** Summary of livestock systems, priority production systems and major issues (Devendra et al, 2005)

Type of livestock system	Priority production system	Regions					Major issues within systems
		Asia	SSA	CA	WANA	LAC	
1. Landless	Peri-urban/urban dairy production	*	*		*	*	Surface water contamination
	Peri-urban/urban poultry and pig production	*	*	*	*	*	Zoonosis
	Feedlot (cattle or small ruminants)	*	*	*	*	*	Waste disposal
	Goat and sheep production	*	*	*	*	*	Nutrient flows
							Overgrazing
2. Crop-based mixed	Integrated systems with annual crops (ruminants and non-ruminants plus fish)	*	*	*	*	*	Food-feed systems
	Integrated systems with perennial crops (ruminants)	*	*			*	Year-round feeding systems
	Beef and dairy production	*	*	*	*	*	Nutrient flows/soil fertility
	Goat and sheep production	*	*	*	*	*	Productivity enhancement
							Intensification and specialisation
							Overgrazing
3. Agro-pastoralist	Cattle		*	*	*		Feed supplies/drought strategies
	Goat and sheep production		*	*	*		Property regimes
							Overgrazing
							Trypanosomiasis
4. Range-based	Goat and sheep production	*	*	*	*	*	Drought strategies
							Overgrazing
							Property regimes
							Marketing

**Notes:**

- i SSA–sub-Saharan Africa; CA–Central Asia, WANA–West Asia and North Africa, LAC– Latin America and the Caribbean.
- ii \* Indicates that both the production systems and animal species are equally important within the region.
- iii Major issues, *inter alia*, are those that currently merit R&D attention. Across regions, the issues are broadly similar as is the case of dairying. Dairy production includes buffaloes and cattle, especially in Asia.

*Gender equality and empowerment*

Despite years of gender sensitisation in many research and extension organisations in many countries, the role of women in livestock production and in the marketing of animals and their products continues to be underestimated, and this needs to be corrected. There needs to be better understanding of the role and contribution of women in farming systems, including women’s control and use of productive assets, in decision-making processes in agriculture, and the stability of farm households.

Achieving gender equality depends on several different issues, related to defining roles and responsibilities, rights of ownership, women’s control over assets (natural resources, information and family and animal health), access to livestock services and markets, and decision-making powers. Among the initiatives highlighted to promote greater equality between the genders are empowering women and promoting activities that support women in organising themselves. There is increasing evidence that empowerment is central to women’s control and use of productive assets, bargaining power, increased participation in social and credit programmes, and networking. This, in turn, leads to improved health, welfare and stability of households.

In the future, intensifying the promotion of gender equality and women’s empowerment through livestock needs to take cognisance of the following issues identified by Waters-Bayer and Letty in Chapter 3:

- ▶ use gender analysis as an ongoing, not a one-off, exercise;
- ▶ focus on women and their specific needs, constraints and capacities;
- ▶ strengthen local women’s organisations;
- ▶ improve women’s and girls’ access to education and training;
- ▶ recognise dynamism and openings for positive change; and
- ▶ seek gender equality in livestock services and organisations.

### *Livestock and the environment*

In Chapter 4, Herrero *et al.* discussed in some detail the various complex issues involving the environment, notably land use systems, nutrient cycles and water. Equally important are the emergence and inevitability of climate change on livestock and the need for adaptation and mitigation. Greenhouse gas (GHG) emissions from livestock are a continuing threat and determining ways to reduce these provides continuing debate. In this context, Smith *et al.* (2007) have suggested three ways to deal with the problem: (i) direct reduction, (ii) remove CO<sub>2</sub> from the environment and (iii) offset emissions through indirect effects.

The effects of livestock on the environment in the future will be largely mediated by the looming threat of climate change, which establishes the need for innovative strategies to cope with the various complex issues. Given the relative infancy of the science to deal with these various issues, very urgent and vigorous research is needed in the immediate future. Associated with this, major issues that need to be addressed to develop more innovative strategies include, *inter alia*:

- ▶ manipulation of animal diets;
- ▶ manure management; and
- ▶ production systems that promote carbon sequestration.

### *Risk and vulnerability*

Risk and vulnerability are two critical factors affecting small farm systems and livestock keepers. There is no doubt that livestock enterprises make a significant contribution to reducing risks. Risk factors are greatest in monoculture enterprises such as intensive dairy production units that depend on external inputs such as imports of germplasm and cereals. However, such risks are much lower in mixed farming systems due to their diversification. Several case studies in the developing countries confirm this view. In Africa, for example, Vandamme, et al in Chapter 7 describes a study in Burundi found that households kept livestock as a management strategy to reduce vulnerability to failed income generation from crops. In South Africa, collective action by a farmers' association enabled members to generate additional income by keeping sheep.

While risks affect everyone in all environments, vulnerability has a more serious impact on the resource poor, especially those living in the less favoured, harsher, limited rainfed environments found in many parts of North Africa, northern India and western China. Climate changes thus provide a

clear distinction between the two elements of risk and vulnerability (Warren *et al.*, 2006). More importantly, climate change threatens to have the greatest impact on the poorest of the poor and increasing the poverty dilemma. The effects are mediated through reduced water availability, reduced length of growing period, and food and nutritional insecurity. The reduced availability of crop residues affects livestock performance and productivity, which in turn affects farm income and livelihoods. In developing communities, this will translate to exacerbation of mass poverty.

### *Value chains and innovation*

Value chains and innovation are key components of the production systems, and it is important to ensure that these are in place to support the efficiency of production. Several research and industry development issues were identified by McDermott *et al.* in Chapter 9 that needed better understanding as well as assessment. These included definition of type of product, production systems, market types and marketing systems (rural, urban and international).

From the standpoint of livestock keepers in developing communities, there is an overriding need to empower them with ways to compete in markets by reducing transaction costs, increasing access to both rural and urban markets and linking them to related industries such as food processing, and increasing their understanding of the value chain. Together with this, the importance of networking and cooperative development will enhance their bargaining power. The value chain needs to be considered in totality from production to post-production to consumption systems.

### *Small farm systems*

Small farm systems and smallholder farmers are at the heart of the development focus on poverty alleviation projects and strategies for improvement. Globally, out of an estimated 470 million small farms with less than 2 ha of land, 85 percent are smallholders. Of these, 87 percent are found in Asia and 8 percent in Africa (Nagayets, 2005). These figures do not include several million landless farmers and agricultural labourers, especially in Asia.

To improve the productivity and contribution of small farms, it is first essential to have affirmative policy and institutional commitment that can provide an emphatic agenda for development. For small scale farmers, survival is foremost and policies need to be supportive of this basic objective. In order to push for increased productivity gains, the agenda also will need to be backed by increased investments. This is justified by past evidence, such as the Green Revolution in Asia, which clearly showed that investments in agriculture could give significant benefits. Given the very complex issues involved, such as the interactions of the system components and now climate

change threats, the agenda for successful development is extremely challenging, but can bring tangible results, rural prosperity and agricultural growth (Devendra, 2007; 2010). It is pertinent to draw attention to the recent calls by IAASTD (2008), IFAD (2009) and the G8 on the enormous potential of small farm systems and small scale farmers, and the need for their increased emphasis on agriculture in the future.

### *Climate change*

The effects of climate change are anticipated to have concerning impacts in the future, especially for small farms and small scale farmers who will be most affected. Observed changes such as hot days, droughts and flash floods have already affected biological systems in many parts of the world and are projected to increase. The problems are exacerbated by the direct effects on water, crop growth and biodiversity. Increased temperature, for example, will affect the length of the growing period, cropping patterns and yields, and lead to shifts to crops that are more adapted to high temperatures, production of more fibrous feeds, increased browse in rangelands, increased concentration of small ruminants, overgrazing and environmental degradation.

Table 2 summarises the effects of climate change on land use and livelihood systems. The effects are serious and wide ranging, and are cause for, *inter alia*, reduced soil moisture, expansion of semi-arid and arid AEZs, increased droughts, increases in rangelands, woody encroachment and desertification, and increased overstocking of heat-tolerant animals, such as goats, which can result in soil degradation, reduced biodiversity and other effects on ecosystems, especially in the rangelands. The resultant trend will be a shift out of agriculture. With animals, the key effects are heat stress, and the quality and availability of the feed resources.



**Table 2:** *Effects of climate change on land use and livelihood systems of the poor*

Land use system	Livelihood systems of the poor *
Reduced soil moisture	Reduced income
Expansion of semi-arid and arid AEZs	Increased poverty
Increase in droughts	Increased vulnerability
Increase in rangelands	Inability to adapt to heat stress
Woody plant encroachment	Increased food and nutritional insecurity
<b>Desertification</b>	
Increased overstocking of heat tolerant animals, specifically goats in the rangelands, with resultant degradation	Increased susceptibility to diseases
Increased salinisation	Reduced self-reliance
Reduced biodiversity	Increased urban migration
<b>Effects on the systems</b>	
Reduced systems services	
Shift out of agriculture	

\* Includes the landless

The poor and the landless in small farm systems are the most vulnerable to the effects of climate change. This is because of their lack of adaptation, limited capacity for adaptation and limited access to new technologies and services that can reduce risks and promote adaptation through, for example, cropping patterns. The effects on the poor include reduced income, increased poverty, increased vulnerability, pressures to adapt to heat stress, increased food and nutritional insecurity, reduced opportunities, reduced self-reliance, and an increase in urban migration. The net effects of these limitations are widespread vulnerability, food insecurity, and negative impacts on livelihoods and agricultural development.

Climate change poses a direct threat to livelihoods through, for example, the expansion of dryland agriculture in areas that are very vulnerable to drought, such as South Asia and many parts of sub-Saharan Africa. Such threats are projected to increase and seriously reinforce poverty of millions of poor rural people that are constantly deprived and experience vulnerability. Extreme difficulties and agricultural constraints are therefore inevitable, increasing risks and human despair. It is already bad enough for the poor to eke out livings in harsh conditions without their having to deal with the additional burden of climate change, which threatens to exacerbate their circumstances and worsen the situation even more.

Human health and livelihoods are also affected through complex interactions of temperature, rainfall, humidity, water, air quality, pollution, poor nutrition and inadequate adaptation. Poor people will be most vulnerable to these vectors, which will result in ill health and a shorter life span. Famines, floods and monsoons add to the problems. The consequences of the effects on human health and malnutrition, in turn, have serious effects on human development. One result of this is reduced adult labour on farms to perform farming activities and agricultural production. Thornton *et al.* (2009) recently reviewed in detail the impacts of climate change on livestock and livestock systems in the developing countries, including a summary of key knowledge gaps and researchable issues.

### *Animal health*

Animal health issues are emerging as a major issue of future concern, especially in regard to human health risks. The World Bank (2009) reported that 75 percent of the diseases that have emerged over the past 15 years are of animal origin. Strategies and control measures are urgently needed to mitigate specific diseases. The risks give rise to social insecurity and are exacerbated when there is discord in establishing the origins of the disease and measures to deal with the problem. This clearly needs to be avoided. A good case in point concerns avian flu, the cause of which may be due to one of the following:

- ▶ traditional village extensive poultry-rearing systems in Asia;
- ▶ mix of wild birds within the village systems; or
- ▶ practices associated with intensive poultry production.

The objective of the World Health Organization (WHO) *One World One Health* concept is to integrate human and animal health systems in ecosystems. This is commendable and the practical implications need urgent and wider application.

## **5. Future direction**

In looking toward enhancing the contribution of livestock, a synthesis of the available information identifies several important issues that need to be addressed urgently. These issues, presented below, constitute the challenges and pathways for future direction.

- ▶ The multifunctional role and contributions of livestock are varied and numerous, but are currently inadequate to meet projected needs. Vigorous development strategies are needed to enhance nutritional and food security, and to improve livelihoods of developing communities.

- ▶ Prevailing livestock production systems are unlikely to change in the foreseeable future, although specialisation and intensification are inevitable. These systems have been severely hampered recently, especially in small farm systems, due to rising costs of production inputs, unpredictable markets and other externalities.
- ▶ Development policy and livestock production objectives need clearer definition, as well as institutional commitment for poverty alleviation projects.
- ▶ Predictable improvements and sustainable development that have a poverty-alleviation focus will require initial assessments and response to important prerequisites in the R&D agenda such as understanding the biophysical environment, aspirations of farming communities, constraints and real needs, gender equality and empowerment, risks and vulnerability, value chains and innovation and partnerships.
- ▶ Given the range and complexity of the issues involved, interdisciplinary R&D using systems perspectives and community-based participation are essential. These efforts need to focus directly on small farm systems, which in Asia and Africa alone account for 95 percent of the 470 million small farms worldwide that have less than 2 ha of land.
- ▶ Livestock provide an important entry point for the development of rainfed environments.
- ▶ Value chains should be seen in the broader context of the production-post-production-consumption systems theme.
- ▶ More aggressive and innovative efforts are necessary to improve on past efforts in projects designed to address poverty alleviation, which have now been exacerbated.
- ▶ Pro-poor poverty initiatives are threatened by climate change, which has to be incorporated into the R&D agenda.
- ▶ Creation of appropriate networks will enhance R&D capacity.
- ▶ Increased investments in livestock R&D are urgently required.
- ▶ Promotion and development of community-based self-help groups and farmer associations and cooperatives, as well as of technology transfer can be enhanced through training and empowerment.
- ▶ With specific reference to the developing world, much more needs to be done to accelerate information exchange through innovative and enlightened networking, tapping into the knowledge capital of the developed world, and strengthening South-South linkages, meetings, exchanges and visits.

## 6. Conclusion

The challenges for livestock production in the face of current realities are overwhelming and need urgent resolution. These include frontal attention to the following, *inter alia*:

- ▶ increasing animal protein supplies to match human needs;
- ▶ increasing efficiency in natural resource management;
- ▶ increasing food and nutritional security;
- ▶ mitigating or adapting production systems to deal with climate change threats;
- ▶ identifying ways to eliminate the poverty dilemma;
- ▶ establishing more concerted poverty alleviation and pro-poor development projects;
- ▶ improving livelihoods of smallholder farming communities;
- ▶ improving self-reliance of smallholder farmers; and
- ▶ investing in agricultural growth.

The resolution of these issues hangs in the balance in the developing world. Revitalising pathways to increase productivity and the multifunctional contribution from livestock for developing communities in the future is, therefore, compelling and challenging. Addressing the many interrelated issues is a collective task, emphasising:

- ▶ the enduring evolutionary links between humans and livestock,
- ▶ the continuing multifunctional contribution of animals, and
- ▶ the demonstrable capacity of animal production as one of the important sustaining industries for human welfare in the future.

This vision is consistent with the **Cape Town Declaration on Principles for Animal Production** that was unanimously endorsed at the conclusion of the 10th World Conference on Animal Production, which states:

- ▶ Animal production is practiced for the wellbeing of the human population.
- ▶ Animal production is practiced with regard to human dignity.
- ▶ Animal production is practiced using domesticated and semi-domesticated animals or game that have been adapted to the circumstances of production.
- ▶ Animal production is practiced with regard to sentient animals in a morally justifiable manner.
- ▶ Animal production is practiced with regard to the impact it may have on the environment.

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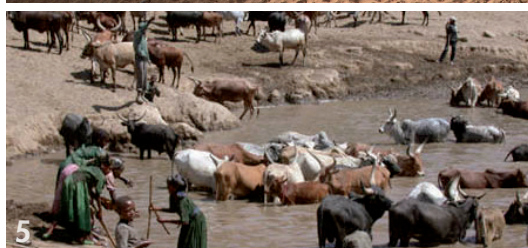
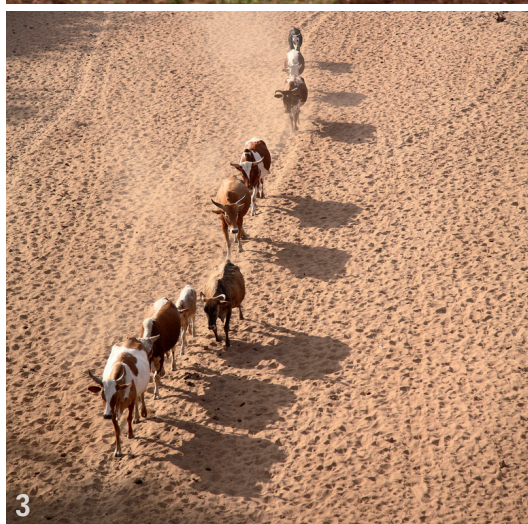


1. Madhabi Nandi collects dung to mould into Ghute, palmsized pallets of dung. India, West Bengal, Brahampur, Arwa village.
2. A child, Niger.
3. India, Rajasthan, Tonk district, Nagar village.
4. Woman and child walking to the market from Kunming to Da Li, Yunnan Province, China.
5. Woman carrying a milk churn. India, Rajashan, Tonk districk, Nagar village.





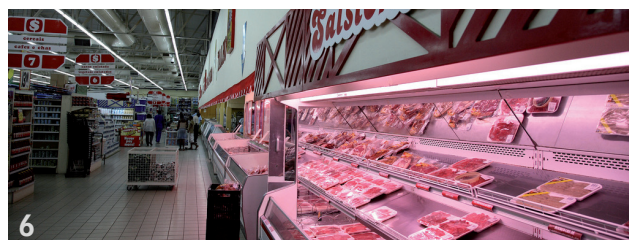
1. Children learning, Niger.
2. First piglets, Lonpongsheanghah, Nagaland, India.
3. Testing milk, India, Andhra Pradesh, Ramchandrapuram village.
4. Preparing fodder samples for improved animal feeding, Patancheru, Hyderabad, Andhra Pradesh, India.
5. Participatory Epidemiology Network for Animal and Public Health. Benin field work.
6. Vaccinating calves in Kenya.



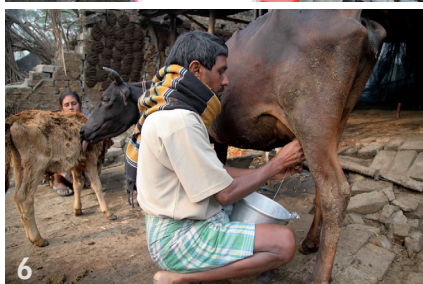
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1. Mozambique, Chokwe, Lhate village.
  2. Climate change threat.
  3. Mozambique, Tete province, Pacassa village.
  4. Mozambique, Tete province, Pacassa village.
  5. Awash River Basin (Batu Degaga), Oromiya, Ethiopia.



1. New pig feed technologies.
2. Goat in ricefield, India, West Bengal, Berhampur, Kumra Daha village.
3. Buffalo with calf, India.
4. Dia-Rajasthan Tonk District Nagar Village, India.
5. Cattle being watered at a waterhole in Niger.
6. Romosinuano cattle breed in South America.
7. Fodder as supplementary feed in Niger.



1. Farmer carrying fodder, moving with his pig. Zi Keza Village, Nanjian County, Yunnan Province, China.
2. Poultry shelthers, Mozambique, Garue.
3. In the early morning, Vaz Tome carries his goat to the market. Mozambique, Tete province, Muchamba village.
4. Vendors selling chickens. Mozambique, Quelimane.
5. Poultry sellers at the morning market. Mozambique, Garue.
6. Shoprite in Maputo, Mozambique.



1. Xipamamami traditional market, traders in pork and beef. Mozambique, Maputo.
2. Madhabi Nandi spreads out Ghute to stick to walls. India, West Bengal, Brahampur, Arwa village.
3. Milk for nutrition. Ethiopia.
4. Draft hour. India, West Bengal, Brahampur, Kadmati village.
5. Chokwe market. Mozambique, Garue.
6. Landless farmer Bijay Ghosh milks his cow. India, West Bengal, Brahampur, Kadmati village.
7. Ploughing with cattle in southwestern Ethiopia.

