17 Economics and Policy Research at ILRI, 1975–2018

Mohammad Jabbar¹, Steve Staal², John McIntire³ and Simeon Ehui⁴
¹Dhaka, Bangladesh; ²International Livestock Research Institute, Nairobi, Kenya; ³Santa Barbara, California, USA; ⁴World Bank, Washington, DC, USA

Contents

Executive Summary 640
  Goals of economics and policy research 640
  Research spending 640
  Scientific impacts 640
  Development impacts 641
Introduction 641
Policy Problems 642
  The historical problem of supply response 642
  Markets, institutions and competitiveness 648
  Ruminants 648
  Pigs and poultry 650
  Animal health services and productivity 653
Responding to the ‘Livestock Revolution’ 655
  Policy and technical barriers to smallholder dairy development 656
    Dairy reform in Ethiopia 656
    Dairy reform in Kenya 658
  Comparisons of dairying in South Asia and East Africa 660
Land rights 661
  Pastoral systems 662
  Land tenure, resource allocation and productivity 663
  Collective action for common resource management 664
  Land tenure and fodder trees 666
Livestock and poverty 666
  Food security and nutrition 667
IBLI in the arid rangelands of Kenya and Ethiopia 668
  Impact 669
  Policy lessons 669
  Livestock sector analyses and master plans as part of development policies 669
The Future 670
References 671

© International Livestock Research Institute 2020. The Impact of the International Livestock Research Institute (eds J. McIntire and D. Grace)

639


Executive Summary

Goals of economics and policy research

The goals of livestock policy and economics research at the International Livestock Research Institute (ILRI) have been to increase smallholder returns from animal agriculture by: (i) analysing the productivity and targeting of livestock-based technologies; (ii) identifying policy barriers that lower farm prices, raise input costs or lower the financial, information, and risk costs of new agricultural innovations; (iii) supporting institutions that improve productivity, create assets and improve the performance of value chains; and (iv) creating a policy and regulatory environment that allows animal agriculture to contribute to growth and poverty reduction.

Research spending

International Livestock Centre for Africa (ILCA) spending on economics and policy research was some US$48 million from 1975 to 1994, or 13% of the ILCA total of US$374 million. The sum of livestock systems research, which often had a policy component, plus economics and policy research during the ILCA era was US$120 million or 32% of the 1975–1994 total.

ILRI lifetime spending on economics and policy research has been about US$198 million since 1975, or 11% of the 1975–2018 total of US$1.75 billion. The sum of economics and policy work plus livestock systems research, which nearly always made some policy recommendations, was about US$375 million, or 21% of the 1975–2018 total.

Scientific impacts

The scientific impact of economics and policy research at ILRI and its predecessors, ILCA and the International Laboratory for Research on Animal Diseases (ILRAD), has been substantial:

- Definition of a path from research to development impact known as ‘Livestock – A Pathway out of Poverty’.
- Contributions to global knowledge about distortions in agricultural incentives via a wide range of livestock system, value-chain, trade and incentive studies.
- The notable scientific achievement comprising the joint effort of ILRI, the International Food Policy Research Institute (IFPRI) and the Food and Agriculture Organization of the United Nations (FAO) to produce a study of global livestock trends: ‘Livestock to 2020: the next food revolution’ (Delgado et al., 1999).
- Informed pro-poor regulatory systems for improved dairying in Kenya and Ethiopia, for live-animal marketing in Sudan, and for better structuring and financing of animal health in various livestock systems.
- Using remote sensing and household survey data, development of an index-based livestock insurance product, achieving wide scientific impact through the many well-cited papers produced from that data in Kenya and Ethiopia.
- Developing new methods: incorporating geographic information systems (GIS)-derived variables in econometric analysis, integrating models through farm, sector and global levels, including participatory approaches in field investigations and in the derivation of policy recommendations.

The second scientific impact was to develop technical and economic models derived from original field data that were applicable to policy problems:

- Collected and analysed data needed to support policy measures, including field surveys, modelling with GIS, bioeconomic models and surveys, randomized controlled trials.
- Property rights studies of grazing land, arable land and tree tenure, leading to site-specific policy recommendations in Ethiopia, Kenya and some countries in West Africa. This included demonstrations of the scope and impact of collective action in land rights, livestock value chains and natural resource management.
• Quantification of environmental constraints to growth, including soil erosion constraining higher land productivity in Ethiopia.
• Identification of barriers to women’s participation in technology and product markets, notably in Nigeria and Kenya.
• The landmark work on dairy reform in Kenya, which used a combination of an innovative data set, modelling and communications strategy to achieve substantial economic benefits.

Development impacts

ILRI’s policy and economics research, with the exception of the Kenya dairy policy effort, had limited identifiable development impact on output or equity. Some indication of development impact can be seen in the following:

• Analytical and organizational contributions to dairy market reforms in Kenya that benefited small producers and poor consumers. The estimated net present value (NPV) of these reforms, in terms of additional producer and consumer benefits minus reform programme costs, was US$230 million.
• Purchases of index-based livestock insurance (IBLI) policies in Kenya at an approximate amount of US$25 million and pay-outs to herders of US$10 million; purchases of IBLI policies in Ethiopia of US$2.5 million and pay-outs of US$370,000; and adoption by the government of Kenya of a national IBLI policy, based on the ILRI/IBLI model, which now provides insurance to 80,000 herder beneficiaries in the risky arid and semi-arid areas of Kenya.
• Identification of measures to promote the supply response after the ‘Livestock Revolution’ including supporting infrastructure, targeted producer transfers, definition of the conditions for successful collective action, and modernization of sanitary and phytosanitary (SPS) standards.
• Contribution to the design and analysis of reforms of property rights in mixed crop–livestock farming systems in Ethiopia after overthrow of the Derg in 1991.
• Evaluation of the effects of property rights, including traditional informal tenure, on land use, land management and tree tenure as it affected incentives to adopt alley farming practices.
• Contribution to reforms of animal health services in sub-Saharan Africa.
• A national programme to control classical swine fever launched in India following an ILRI study disclosing the economic impacts of the disease in three states in the country’s north-eastern region.
• Livestock master plans: the major achievement in influencing public expenditure was production of livestock master plans in Ethiopia, Rwanda and Tanzania and in the state of Bihar, India.
• Capacity development: the main achievement was to link economists and scientists in other programmes and in other institutions through the African Livestock Policy Analysis Network (ALPAN), the African Trypanotolerant Livestock Network (ATLN) and the epidemiology-economics programme started at ILRAD in 1987. The epidemiology-economics work has continued for 30 years (see Chapters 5 and 6, this volume) and has had a strong scientific impact in proposing solutions to animal health problems.

Introduction

This chapter defines policy as the actions of governments and public agencies. Policy actions can include, inter alia, the writing and enforcement of laws and regulations; the funding or conducting of research that investigates public actions; the provision of information and other inputs; and the building, operating or funding of productive infrastructure (e.g. laboratories for disease diagnosis) and market infrastructure. In their policy actions, governments typically make use of fiscal instruments such as taxes, subsidies, and wage and price controls, as well as institutional constructs and measures (organizations, rules and regulations).
Two factors drive demand for public policy. The first consists of market failures (typically characterized by inefficient distribution of goods and services), negative externalities (when production and/or consumption imposes external costs on third parties, causing social costs to exceed private costs) or of ‘free-riders’ (where some individuals consume more than their fair share or pay less than their fair share of the cost of a shared resource). To address such market failures, governments may intervene to correct market distortions to improve efficiency and equity. The second driver of demand for public policy is ambitions to achieve social objectives of efficiency and equity through public goods that maximize society’s return and ensure the equitable distribution of returns.

Zilberman and Heiman (2004) placed studies of public policy into three classes:

- Class I: advancing scientific understanding in describing systems and markets, assessing performance of markets, making sectoral accounts and estimating productivity.
- Class II: contributing to technical change that lifts productivity, such as breeding new stock or forage plants.
- Class III: advising on policies to improve efficiency or equity, such as improving external terms of trade, building institutions, investing in public goods, eliminating market distortions and calculating the costs of bad policies.

Studies of scientific understanding and technical change are of a ‘diagnostic’ nature: they provide information to agents – individuals, firms and sectors – with or without specific policy implications. Such studies may indicate market failures, negative externalities, or free-rider problems and their underlying causes, and suggest interventions as corrective measures. The focus of this chapter is on Class I and III types of policy studies, ranging from diagnostic market performance studies to analyses of the impacts of interventions and policies. Table 17.1 summarizes policy research impacts by policy class and gives specific problems addressed. Table 17.2 gives selected applications of bioeconomic models to policy problems.

Policy Problems

The overall goal of economics and policy research at ILRI and its predecessor ILCA has been to increase smallholder returns from farming with animals. This research has sought to: (i) analyse the targeting and productivity of livestock-based technologies; (ii) identify policy barriers that lower farm prices, raise input costs or increase the financial, information and risk costs of new livestock-related innovations; and (iii) support institutions that improve livestock productivity, create livestock assets and improve the performance of livestock value chains.

The following problems have been the focus of ILCA and ILRI economics and policy research:

- The historical problem of supply response;
- Animal health services and productivity;
- Responding to the ‘Livestock Revolution’;
- Policy and technical barriers to smallholder dairying;
- Livestock and poverty;
- Markets, institutions and competitiveness;
- Land tenure; and
- Livestock master plans.

Economic and policy analyses linked to specific technologies are discussed for animal health in Chapters 1–9 and for feed production in Chapters 11–14 (this volume).

The historical problem of supply response

An initial problem of policy research at the founding of ILCA in the mid-1970s was how to stimulate supply through higher productivity. This led to policy research on the structure of production and trade and on the role of incentives in raising production. The research on this problem had very limited impact and has largely been forgotten, mainly because it failed to use ILCA’s comparative advantage in farm data access and analysis.

The initial ILCA policy papers analysed subcontinental trends in production, demand and trade, and their drivers (Montgolfier-Kouevi and Vlalonou, 1981; Addis Anteneh, 1984; Sandford, 1985). These studies highlighted that Africa’s low livestock productivity and growth rates contrasted sharply with the rapidly growing demand for animal-source foods, which implied an increasing dependence on imports. National
Table 17.1. Livestock policy research impacts by class and problem.

| Themes                      | Policy Class I: providing information | Policy Class II: contributing to technical change | Policy Class III: improving efficiency and equity |
|-----------------------------|--------------------------------------|-------------------------------------------------|-------------------------------------------------|
| The problem of supply response |                                       |                                                 | Perry and Randolph (1999) on animal disease; Jones and Thornton (2009) on crop–livestock interactions as affected by climate change |
| Animal health services      | Scenario modelling after 1995: Thornton (2010), Herrero et al. (2010); major impact for ILCA before 1995; Addis Anteneh on public services (1983, 1984, 1991); Thornton et al. (2011), Robinson et al. (2011) on mapping global livestock McIntire et al. (1992); Pingali et al. (1987) | Perry et al. (2002) on animal health and poverty; Kristjanson et al. (1999) on trypanosomiasis vaccine; McDermott and Arimi (2002) on brucellosis, McDermott and Coleman (2001) on trypanosomiasis control strategies | Perry and Randolph (1999) |
| Responding to the Livestock Revolution | Thornton et al. (2002) on poverty analytics |                                                 | Thornton et al. (2002) on poverty analytics; Giller et al. (2011) on targeting technical change |
| Livestock assets, poverty, and financial markets | Holloway et al. (2000a) on dairying in Ethiopia | Reid et al. (2000b) on land use in Ethiopia, Berhanu Gebremedhin on land conservation in Ethiopia, Franzel and Wambugu (2007) on fodder shrubs | Coughenor et al. (1985) on pastoral models, Lawry et al. (1994); McCarthy et al. (1999) |
| Barriers to smallholder dairying | Verburg et al. (2009), Fritz et al. (2015) on cropland and field size | | |
| Land tenure, property rights, and institutions | Randolph et al. (2007) on role of livestock, Thornton et al. (2011) on adaptation to climate change | Minor impact | Coughenor et al. (1985) on pastoral models, Randolph et al. (2007) on role of livestock, Havlik et al. (2013) on adaptation to climate change; Shapiro et al. (2015) |
Table 17.2. Selected applications of bioeconomic models, various years.

| Problem/study          | Theme and chapter in this volume | Region/country/climate       | Method            | Objective function                                                                 | Treatments                          | Policy recommendations                                      | Technical recommendations                                      |
|------------------------|---------------------------------|-------------------------------|-------------------|------------------------------------------------------------------------------------|------------------------------------|------------------------------------------------------------|------------------------------------------------------------|
| **ECF**                |                                 |                               |                   |                                                                                   |                                    |                                                            |                                                            |
| Gettinby *et al.* (1988) | Acaricide resistance/           | Sub-Saharan Africa; subhumid  | Process simulation| Minimize acaricide resistance in treated tick populations                         | Acaricides                         | Regulate acaricide use                                      | Elucidate genetic basis of acaricide resistance in ticks   |
|                        | Ticks (Chapter 10)              |                               |                   |                                                                                   |                                    |                                                            |                                                            |
| Mukhebi *et al.* (1992) | ECF (Chapters 5 and 6)          | Kenya; subhumid               | Partial budgeting | Financial and economic returns to ITM and tick control; IRR 48%                   | ITM and acaricides                  | Monitor benefits and costs of dipping frequency carefully   | Joint use of acaricides and ITM                             |
|                        |                                 |                               |                   |                                                                                   |                                    |                                                            |                                                            |
| Nyangito *et al.* (1996a,b) | ECF immunization and tick control/ECF, ticks (Chapters 5, 6, and 10) | Kenya; subhumid          | Whole-farm simulation | Financial returns to ITM and tick control                                          | ITM and acaricides                  | Monitor benefits and costs of dipping frequency carefully   | Joint use of acaricides and ITM                             |
|                        | Ticks and their control (Chapter 10) | East Africa; subhumid and humid | Literature review | Financial and biological sustainability of long-term acaricides                    | Acaricides in rotation and combination |                                                            | Strategic application of acaricides                         |
|                        |                                 |                               |                   |                                                                                   |                                    |                                                            |                                                            |
| **Cattle productivity** |                                 |                               |                   |                                                                                   |                                    |                                                            |                                                            |
| Cartwright *et al.* (1982) | Beef production/               | Botswana; arid                | Herd simulation   | Output and profit maximization                                                    | Weaning ages of calves             | NA                                                        | Manage weaning ages and milk offtake policy                 |
|                        | livestock systems (Chapter 15)   |                               |                   |                                                                                   |                                    |                                                            |                                                            |
| Konandreas *et al.* (1983) | Beef and milk production/      | Botswana; arid                | Herd simulation   | Profit maximization of product and input choice                                   | Feed supplementation in cross-bred and indigenous cows | Supplementation economically superior in cross-bred cows; no public policy implications | Feed supplementation                                        |
| Authors            | Systems and Practices                                                                 | Countries/regions                        | Methods                                                                 | Objectives                                                                 | Recommendations                                                                 | Policies/Recommendations                                                                 |
|--------------------|---------------------------------------------------------------------------------------|------------------------------------------|------------------------------------------------------------------------|---------------------------------------------------------------------------|--------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| Thornton (1987)²   | Dual-purpose beef and milk production/livestock systems (Chapter 15)                   | Colombia; humid and subhumid             | Simulation model from station trials and field surveys                 | Optimize beef production                                                  | Improved grass-legume pastures in dual-purpose systems                              | None (pending more results on pasture outcomes)                                          |
| Powell et al. (1995)| Soil fertility management/livestock systems (Chapter 15)                               | Several sub-Saharan African countries; subhumid and semi-arid | Survey, station trials, tabular models, deterministic simulation       | Yield and financial optimization of organic and mineral soil amendments   | Mulching, manuring, mineral fertilizers, crop-residue management                    |                                                                                                |
| Elbasha et al. (1999)| Planted forages (Chapter 13)                                                           | West and Central African countries; subhumid and semi-arid | Survey, herd simulation model, tabular model of forage production      | Ex post economic surplus; ‘research paid for itself’                      | Planted forages, ‘fodder bank’ (usually *Stylosanthes* spp.)                       | Most recommendations technical; policies include providing extension information, credit and subsidized seed |
| Kristjanson et al. (2001)| Dual-purpose cowpea/planted forages (Chapter 13)                                       | Central and northern Nigeria; subhumid and semi-arid | Survey and tabular model after station trials                          | Ex ante economic surplus; cowpea grain 128–154% of NPV gross benefits; cowpea hay from −28% to −54% | Improved dual-purpose cowpea cultivars                                             | No technical recommendations                                                             |
| Kristjanson and Zerbini (1999)| Dual-purpose pearl millet and sorghum/multidimensional crops (Chapter 14)            | 105 districts within nine states of semi-arid India | Ex ante deterministic simulation                                      | Ex ante economic surplus; meat and milk productivity (IRR 26–43%)         | Higher straw quality in pearl millet and sorghum                                 | No policy recommendations                                                             |
| Valbuena et al. (2012)| Conservation agriculture                                                               | 12 sites in nine countries in sub-Saharan Africa | Literature and data review                                            | Optimize crop-residue uses among feed and mulch                          | Mulching versus feeding                                                            | Value output and soil quality                                                            |

Continued
Table 17.2. Continued.

| Problem/study | Theme/part and chapter in this volume | Region/country/climate | Method | Objective function | Treatments | Policy recommendations | Technical recommendations |
|---------------|--------------------------------------|-------------------------|--------|--------------------|------------|------------------------|--------------------------|
| Trypanosomiasis ILCA/ILRAD (1988) | Trypanosomiasis/ livestock systems (Chapters 2 and 3) | East Africa/ Kenya coast; humid | Survey and tabular model | Optimize use of trypanotolerant stock | Trypanocidal drugs, sprays, traps, trypanotolerant stock | Choice method of trypanosomiasis control as functions of challenge, livestock system and susceptibility of animals |
| Itty (1992), Itty et al. (1988) | Trypanotolerant livestock and trypanocides | Several sub-Saharan African countries; subhumid | Surveys, herd/ flock deterministic simulations | Optimize use of trypanotolerant stock | Vector control, trypanocidal drugs, trypanotolerant stock | Policy choice among treatments as function of land potential and stock density |
| Agyemang et al. (1997) | N’Dama cattle and milk offtake | The Gambia; subhumid | Herd measurements, deterministic simulations | Profit maximization | Milk offtake of trypanotolerant stock | Private management recommendation of partial milk offtake |
| Kristjanson et al. (1999) | Trypanosomiasis vaccine/ trypanosomiasis (Chapters 2 and 3) | Sub-Saharan Africa; subhumid and humid | Ex ante simulation | NPV of net benefits to vaccine | Vaccine | None |
| McDermott and Coleman (2001) | Trypanosomiasis (Chapters 2 and 3) | Sub-Saharan Africa; humid and subhumid | Deterministic epidemiological model without prices or costs | Rate of trypanosomiasis prevalence | Curative drugs, vector control, trypanotolerant cattle, vaccine | None |
| Reid et al. (2000a) | Environmental effects of trypanosomiasis control/tick-borne disease | Sub-Saharan Africa; humid and subhumid | Survey and time-series projections | Rate of change of tsetse infestation as function of population growth | Implicit treatments of population growth and land use intensity | None |
| Dairying Nicholson et al. (1999) | Dairying | Coastal Kenya; humid | Household surveys | Impact of dairying on income and employment | Breed, feed, management, disease control | Promoting access of smallholders to dairy technology through financial and institutional measures | Not specific |
| Study                  | Subject                                                                 | Location          | Methodology                                      | Impact                                                                 | Policy Measures                                                 | Target Area                                                    |
|------------------------|------------------------------------------------------------------------|-------------------|--------------------------------------------------|-----------------------------------------------------------------------|------------------------------------------------------------------|-----------------------------------------------------------------|
| Kaitibie et al. (2010a) | Reform of dairy marketing policy                                       | Rural Kenya, mainly highlands | Household surveys, market surveys                 | Impact of dairy market reforms income and employment                   | Liberalization of raw-milk trade                                 | Promoting direct sales of raw milk by smallholders and traders  |
| Other diseases         | Brucellosis/ veterinary epidemiology (Chapter 5)                       | Kenya; subhumid    | Simulation of RVF epidemics                      | Reduce human and animal health effects of RVF measured in disability-adjusted life years | Vaccination and disease surveillance                              | Enhanced surveillance and earlier vaccination                   |
| Kimani et al. (2016)   | RVF/ECF (Chapter 6)                                                   | Kenya; subhumid    | Simulation of RVF epidemics                      | Reduce human and animal health effects of RVF measured in disability-adjusted life years | Vaccination and disease surveillance                              | Enhanced surveillance and earlier vaccination                   |
| Vertisol technology and land management | Improved drainage as part of broad-bed management/ livestock systems (Chapter 15) | Ethiopia; highlands | Farm budget analysis and linear programming model | Profit/ha                                                             | Enhanced Vertisol drainage and tillage quality                    | Extend the technology; reduce cost of the BBM                    |
| Gryseels (1988); Gryseels and Anderson (1983); Getachew Asamenew et al. (1993) | Enhanced Vertisol drainage and tillage quality | Ethiopia; highlands | Farm budget analysis and linear programming model | Profit/ha                                                             | Enhanced Vertisol drainage with BBM                              | Expand credit supply, reduce cost of the BBM                    |
| Rutherford (2008)      | Improved drainage as part of broad-bed management/ livestock systems (Chapter 15) | Ethiopia; highlands | Farm and market surveys, analysis of research and development costs | Estimate return to research in the BBM                                | Expand use of BBM for pond construction and field irrigation     | Expand use of BBM for pond construction and field irrigation    |

BBM, broad-bed maker; ECF, East Coast fever; ITM, infection-and treatment method; IRR, internal rate of return; NA, not applicable; NPV, net present value; RVF, Rift Valley fever.

*Thornton (1987) was part of a CIAT effort on modelling beef production, beginning roughly with CIAT (1975).
trends differed significantly and there was significant cross-border trade in live animals among many countries, especially in West and East Africa. In West Africa, the large cities in the coastal region in the south were major centres of meat and milk consumption, while livestock production was concentrated in the arid, semi-arid and subhumid zones in the Sahel to the north. A similar pattern – production in the pastoral and agro-pastoral zones and consumption in the cities – held in East Africa. This policy work established that demand was not a constraint to growth of African livestock and agriculture more generally.

Several early studies, notably Jahnke (1982), observed the poor incentives for all agricultural production in sub-Saharan Africa due to low official prices and overvalued exchange rates as domestic factors, and as a result of dumping and food aid as external factors. The 1970s and 1980s generated extensive study of price incentives in global and sub-Saharan African agriculture culminating in the landmark work of Schiff and Valdés (1992) to which ILCA and ILRI made little contribution.

ILCA contributions on incentives problems were microeconomic. An ILCA paper argued that international trade and pricing policies were particularly important for livestock given the widespread trade in live animals in sub-Saharan Africa (Solomon Bekure and Macdonald, 1985). First, many people derive income from livestock production and these incomes are directly affected by livestock prices. Second, consumers spend an important share of their income on livestock products and this share will rise with economic growth. Third, livestock pricing policies are important to governments because of their implications for incentives, public spending and revenue. The study further argued that ‘positive’ policies – enhancing effective measures – improved efficiency in live-animal markets where transport costs were high. Examples of such ‘positive’ policies were gazetting animal trekking routes to reduce costs of crop damage along the routes and establishing water and feeding facilities to reduce weight loss and mortality in transit. ‘Negative’ policies – eliminating ineffective measures – could also improve the efficiency of livestock markets, such as by eliminating arbitrary or discriminatory licensing of traders and other intermediaries and by reducing protection to uncompetitive public agencies, such as parastatals, which were producing, trading or processing livestock products. Related studies of import competition in dairy products were inconclusive in terms of policy recommendations (von Massow, 1989).

Two trade studies were conducted around the time of the ILCA/ILRI merger in 1995. The first compared the effects of livestock policies on output, consumption, trade and government revenues in Côte d’Ivoire, Mali, Nigeria, Sudan and Zimbabwe (Williams, 1993). The study found that inflation and exchange rates were key variables in livestock pricing policies, and that some success had been seen in stabilizing real domestic prices. As a result of policy changes in exchange rates and domestic prices since the 1980s, there had been a shift away from taxing livestock producers. These changes had positive impacts on beef production and consumption in all study countries except Côte d’Ivoire, with mixed effects on exports.

The second study reviewed macroeconomic, sectoral and trade policies based on information developed for international farm trade negotiations (Williams et al., 1995). The study focused on ruminant livestock in Africa, Asia and Latin America and on pork and poultry in West Asia and North Africa. It found that, along with macroeconomic, sectoral and trade policies, investments in infrastructure, animal health, and processing and marketing facilities were required to promote efficient resource use and growth in production, consumption and trade. It projected positive effects on livestock product supply from better incentives through trade liberalization, though the effects varied by region, country and commodity.

Markets, institutions and competitiveness

Ruminants

Market participation by smallholders can allow them to expand crop and livestock supply. To identify barriers to wider market participation, ILRI policy research has focused on the structure, conduct and performance of product and input markets with a particular emphasis on market access.
Kebede Andargachew and Brokken (1993) analysed sheep price patterns in the central highlands of Ethiopia to determine the effects of animal and market characteristics and season on price. Weekly price variations were evident in redistribution, intermediate and terminal markets. Animal characteristics (weight, age, body condition, sex and colour), as well as purpose for buying and buying season, were important in explaining price variation. The findings indicated that producers targeted market strategies to gain from coordination of fattening, breeding and trading operations. The study did not find any subtle market inefficiencies that might be addressed by policy beyond the obvious measures of increasing market density and lowering transaction costs by providing infrastructure.

ILRI collaborated in a study led by the Ethiopian Agricultural Research Organization (EARO) in which hedonic price models were used to determine seasonal and intermarket differences in prices of sheep in Ethiopia (Ayele Solomon et al., 2003). There were significant differences in prices among seasons and markets. Seasons in which farmers faced severe cash shortages exhibited the lowest adjusted prices for animals they sold, indicating that, although livestock may provide a fallback position for cash in times of crisis, terms of trade may be worst when farmers need cash the most. In general, there was no clear progression in price of sheep along the primary to terminal market chain ending in Addis Ababa as would normally be expected, except that the farthest market had the lowest price. In the case of goats, the price differences between markets followed to some extent the expected differences between primary, secondary and terminal markets. One possible reason for the different price progression along the supply chains of sheep and goats is that, in general, the Ethiopian highlands are not a major production or consumption area for goats, so supplies come mainly from the lowlands, with the result that the price movement followed the market chain from primary markets in pastoral areas to the terminal market in Addis Ababa. On the other hand, most of the higher-quality sheep originating in both highlands and lowlands are bought by exporters and processors in the intermediate markets so both average quality and price are lower at the Addis Ababa terminal market. The implication is that producers and traders respond to market opportunities, so better transmission of demand and price information will benefit them.

A series of studies of livestock trade in Nigeria found that markets were quite responsive to incentives. Regular supply–demand imbalances, determined by regional comparative advantage, were corrected by live-animal trade from other regions of the country (Jabbar, 1993, 1995, 1998). Seasonal excess demand for small ruminants in southern Nigeria was met by supplies from the north. These findings suggested that production technologies that contribute to a regular increase in supply might be appropriate for smallholders, while seasonal commercial production might be geared to peak season markets.

A series of studies on cattle breed preferences applying hedonic analysis of cattle prices in south-west Nigeria found small but significant price differentials by breed (Jabbar et al., 1995, 1997; Jabbar and Diedhiou, 2001). In these studies, Muturu, a locally adapted West African Shorthorn breed, illustrated the relationship between farmer preferences and market values of cattle breeds. Even though Muturu is known for its superior abilities to resist diseases, particularly trypanosomiasis, and is productive under high humidity, heat stress, water restriction and poor-quality feed, the Muturu was rated the least desirable for market value and mobility. For producers, the perceived limited marketability, low market value and the need for mobility to market are important components of the returns to raising Muturu. For these reasons, farmers’ aversion to Muturu as an investment imply little scope for its in vivo conservation. Eliciting farmers’ knowledge about traits of breeds and their relationships to prices can be useful for designing breeding policy and strategy for breed development programmes (Jabbar et al., 1999).

Another study on the spatial integration of livestock markets in Niger found that livestock markets were ‘related, but not closely integrated’ (Fafchamps and Gavian, 1996). The authors suggested policy options for improving livestock market efficiency by investing in animal transport and lifting official restrictions on animal trade.

Ayele Solomon et al. (2003) surveyed livestock markets and traders in the highlands of
the Amhara, Oromiya and Tigray regions in 2000 and 2001. They showed that the numbers of agents (wholesalers, brokers and retailers) who trade many species had increased significantly since the collapse of the Derg regime 1991. This expansion in the numbers of agents, combined with small numbers of inspectors, led to many unlicensed traders, irregular inspections and a scarcity of fencing, feed and water troughs.

Jabbar et al. (2008) found that Ethiopian livestock markets were characterized by non-standardized products and lack of public information about quantities and prices. Consequently, livestock trading was largely a personalized business among brokers with regular buyers and sellers; this regularity is a form of social capital used for gathering information, searching buyers/sellers, negotiating prices and enforcing contracts. Business relationships were based principally on trust developed over time, without strong ethnic, religious or family ties. Although most transactions were conducted in the physical presence of parties, contract disputes were common and were typically settled mainly through informal means as formal legal systems were absent or expensive. It was argued that policies to reduce transactions costs and multiple taxes while increasing access to market information would improve trader margins and market performance.

Examining the factors that affect market participation and sales by households, Ehui et al. (2003) showed that physical capital (ownership of different species of livestock and landholdings) and financial capital (crop and non-farm income) are the main factors influencing market participation and sales, rather than the distance to markets and towns. These results suggested that constraints to production of livestock and livestock products (e.g. capital to purchase animals, feeds and processing equipment) were the main factors limiting market participation.

Baltenweck and Staal (2007) explored spatial measures of market access for milk and beans in the Kenyan highlands. Measures of market access were used to create spatial price decay functions in relation to transaction costs. The effects of market access differed significantly depending on the traded good. The analysis also demonstrated that spatial price formation could be used to generate more accurate measures of unit distance marketing costs than other approaches and hence indicate priorities for public investments to reduce those costs.

Bahta and Malope (2014) examined the competitiveness of smallholder beef farmers in Botswana using data from randomly selected producers. There was significant inefficiency, with about 74% of the variation in actual profit from maximum profit between farms arising from differences in farmer practices. The mean profit-efficiency level of 0.58 suggested scope to improve beef profitability with current technology. Profit drivers included education, distance to market, herd size, access to information and crop income. The main policy lesson was to improve market access so as to raise profits among smaller producers.

Pigs and poultry

With the merger of ILCA and ILRAD into ILRI in 1995, the mandate of the new institute expanded to include pigs and poultry. A series of ILRI-led studies in Asia beginning in the 1990s identified constraints to smallholder production in non-ruminant livestock.

Lapar et al. (2003a) studied a cross-section of smallholders in northern Luzon, in the Philippines. They investigated factors motivating smallholders’ decisions to sell products or consume them as functions of transaction costs, labour mobility, capital formation and indebtedness. The strong effect of animal numbers on the participation and selling decisions of farmers suggested that policy interventions may be needed to support smallholder access to input and output markets. The availability of alternative occupation opportunities, however, significantly affected the viability of social and economic prescriptions, and policy makers must be cognizant of these results when targeting objectives for smallholders. Remittances had a positive influence on market participation, suggesting the importance of financial security in enabling smallholders to manage risks and subsistence requirements.

Costales et al. (2006) studied how scale affected access to markets by hog producers in southern Luzon, a major hog-producing area in the Philippines. Regional data indicated that between the 1990s and 2000s there had been an expansion of larger hog farms and displacement
of small farms. The study applied a probit model to identify factors that determine participation in hog production and applied a profit-efficiency model to identify the role of transaction cost barriers in smallholder performance. The model results showed that the decision to participate in hog production was positively influenced by the availability of family labour and by the capacity to deal with fixed transaction costs for access to financial resources. Market participation was negatively influenced by higher opportunity costs of family labour due to access to off-farm job markets and by distance to hog markets outside the village. Comparison of contract and independent growers among hog producers showed that most contract growers tended to specialize in fattening pigs to slaughter. In contrast, independent producers tended to combine the production of weaners (piglets) with slaughter hogs or specialized in weaner piglet production. In general, contract growers had larger levels of operations than independent growers. Contract growers exhibited better access to output markets and to good-quality feeds and stock, feed credit, veterinary health services and credit for expansion purposes.

One study analysed contract farming in Bangladesh poultry (Jabbar et al., 2007), while another covered pig farming in Vietnam (Tiongco et al., 2009). The Bangladesh study found three emerging contracts – production marketing, formal input marketing and informal output marketing. The profitability of broiler farms did not differ significantly between contract and independent farms, but it differed between the two sample districts. Contract layer farms performed much better than independent layer farms. These differences were due to differences in the feed conversion ratio, fattening days and sale weight for broilers, and egg production per bird per laying period and length of laying period for layers. Based on a sample of independent poultry farms in five districts, the key reasons for business failure after 1 or more years of operation were identified as high input prices, irregular supply of day-old chicks and poor-quality veterinary drugs. Some input market problems have been solved by contract farming in other contexts, but formal contract farming seems to have offered few opportunities for commercial poultry farmers in Bangladesh.

The study on pig contract farming conducted in four provinces in northern Vietnam showed that there was limited scope for smallholder pig producers to participate in formal contracts; however, smallholders were found to participate in informal contracts with cooperatives and with input/output traders that facilitated their access to pig markets. To understand the drivers of these smallholders to participate in these types of contractual arrangements for pig and piglet production, a multinomial logit model was applied. The results suggested that the significant determinants of smallholders’ participation in contractual arrangements are age, proportion of time spent in pig-raising, location, distance to veterinary shops and access to animal health services.

A study on livestock development in Vietnam identified barriers to input and output markets for smallholders (Lapar et al., 2003b). The uncertain quality and high prices of animal feeds, including raw materials for feed processing, the variable quality and high cost of more productive animal breeds, and the high costs of veterinary inputs were found to be the principal barriers in livestock input markets. Constraints to reaching output markets included poor-quality and unsafe meat and meat products, lack of a legal framework and standards, bottlenecks in the distribution channel and limited access to information. In addition, the prevailing marketing system and channels for each type of commodity from farm to market have evolved into a multi-stage system that is characterized by high transaction costs and lack of market integration.

Another study in Vietnam addressed whether national livestock production can remain competitive under rapid demand and import growth (Akter et al., 2004). The study applied a policy analysis matrix to assess the competitiveness of poultry and pig production based on 1999 data from a sample of 2213 farms. Poultry and egg production from cross-bred and exotic breeds were competitive in the north, while egg production from local breeds was uncompetitive in the south due to low productivity and high per-unit cost. Economies of scale in poultry production existed in the north but were not so clear in the south. Domestic prices of outputs and inputs were higher than world prices due to trade protection. In the long run, small poultry farmers might not be able to compete in a more
liberalized economic environment with low-productive local breeds and higher per-unit cost; policy support such as access to credit and inputs for smallholders would be needed to maintain their competitiveness.

Pig production under existing technologies and market conditions was highly competitive, especially with local and cross-breeds in the north and exotic breeds in the south. At the time of the survey, the producers in the south were apparently benefiting due to a greater role of formal market conditions, which favoured cross-breeds and exotic breeds, while in the north, policy interventions made input costs higher and output prices lower. Some economies of scale were demonstrated in pig production, in that medium-sized farms were more cost-effective and small farms were least competitive.

Using the same data set for Vietnam, stochastic frontier production functions were used to assess the effects of market and other factors on technical efficiency, respectively, in poultry (Jabbar and Akter, 2006) and pig production (Jabbar and Akter, 2008) In the developing-country production environment, farm production efficiency is often measured in terms of on-farm resources and producer characteristics. In these studies, it was postulated that input and output market-related factors also influence farm production decisions and hence farm efficiency.

In the case of poultry, in general there are significant differences in the production behaviour and efficiency levels between the north and the south among farms producing different breeds, between mixed and specialized farms, between household and commercial farms, and among producers located in different agroecological regions. Sale at marketplace rather than at the farm gate, market distance and flock size significantly reduced inefficiency in both regions. Contract farming or sale, the number of visits by extension staff, family labour supply, land size and education levels of households had significantly reduced inefficiency in the north but had no significant effect in the south. The direction and significance of influence on efficiency differ between the two regions for credit use, inputs from government, ratio of home-produced crude feed, producer age and gender of the household head. Therefore, opportunities exist for improving average efficiency through interventions in a number of product and input market domains and household characteristics that may improve access to information, technology and management decisions.

In the case of pigs, there are significant differences in production behaviour and efficiency levels between the north and the south among farms producing different breeds, between mixed and specialized farms, between household and commercial farms, and among producers located in different agroecological regions. Access to better output markets, land size, herd size and education of the household head significantly reduced inefficiency, while access to government-supplied inputs, age of the household head, female-headed households and family-supplied crude feeds significantly increased inefficiency in both regions. The direction of influence on efficiency differs between the two regions for access to credit, proportion of output sold at market rather than at the farm gate and family labour supply. Generally, market-related factors had a more consistent influence on production efficiency in the south of Vietnam, where the experience of market economics is longer than in the north. Policy actions on providing better extension, more timely access to better-quality inputs through the private sector, making credit more easily accessible to smallholders and providing opportunity to sell output at better-priced secondary markets are expected to increase productivity and reduce inefficiency among producers located in different agroecological regions.

In some countries, local products are shielded from international competition by ‘natural’ factors influencing the purchase of products, such as strong local tastes (or preferences) that favour the local product and the absence (or relative absence) of complementary retail outlets or home appliances suitable for storing and preparing potential imported substitutes (Tisdell, 2009). The desire for fresh meat rather than chilled or frozen meat, the absence of supermarket outlets and limited refrigeration possibilities in homes can limit imports into developing countries of meat supplied by developed countries. This study gave some simple economic analysis of how local producers of livestock benefit from natural protection. Drawing on the results of research completed in Vietnam and other sources, factors that provide natural
protection to Vietnam’s pork industry were identified, with particular attention given to their implications for small-scale household pig producers compared with larger-scale commercial pig producers. It was noted that the protection of Vietnam’s pig industry was not based on a preference for pork from local breeds but arose for other reasons.

**Animal health services and productivity**

Policy aspects of animal health research at ILCA concentrated initially on institutions – who provides animal health services, how can services provision be more efficient and what is the scope for private provision? Public agencies were the main providers of animal health services throughout sub-Saharan Africa before 1980. After the introduction of structural adjustment programmes in the late 1970s and early 1980s and given the failure of veterinary services to reach many livestock farmers, the form and pricing of veterinary services became important policy issues. The debate centred on the justification for public financing of animal health services, especially those that could be considered private goods, such as curative services.

Addis Anteneh (1983, 1985) reviewed national information on the financing of livestock services in selected African countries. He found that: (i) services were underfunded with respect to the share of livestock in agricultural gross-domestic product (GDP); (ii) costs were mostly operating budgets and hence capital funding per staff was generally inadequate; (iii) services were largely funded with public resources and foreign aid, not with user charges, which discouraged user participation in service management; (iv) there was potential for more public spending because user charges – head taxes, slaughterhouse fees and taxes – were sometimes greater than public spending on livestock services, indicating that livestock revenue had been diverted to other sectors; and (v) the quality of veterinary services was low because of lack of funding, especially for non-staff variable costs.

A later study on financing livestock services (Addis Anteneh, 1991, Part 7) arrived at similar conclusions: (i) livestock services were again underfunded; (ii) staff costs dominated services to the detriment of non-staff variable costs, such as drugs and fuel; (iii) cost recovery was limited as a share of livestock service budgets; and (iv) private service delivery was weak, partly because of resistance from the public veterinary sector.

Mohammed Mussa and Gavian (1994) reviewed the privatization of animal health services in Ethiopia. They argued that vaccination and vector control are public goods because the benefits extend to the whole economy, while curative services (diagnosis and treatment) of non-transmittable diseases are primarily private goods (although some effects of repeated curative treatments, such as induced resistance to trypanocides or other antibiotics, would become public goods). The policy lesson is that preventative services work better when managed by the state, while privatization is feasible for curative treatments.

The question of payment for public services was studied by Swallow and Woudyalew (1994) who investigated whether communities in south-west Ethiopia would pay in cash and/or labour for trypanosomiasis control. When asked about the maximum amounts of money and/or labour that they would be willing to pay, 59% of households volunteered both money and labour and only 3% volunteered neither. Willingness to contribute money was related to the gender of the household head, the number of cattle held by the household and the participation of the household in a monitoring exercise being conducted by the research organization. Willingness to contribute labour was related negatively to off-farm employment status of the head of the household, and positively to the information available to the respondent about the programme. Apart from direct applicability of these results to increase local involvement of the affected population in the control programme, the study stressed that the methodology used here, when integrated into a participatory research approach, can generate practical results for evaluating the prospects for local participation in the provision of public goods.

Hall et al. (2004) evaluated the welfare effects of herd health programmes on smallholder dairies in central Thailand. Dairy farmers had appropriate incentives to adopt herd health measures; following adoption of control measures, there was an improvement in the efficiency
of policy support to dairying. Following a reduction in disease incidence on adopters’ farms, the study found an increase in farm profits.

Outbreaks of Rift Valley fever (RVF) in East Africa in the past prompted a ban by Middle Eastern countries on imports of live animals from that region. Nin-Pratt et al. (2003a) evaluated the certification of exported live animals granted in an RVF-free zone, as a case for Ethiopia, as one way of handling RVF and complying with international regulations. The study also examined policies (export tax, sales tax and increased transaction costs) to make producers bear programme costs. The study concluded that implementing an animal health programme in Ethiopia’s Somali region was economically feasible and would benefit poor livestock producers. It suggested that increasing taxes on livestock sales offered the best way to fund the health certification plan. This option, in which a transfer from middle and better-off producers to poor livestock producers is implicit, reduces harms to exports and welfare and increases benefits to the poor.

While Ethiopia has been a major supplier of animals to Middle Eastern markets, its market share has varied (Asfaw Negassa and Jabbar, 2008). The reasons included an inadequate supply of good-quality live animals to the export abattoirs in Ethiopia, with some abattoirs operating at less than half their capacity, which raised the average fixed costs per animal and reduced competitiveness in export and domestic markets. Livestock census data revealed very low commercial offtake rates of cattle and goats from Ethiopia’s smallholder farmers and pastoralists. This limited market participation by Ethiopia’s smallholders and herdiers implied that, under the prevailing production and marketing conditions, small-scale farms and pastoral systems were not supplying sufficient numbers of good-quality live animals at competitive prices to make efficient use of the country’s meat-processing capacity in its export abattoirs, lowering the competitiveness of Ethiopia’s domestic and export livestock markets.

In addition, SPS barriers and animal diseases have traditionally constrained market access. A system dynamics model was applied to examine a proposed SPS certification system. The model’s results indicated that the system may not be viable for beef exports to Middle Eastern markets, but the binding constraint was domestic input costs rather than the costs of compliance. Sensitivity analyses revealed that, while investments in feed efficiency and animal productivity would enhance Ethiopia’s export competitiveness, the highly competitive nature of international beef markets may still prevent market access by Ethiopia’s beef producers (Rich et al., 2008; Rich and Perry, 2009).

Somalia was a traditional supplier of live sheep, goats and camels to Middle Eastern markets. Following the collapse of the Somali state in 1991, a rapid appraisal identified the institutions active in livestock exports (Mugunieri et al., 2008) to understand informal policies. A more detailed study was then conducted with exporters to understand how the Somali origin satisfied import requirements for product quality and cost (Asfaw Negassa et al., 2008). Constraints along the export chains were mapped, and appropriate steps for addressing the constraints were recommended. The recommendations included: a certification system for health and quality; provision of market information, training in market opportunities for traders; formation of trade associations and other collective action forums to share information, capital, and strengthen ability to negotiate; and harmonization of informal and formal taxes and fees in marketing chains.

Sudan (including South Sudan, which became independent in 2011) was an historical exporter of live sheep and sheep meat to the Middle East, but its market share has fallen over time because Sudanese supply failed to meet Middle Eastern standards. A study analysing supply-chain constraints for Sudanese exports of sheep and mutton found that they faced long costly journeys by trekking or trucking, which reduced the animals’ health and quality (El Dirani et al., 2009). A high incidence of disease and mortality and low offtake rates among traditional producers limited the supply of high-quality animals. There were elaborate systems of inspection, testing and screening for diseases and other SPS standards in the supply chains, but, because of poor enforcement, too many unacceptable animals remained in the export lots, which led to rejections at destination. Although major markets in Sudan’s hinterlands were integrated with the terminal market in Khartoum, as indicated by price cointegration, responses to price shocks
were variable among markets, with some markets more responsive than others and with supply markets responding more quickly and intensely to shocks than terminal markets. Policy recommendations to increase supply of export quality animals were to: invest in health, extension and higher-quality inputs leading to increased offtake rate especially from larger flocks; to reduce rejection rate throughout the long supply chain, increase investment in proper laboratory facilities including equipment and trained manpower; rigorously enforce screening procedures and standards, and enhance coordination among various agencies involved in supporting export oriented production and trading.

**Responding to the ‘Livestock Revolution’**

A third policy problem has been how trade and globalization affected incentives for livestock production in poor countries and what policy could do to mitigate adverse effects or to exploit favourable effects. This problem became more acute at the turn of the century as growing populations, urbanization and rising incomes in developing countries fuelled a rapid increase in demand for animal-source foods, a phenomenon that became known as the ‘Livestock Revolution’.

A 1999 collaborative study involving IFPRI, FAO and ILRI, ‘Livestock to 2020: the next food revolution’ (Delgado et al., 1999) – became known as the Livestock Revolution study, used a global model to analyse changing supply and demand as they affected poverty, nutrition and health, and the environment. From 1971 to 1995, meat consumption in developing countries grew almost three times as fast as in developed countries. It was projected that by 2020, developing countries would be consuming 100 million t more meat and 223 million t more milk than they had in 1993, dwarfing the projected increases in meat and milk consumption in developed countries. Again from 1993 to 2020, per-capita consumption of meat and milk in developing countries was projected to increase, respectively, by 42% and 55%, in contrast to developed countries, where meat consumption was projected to increase by 9% and milk consumption to decrease by 2%. Much of the increased consumption in developing countries would come from imports and would therefore pose both a threat and an opportunity to domestic producers.

The ‘Livestock Revolution’ study warned that smallholders might not benefit from rapid growth in international trade. It recommended new measures to defend smallholder interests:

- **Removing policy distortions** that promote artificial economies of scale, such as credit and tax breaks and other subsidies and trade protection or support to large-scale producers.
- **Building institutions** to link smallholders to markets, for example by facilitating vertical integration of smallholders, cooperatives and other forms of collective action.
- **Creating public goods** through the provision of services for animal health and livestock extension, research and education.
- **Regulating the environmental and public health costs** of livestock production and consumption, such as water pollution and land degradation on the one hand and, on the other, the obesity epidemic and the emergence of new human diseases originating in livestock.

Nin-Pratt et al. (2001) analysed the role of China as an importer of livestock and other farm products. They analysed productivity growth in China’s pig and poultry sectors and projected China’s meat trade to 2010 in a general equilibrium model of the Chinese economy. China’s net trade position was projected to be sensitive to posited growth of its GDP and its non-ruminant productivity, implying uncertainty in the policy contexts of other developing countries.

A similar study (Nin-Pratt et al., 2003b) examined the implications of trade liberalization on Vietnam’s smallholders, including the consequences for poverty alleviation. While the impact of trade liberalization on Vietnam’s livestock production tended to be small, a more open Vietnamese economy would increase competitive pressure on domestic producers.

New non-tariff barriers have emerged in the form of more stringent SPS standards. The implications of such barriers were studied for exports of live animals from the Somali region of Ethiopia to the Middle East, where the exporters faced major high costs of compliance with the standards required by the importers (Nin-Pratt et al., 2003b).
et al., 2003a). Moreover, a ban on livestock exports from the Horn of Africa imposed by Saudi Arabia in 1998 and 2000 following an outbreak of RVF severely affected trade. The cost to the Somali economy of the ban was estimated to be at least US$21.8 million, with the total reaching up to US$36 million under some scenarios. The estimated loss in regional value added was US$195 million, almost equal to the value added produced in an average year. In the short run, middle- and higher-income households could manage the negative effects of the Saudi import ban by increasing consumption. Poor pastoralists with limited production capacity, however, would lose income because increased consumption of their own production was insufficient to compensate for export losses.

An important concern from the Livestock Revolution was that large producers would displace smallholders as markets opened because they could exploit economies of scale in production and in finance. A study in Bangladesh analysed the effects of policy and scale on the efficiency of dairy and poultry farms (Jabbar et al., 2005). For dairy, they showed that breed, management, feed cost, choice of markets and access to credit for liquidity and to extension contact at times of real need to solve a production constraint were significant variables affecting the profitability and efficiency of dairy farms. Policy interventions – infrastructure, waste management, access to finance and creation of producers’ organizations – favouring small farms would increase the overall efficiency of the dairy sector.

Baker and Enahoro (2014), in an overview of six studies, argued that information from a large number of household studies on livestock was not fully utilized by aggregate models, which failed to recognize heterogeneity, dynamics and exogenous forces on livestock systems. Household-level studies are not standardized and rarely identify and characterize key drivers and mechanisms for exploiting heterogeneity in policy analysis. The analysis defined and addressed the dichotomy in approaches to policy analysis for developing countries’ livestock sectors and the gap in analytical approaches and identifies aspects of the way forward. Evidence was presented of inconsistencies and practicalities that emphasized the gap, but all studies presented evidence of integrative progress and listed opportunities for accelerating it.

Policy and technical barriers to smallholder dairy development

Dairying was an important theme in the early ILCA policy work because of its potential for expansion in sub-Saharan Africa, its potential benefits to smallholders as a source of economic growth and the growing political problem of rising imports. Early stage studies were conducted in Nigeria, Ethiopia and Kenya.

Research in Nigeria has examined demand, price determinants, policy reforms, and market development. Jabbar and di Domenico (1990, 1993) and Jansen (1992) described dairy consumption and its determinants in northern and southern Nigeria. In both regions of Nigeria, the type of product consumed, and the frequency of consumption differed markedly among ethnic groups and between urban and rural populations. In the south, per-capita income of dairy-consuming households did not differ significantly. Among the consumers, the income elasticity of dairy consumption was higher for rural households in the south-east. In northern Nigeria, dairy product demand was found to be income inelastic, and larger households tended to consume relatively fewer dairy products per household member than smaller households. The strongest conclusion from these studies was that pricing structures and local consumer preferences for traditional products argued for development of traditional production systems using indigenous cattle breeds. Production increase would require provision of breeding and health services and better feeds. Support for better processing, storage and transportation of traditional products would be required to access higher-income urban consumers.

Dairy reform in Ethiopia

The question of dairying potential was particularly important in Ethiopia, where bad policies had limited growth in dairying. A sequence of studies – Mbogoh (1984), von Massow (1989) and Brokken and Senait Seyoum (1992), and later Mbogoh (1992) and Mbogoh and Ochuonyo (1992) – identified policy and technical barriers to dairying in Ethiopia. A later review of dairy development in Ethiopia over 50 years: (i) identified trends in production, consumption, policy and development interventions; (ii) provided
Evidence of the potential impact of improved dairy cattle; (iii) examined factors that promote smallholder dairying; and (iv) identified policy and technology issues for public interventions (Ahmed et al., 2003).

Ethiopian dairying has passed through three phases, matching shifts in national economic policies. Since the early 1990s, the transition to a market economy has taken place and the dairy sector has been growing. Milk production during the 1990s expanded at an annual rate of 3.0% compared with 1.6–1.7% during the preceding three decades. Some 60% of the growth in milk production was due to herd growth; only 25% was due to higher productivity per animal.

There were institutional reasons for lower productivity in Ethiopia. Although dairy cooperatives in Ethiopia were not as strong as in Kenya, cooperatives induced increased participation of smallholders in fluid milk markets in the Ethiopian highlands. The survival of the milk groups that supplied inputs and processed and marketed dairy products depended on their continued ability to capture value-added dairy processing and to return those value-added benefits to their members.

Contrasts between Kenyan and Ethiopian dairying were investigated to elucidate the roles of cooperatives in reducing transaction costs. The similarities of the highland agroclimates in Kenya and in Ethiopia imply that dairy development in Ethiopia would benefit from the Kenyan experience, yet Ethiopia’s dairy system was for many years less productive than Kenya’s. Part of the difference was attributed to informality – in the early 1990s, Ethiopia had not developed a formal dairy system and some 88% of urban milk supply passed through informal markets (Staal, 1995). Another reason was policy taxation – Kenya and Ethiopia both had an international comparative advantage, but Ethiopian supply was restrained by an overvalued currency causing low domestic producer prices. The devaluation of the Ethiopian birr (ETB) in the early 1990s greatly improved the potential of agricultural production for import competition and for export markets.

Staal et al. (1997) argued that: (i) the growth in smallholder dairying was limited by high transaction costs for both production and marketing; (ii) transaction costs across producers in what appeared to be a single market (e.g. fluid milk in Addis Ababa) explained why producers accepted widely different prices for a homogeneous product in the same markets; and (iii) contracts between producer and buyer cooperatives played a central role in reducing transaction costs.

Subsequent work explained the impact of transaction costs and the choice of production techniques on decisions to sell fluid milk to Ethiopian cooperatives (Holloway et al., 2000a,b). Creating local markets to minimize the time required to sell milk increases the number of producers and amounts sold. Institutional investments, such as the formation of milk groups, provided a less costly mechanism for increasing market participation. Although milk groups are a simple institutional innovation, they appear to be a necessary first step in developing more sophisticated cooperatives.

Farmer cooperatives have been identified as catalysts to market participation. Analysis of data from the Ethiopian highlands where farmers organized themselves in a dairy cooperative showed that male household heads and extension visitations affected cross-bred cow adoption positively, while credit use and the number of local-breed cows currently milked affected adoption negatively (Holloway et al., 2000b). Male heads of household, extension visits and the number of local-breed cows affected output positively, while credit use affected output negatively, as did distance to market. This study also suggested that extension is a potentially important catalyst for market expansion. Consequently, several important questions arise concerning the actual impacts of extension on participation, the number of extension-requesting households willing to pay for services if it was privatized, the corresponding demand schedule for extension services and the requisite conditions for the existence of a private market for the service.

One study addressed these transactional issues (Holloway and Ehui, 2001). For each unit increase in extension, the transaction cost was lowered by ETB0.62. Hence, extension was shown as a promising market-entry catalyst. Furthermore, the willingness to pay for one additional extension visit ranged from ETB0.6 to ETB6.7. The study estimated the marginal cost of each extension visit at ETB2.1, based on the annual extension budget of the local administrative
units and the estimated number of extension visits made during the year. The willingness to pay estimates showed that some 39% of participating households would purchase extension services.

Reinforcing the findings of Holloway et al. (2000a), other studies found that households with a higher education level, a larger number of cows and a greater non-farm income were positively associated with value of sales of dairy products. This suggests that income from the sale of milk, butter and cheese can be increased through education and training, especially targeting women (Holloway et al., 2000b; Ehui et al., 2003; Lapar and Ehui 2004).

Dairy reform in Kenya

The most productive policy research at ILRI was the long-term engagement in Kenyan dairying. Kenya was an attractive site for policy research in that its dairy sector was highly productive, it had high unrealized potential and major policy barriers to achieving that potential, and it had a base of technical and economic research to inform policy recommendations.

In a study of adoption of improved dairy cattle and related technologies, a methodological innovation was generated by applying GIS-derived variables in econometric analysis. This study by Staal et al. (2002) demonstrated the usefulness of integrating GIS-measures into analysis of technology uptake for better differentiating and understanding locational effects. A set of GIS-derived measures of market access and agroclimate were included in a standard household model of technology uptake, applied to smallholder dairy farms in Kenya, using a sample of 3330 geo-referenced farm households. The three technologies examined were keeping dairy cattle, planting specialized fodder and using concentrated dairy feed. Logit estimations were conducted that significantly differentiated the effects of individual household characteristics from those related to location. The predicted values of the locational variables were then used to make spatial predictions of technology potential. Comparisons were made with estimations based only on survey data, which demonstrated that, while overall explanatory power may not improve with GIS-derived variables, the latter yielded more practical interpretations, which was further demonstrated by predictions of technology uptake changing with a shift in infrastructure policy. Although requiring large geo-referenced data sets and high-resolution GIS layers, the methodology demonstrated the potential to better unravel the multiple effects of location on farmers’ decisions on technology and land use.

The above study was done within the framework of ILRI’s Smallholder Dairy Project, a joint initiative with the Kenya Agricultural Research Institute (KARI) and the Kenya Ministry of Livestock Development, which began in 1997 to address farming practices, marketing and extension. The policy aim of the Smallholder Dairy Project was to achieve a better policy environment for raw-milk trading to raise producer prices and to improve supply from smallholders. A policy-change strategy was developed, which included generating evidence about raw-milk markets and working with civil-society organizations who were voices in policy advocacy and had connections to public agencies.

Until 1992, the Kenyan Dairy Board (KDB) officially controlled dairy pricing and marketing. During the early 1990s, as input prices paid by producers increased at a higher rate than the KDB-controlled prices of milk, producers began to divert sales to the informal market. Consequently, supply to Kenya Co-operative Creameries (KCC) fell substantially, causing shortages of processed milk in the formal market. To stimulate supply, the Kenyan government announced the liberalization of dairy prices and the lifting of the KCC monopoly on processed milk sales to urban areas. The market response was an increase in raw-milk supply to the KCC and, consequently, in supply of processed milk to retailers. The benefits of policy reform were limited, however, because few dairy traders entered the market owing to the dominance of KCC, which obstructed price liberalization. The raw-milk sales policy, however, did not change.

The path from policy research to policy change in Kenya dairying has been well chronicled (Leksmono et al., 2006; Kaitibie et al., 2010b). A first step was to investigate dairy market liberalization with a policy analysis matrix (Staal and Shapiro, 1994). Following output price liberalization, Kenya continued reducing government support and intervention within the livestock sector, specifically for veterinary
and artificial insemination services. Policy analysis by ILRI measured the changes between 1990 and 1995 in milk marketing and service provision by the dairy farmer cooperative societies, which played a central role in meeting the needs of dairy production (Owango et al., 1998). Most notable were the changes in the unregulated raw-milk market, which helped increase real market prices paid to producers by up to 50%. Large increases were also observed in the provision of veterinary and artificial insemination services by the dairy cooperatives, whose producer base and credit facilities allowed them to compete with independent private traders.

A contentious policy issue following market liberalization was regulation of the informal milk market, a complex network of farmers and groups selling raw milk directly or through vendors to consumers or shops. The price liberalization of 1992 allowed other private milk processors to enter the market, causing the near collapse of KCC. The liberalization was also interpreted as allowing the sale of raw milk in urban areas, which was technically illegal, and the raw-milk market quickly expanded through small vendors (Staal and Shapiro, 1994). By 2000, this market was estimated to control 80–90% of the total liquid milk market, even though it was fiercely opposed by the KDB, and officials retained the authority to confiscate illegal vendors' milk and equipment. Research by the Smallholder Dairy Project found that this authority imposed constraints on the markets for milk from smallholders as the price for milk paid by the vendor decreased with the quality of milk bought, even though a larger volume of sales would be expected to impose lower unit transaction costs. This result was thought to be due to the fact that vendors were restricted to handling relatively small quantities (e.g. 30 litres/day) due to risks of confiscation (Staal et al., 2002).

Larger producers opposed the reform. The Kenya Dairy Processors Association launched a high-profile ‘Safe Milk’ campaign against raw-milk marketing. The Smallholder Dairy Project found that this authority imposed constraints on the markets for milk from smallholders as the price for milk paid by the vendor decreased with the quality of milk bought, even though a larger volume of sales would be expected to impose lower unit transaction costs. This result was thought to be due to the fact that vendors were restricted to handling relatively small quantities (e.g. 30 litres/day) due to risks of confiscation (Staal et al., 2002).

Private processors changed their marketing strategy to focus on the value and safety of processed, packaged milk without overtly attacking small-scale milk vendors. Some processors also encouraged small-scale milk vendors to trade in processed products.

Virtually all subsequent projects in Kenya’s dairy subsector have used the research results of the Smallholder Dairy Project, and many have also linked with the project’s implementing institutions in other dairy-related activities, both in service-delivery and policy-related areas (Leksmono et al., 2006).
• One point of opposition to reform was health risks from drinking raw milk. Product quality analysis showed that if milk is boiled, a near-universal practice in Kenya, it is almost entirely safe. To further improve hygiene in the informal milk sector, the Smallholder Dairy Project developed a training programme for informal vendors to teach them improved practices for handling milk.

Eventually, the work of the Smallholder Dairy Project achieved an agreement to train and certify small traders of raw milks, with the KDB taking up the training and licensing of traders using guidelines and training materials developed by the Smallholder Dairy Project. There were further revisions of the draft Dairy Industry Act, stalled since 1997, to recognize and formalize the role of small-scale raw-milk traders and to increase the number of groups representing poor farmers.

The change in Kenyan dairy policy to allow greater market participation by small producers had the principal effect of lowering transaction costs, thereby raising prices to producers and lowering prices to consumers. An economic surplus model was used to compute economic benefits of these price shifts, with movements in the milk-supply curve being attributed to the policy changes affecting the informal market. Kaitibie et al. (2010b) reported a best estimate of the net benefits of the reform to have an NPV of US$230 million over 1997–2039.

A study following the Kenya dairy reform clarified the reasons for its political support. Informal milk markets created more employment per unit of product than did formal markets. A study by Omore (2004) of employment in milk markets in Kenya, Bangladesh and Ghana found that informal milk markets employed up to five times as many people per 100 litres of milk handled.

The Smallholder Dairy Project in Kenya not only benefited the dairy sector and the wider economy in Kenya, its experiences created positive externalities (international public goods) in the East Africa region and beyond. The partnership and communication strategy in this reform led to the Smallholder Dairy Project receiving the 2004 CGIAR Communications Award. The project’s extension materials and market agent training materials and methods were taken up by other projects led by the national agricultural research system, ministry and non-governmental organizations in Kenya and elsewhere in East Africa. The project created greater regional awareness among policy makers in Ethiopia, Tanzania and Uganda of pro-poor policy implications of small-scale milk markets. The Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) and its policy programme, the Eastern and Central Africa Programme for Agricultural Policy Analysis (ECAPAPA), built on the Smallholder Dairy Project and ILRI policy recommendations to seek harmonized pro-poor dairy policies in the region. Through ECAPAPA, dairy policy makers and regulators in Rwanda, Tanzania and Uganda adopted new institutional approaches and appropriate technologies to harmonize standards and improve informal milk markets across the region.

ILRI’s results were used to: (i) promulgate common dairy industry standards in East Africa; (ii) advance a regional agreement to promote the movement of certified milk traders across borders; (iii) publish training materials for milk standards, and provide certification of milk traders and accreditation of their trainers; and (iv) train and provide certification of informal milk traders by involving private trainers.

In 2016, ILRI began working with the state government of Assam, India, where the informal market supplied the great majority of local milk. Working closely with Assam’s Dairy Development Department, the training and certification approach of the Smallholder Dairy Project was adapted for Assam and was piloted locally, again with a local non-governmental organization as the main training service provider. Studies showed that trained vendors sold safer milk and demonstrated better knowledge of hygiene. This is thought to be the first time in India that public funds have been devoted to improving the informal (or unorganized) milk market (Lindahl et al., 2017).

**Comparisons of dairying in South Asia and East Africa**

ILRI and FAO’s Pro-Poor Livestock Policy Initiative studied dairy development in East Africa and
South Asia to assess the roles of policies and institutions and their impact on the poor (Staal et al., 2008a,b,c). The dairy sector in South Asia followed a different path to that of East Africa. Consumption of dairy products is higher on average in South Asia than in East Africa owing to demand factors. Differences in growth in South Asia are more related to the possibility of expanding supply to match the growing demand for dairy products. Multivariate econometric models incorporating technology and policy factors showed that India and Pakistan were able to link the agricultural transformation originating in the Green Revolution to successfully expand milk production; this is reflected in the contribution of input markets and technology to growth in milk production. In the case of countries with slow growth in milk production, such as Bangladesh and Nepal, development of cereal production and feed markets and a growing demand did not induce a technical change in dairying, as was the case in India and Pakistan. As in East Africa, development of formal milk markets in South Asia is not associated with increased growth rates.

Detailed analysis of the drivers and impacts of dairy sector growth on employment, income and nutrition was done for Ethiopia and Kenya in East Africa and for India and Pakistan in South Asia. Although informal and commercial dairying coexist in both regions, informal production still dominates and is generally competitive. For example, the study conducted an analysis by district across India, which sought to find evidence that the presence and success of cooperatives was associated with greater dairy development. However, there was little evidence towards this, which suggests that India’s well-known Operation Flood, which used revenues from donated imported milk powder to fund dairy cooperative development, did not play any significant role in driving dairy development in India, where to this day the dairy cooperative sector retains a relatively small market share. The evidence suggests that relatively efficient informal milk markets played the key role in linking producers to growing consumer demand. In fact, the dairy industry grew more quickly in Pakistan, where cooperatives played almost no role, than in India. Policies that build on traditional production systems, with new focus on employment, food safety and quality, are expected to be pro-poor.

The study found that demand factors explain much of dairy development in East Africa, as shown by the rapid growth of milk production in Kenya, Sudan and Uganda. Development of formal milk markets, input markets, technology and policy do not explain the differences between fast-growing countries and the rest, which may imply that much of the increased production in response to demand came from herd growth rather than from productivity growth.

This finding of lack of significance of input market and technology on output growth was supported by an earlier study by Freeman et al. (1998) that analysed the impact of credit on milk output by smallholder dairy producers in Ethiopia and Kenya. It found no consistent relationship between farmers’ credit constraints and their borrowing. However, farms that were credit constrained increased output more when given access to credit than farms that were not credit constrained, indicating that the credit constraint did limit the supply response. This finding indicated that demand for credit become important to acquire inputs to increase output for market.

These results suggest that adjusting supply to type and quality of products demanded, expanding demand by reducing consumer prices and reducing transaction costs will contribute to expand the dairy sector in East Africa.

**Land rights**

Land rights are legally or socially enforceable claims. They can be permanent via ownership or temporary via rental or other fixed-term contracts. The analysis of land rights in animal production is important for two reasons. First, land is the primary factor in both grazing and mixed systems. Second, nearly all modern efforts to expand agricultural production necessarily involve more intensive land use, lowering the amount of land used per unit of output, whether that output is forage, an arable crop such as rice or a permanent crop such as coffee.

ILRI research on land rights has had four themes: (i) early work on pastoral systems, focusing on group ranches and enclosures; (ii) studies on land tenure, resource allocation and productivity beginning in the early 1990s; (iii) collective action for common resource management; and (iv) land rights and fodder trees.
Pastoral systems

Land tenure differs markedly between pastoral and mixed systems. Pastoral/agro-pastoral systems typically use land held in common. Mixed systems depend on private or social land tenure that recognizes certain rights that can be appropriated by individuals or communities.

A common historical view of land rights in African pastoralism was that such rights did not exist or were not enforced. It was argued that this market failure made land use inefficient by weakening incentives to improve it. A common political and development perspective on pastoral land tenure was that it could be ignored as a subject of scientific evaluation; for example, the first major ILCA book was entitled *Evaluation and Mapping of Tropical African Rangelands* but said nothing of land tenure or of changes in traditional forms of land management (ILCA, 1975) as possible remedies on overgrazing. Pratt and Gwynne (1977) mentioned pastoral tenure in East Africa as a barrier to be dismantled on the path to stopping overgrazing, to sedentarizing pastoralists and ultimately to a generalized extension of ranching. The historical work of Gallais, who had meticulously characterized the land administration of the Peulh herders of central Mali in the 1950s (Gallais, 1967) and later proposed a modern legal codification of that system (Gallais and Boudet, 1980), had little effect.

Land rights of common property rangelands was, on the other hand, of immediate interest to ILCA researchers. Sandford’s magisterial book, *Management of Pastoral Development in the Third World*, which is still the most often cited work in the history of ILCA/ILRAD/ILRI, presented a scheme for allocating land ‘among uses and among users’ (Sandford, 1983, pp. 135–136).

Early research published by ILCA on Somalia and Sudan found spontaneous range enclosures – the assertion of private property rights in grazing and the defence of those rights by fencing (Behnke, 1986). Such spontaneous enclosures were influenced by density-dependent factors – commercial animal husbandry, commercial fodder markets and ‘heavy stocking of pastures’ – and by density-independent factors – drought, water development and official land-tenure policies. Behnke found that spontaneous enclosures responded to increasing profits from farming, falling range productivity outside the enclosures and falling costs of enclosures.

The Maasailand study (Solomon Bekure *et al.*, 1991) conducted in Kenya was exceptional in that it made detailed policy recommendations about the land rights of pastoralists.

The Borana study (summarized by Coppock, 1994) in southern Ethiopia found that the Borana system was moving from traditional pastoralism to a semi-sedentary system with more reliance on crops and private grazing. This study highlighted the need for a strengthening of traditional authority in resource management. It further concluded that the agroecological diversity of the Borana rangelands called for selective policies that supported crop–livestock integration and extensive livestock production as necessary rather than a ‘one policy fits all’ approach to the entire area.

In the early 1990s, ILRI sponsored two literature reviews on land tenure and property rights. The reviews of 18 studies on land tenure in Africa (Swallow, 1994; Swallow and Bromley, 1995) asked the following questions:

- How do property institutions affect the use and management of resources?
- How do property institutions create or deny opportunities for the adoption of new technologies and expansion of agricultural production?
- How does the structure of government affect property institutions?
- How do changes in economic and technical conditions affect resource use and property institutions?

The review by Swallow and Bromley (1994) indicated that groups of livestock owners could manage common property rangelands without formal organizations or institutions if the group was relatively small, if entry into the group was costly and if the members of the group did not discount the future heavily. Thus, a local rangeland management regime could only be effective if its institutions were governed locally. It was argued that it was more effective for governments to enforce boundaries among groups than to seek to establish the internal group conditions for efficient resource management (McCarthy *et al.*, 1999).

A collaborative project titled ‘Property rights, risk, and livestock development’ implemented by ILRI, IFPRI and the Göttingen Research Institute
for Rural Development during 1996–1999 sought to support reforms of property institutions and land policies in the semi-arid areas of sub-Saharan Africa. The specific objectives were: (i) a better understanding of how environmental risk affects the use and management of resources under alternative property rights regimes; (ii) identifying circumstances under which land use and property rights change; and (iii) identifying how policy and other external interventions can assist communities to achieve desirable pathways and mitigate negative impacts of undesirable pathways (ILRI, 2000).

Part of the ILRI/IPFRI/Göttingen study focused on the Borana rangelands in semi-arid southern Ethiopia (Kamara, 2001), where ILCA’s historic 1994 study of the pastoral system in the Borana area was characterized by extensive livestock production and was a valuable source of young stock for power and for export (Coppock, 1994; see Chapter 15, this volume). Development in Borana was limited by aridity, causing low plant biomass productivity, and by periodic droughts, causing herd deaths.

The Kamara (2001) study focused on the effects of environmental risk, market variables and population pressure on land use and property rights. The results largely conformed to the principal hypotheses about institutional change. Community cooperation in resource management was determined by demography, wealth, off-farm income and social capital. Rainfall variability affected stock densities only in areas of high rainfall variability. Market variables did not determine stock densities or community level cooperation but did affect land allocation to crops. Changes in property rights were explained by a ban on wildfires, the creation of peasant associations, sedentarization programmes and development interventions (Kamara, 2001). A related study in the same area had examined the evolution of land rights (Kamara, 2000). Kamara found substantial privatization of land, related to the change in national policies after the fall of the Derg in 1991 and, chiefly, as function of rapid growth in population density and cultivation.

Land tenure, resource allocation and productivity

An armed revolution overthrew the Ethiopian monarchy in 1974 and a military regime (the Derg) took power. Under the monarchy, most of the land had been held by the aristocracy and the church. The Derg nationalized all land and redistributed it to farmers on a per-capita basis using local norms, giving them usufruct with no right to sell, rent or transfer. There was provision for periodic redistribution when new families were formed or when some families abandoned farming. The period of the Derg was one of suspended animation as far as ILCA research on land issues was concerned.

Property institutions changed slowly after the overthrow of the Derg in 1991. The new government began to tolerate decollectivization, labour mobility and informal renting within extended families. Changes in land use and the resurfacing of rural factor markets following decollectivization provided evidence that emerging factor markets brought better land use. There were observed changes in adoption of soil conservation, tree planting, crop rotation and fallow practices, and increased use of organic and inorganic fertilizers associated with the new land policy. Selling, hiring, renting, and trade of land, labour and draught animals also grew (Omiti et al., 1999, 2000).

The study of land rights in Ethiopia after the collapse of the Derg was an important part of ILRI’s policy research in the 1990s. One study identified factors influencing the evolution of land-tenure institutions to determine the effect of land tenure on investment, productivity and efficiency in crop–livestock systems and to assess the impact of tenure on household access to feed. For instance, the issue of land access by private commercial investors and land tenure and farming practices in the highlands of Ethiopia was presented in one paper (Gavian and Amare Teklu, 1996) and a second paper presented evidence on the nature of access to land by farmers in one region of the Ethiopian highlands (Gavian and Ehui, 1999).

Two studies dealt with the efficiency of land tenure contracts (Gavian and Ehui, 1999; Ahmed et al., 2002). The first indicated that, although the informally contracted lands were farmed 10–16% less efficiently, the hypothesis that land tenure is a constraint to agricultural productivity was rejected. The second found higher technical efficiency between owner-cultivated or rented plots and sharecropped, or borrowed plots. This difference was attributed to
restrictions imposed on the tenant in the share-cropping and borrowing contracts, which sometimes involved labour and animal power supply by the tenant. A mild policy recommendation was to ‘facilitate more efficient transactions’

Benin and Pender (2001) found that crop yields in the Amhara region were significantly higher, particularly in villages where the last major land redistribution took place in 1997–1998. The authors also found that plots on which households felt more secure (i.e. expecting to operate the plot for the next 5 years) were associated with higher crop yield, suggesting that security of tenure may be associated with other yield-enhancing management practices. Together, these results suggest that improving tenure security can bring about substantial increments in crop productivity.

Examining the evolution since 1991 in land rental markets of the highlands of northern Ethiopia, Benin et al. (2005) showed that changes in the production environment and natural resource endowments, changes in human capital, access to credit, commercialization of cereal production and tenure security are the major forces contributing to the changes in land rental arrangements. Reduction in production risk, through increased availability of moisture or reduced degradation of soil, has reduced the need for risk-pooling arrangements associated with sharecropping in favour of fixed-rent leases. Furthermore, increasing commercialization of cereals caused an increase in land rentals, while an increase in credit supply caused an increase in fixed-rent leases. The same work showed that alternative land rentals had a positive impact on cereal yields, suggesting that tenure innovations after the eviction of the Derg had evolved to reduce production inefficiencies. The most widely cited paper on land tenure and investment in Ethiopia (Deininger and Jin, 2006) found that tenure security could enhance agricultural productivity and that public policy to improve tenure security would therefore be justified.

Related evidence from semi-arid Niger gave evidence on ‘traditional land tenure [as] an impediment to allocative efficiency’ on millet farms (Gavian and Fafchamps, 1996). Gavian and Fafchamps found that land security was important for input allocation decisions, such as the use of labour and manure, but that the degree of tenure insecurity in western Niger would not justify a major change in the tenure system.

---

**Collective action for common resource management**

A subset of the land tenure–productivity problem is that of collective action in common resource management. A long-term area of study by ILCA and later by ILRI was traditional agriculture in highland central Ethiopia which was long constrained by lack of modern inputs, a variable environment and a severe risk of soil erosion. Collective watershed management had been proposed as a model to manage modern inputs while controlling soil erosion. The policy question was whether collective watershed management, as a form of tenure, could achieve these policy objectives.

A public-goods problem of watershed development in Ginchi, Oromia, was presented in a game-theoretical model to study the logic of voluntary contributions to an indivisible public good: namely, a central drainage channel to solve a waterlogging problem that constrained early planting of a high yielding wheat variety (Gaspart et al., 1998). The most striking result of this study was that there is indeed a clear positive relationship between the magnitude of personal stakes and the effort spent on building the drainage channel. In other words, in the equilibrium selection process, a social norm of the kind ‘from each according to his expected gains’ seems to have been at work to favour coordination of individual efforts. Out of 33 members of the community who contributed to drain construction, five had additional leadership roles. Even though, taken singly, the leadership factor was the most statistically significant independent variable, taken together it was self-interested considerations that played the major role.

A bioeconomic model was developed to evaluate watershed management in central Ethiopia. The baseline in the model showed that, without technological or policy intervention, income and nutrition could not be sustainably improved in the watershed without serious soil losses (Okumu et al., 2004). Although cash incomes could rise by more than 40% over a 12-year period, average soil losses could be as high as 31 t/ha. With the adoption of a package of new land-management technologies, however,
the model projected, on average a 10% increase in cash incomes and a 28% decline in aggregate erosion. The policy implications were: (i) the need for more secure tenure to promote new technology; (ii) a shift from subsistence livestock management to commercial; and (iii) a site-specific approach to land management within the watershed (Okumu et al., 2004).

A study in Tigray region, in northern Ethiopia, investigated the determinants of collective action and its effectiveness in managing community woodlots (Berhanu Gebremedhin et al., 2003, 2004). The studies suggest that collective actions may be more beneficial and more effective when managed at the village level rather than at a county (wereda) level. Collective actions were more productive when external interventions were demand driven rather than imposed. Population density and market access affected the probability of successful interventions. Collective actions are more successful in intermediate-population-density communities with poorer market access. At higher population densities and with better market access, private approaches were more effective.

Berhanu Gebremedhin and Swinton (2003) examined the relationships among public and private conservation investments. Public conservation campaigns on private land reduced adoption of stone terraces and soil bunds. Whereas capacity factors largely influenced the adoption decision, expected returns carried more influence for the intensity of stone terrace adoption (measured as metres of terrace per hectare). More stone terracing was built where fertile but erosion-prone silty soils in higher rainfall areas offered valuable yield benefits. The intensity of terracing was also greater in remote villages where limited off-farm employment opportunities reduced construction costs. These results highlighted the importance of appropriate public interventions. Direct public involvement in constructing soil conservation structures on private lands appeared to undermine incentives for private conservation. When done on public lands, however, public conservation activities can encourage private soil conservation. Secure land tenure rights clearly reinforced private incentives to make long-term investments in soil conservation.

A related issue was how tenure security influenced investment in land. A study in Tigray region revealed different causal factors for soil conservation adoption versus intensity of use (Berhanu Gebremedhin and Swinton, 2001). Farmers’ reasons for adopting soil conservation measures varied sharply between stone terraces and soil bunds. Long-term investments in stone terraces were associated with more secure land tenure, more labour availability, proximity to the household and learning opportunities via local food-for-work projects. By contrast, short-term investments in soil bunds were strongly linked to insecure land tenure and the absence of local food-for-work projects.

In Ethiopia, particularly in the Amhara region, one source of tenure insecurity was land redistribution, which had been ongoing since 1974 to equalize land holdings and quality across households. However, its short- and long-term effects may have mixed impacts on farmer land management and productivity. Expectations of future land redistribution may undermine farmers’ incentives to invest in land improvements and soil fertility, as the farmers’ ability to reap the benefits of such investments is undermined. Redistribution might, however, improve access to land of households that have relative surpluses of other important factors of production, such as labour, oxen or cash to purchase inputs, particularly in the context of prohibited land sales and restricted lease markets that exist in Ethiopia. Thus, land redistribution may increase the intensity of land management and use of purchased inputs, which may in turn increase productivity.

A research project in the Amhara region of Ethiopia looked at land degradation and identified options (Pender et al., 2001). That project classified geographical units into various development domains defined by combining production potential or ecology, population pressure (high versus low) and market access (high versus low). It has been found that there are significant differences in the extent of degradation and its causes across the various development domains. Therefore, there are no one-size-fits-all solutions to the problems across the domains. Technology and institutional options suitable for different domains to increase productivity and reduce degradation need to be introduced.

A review article by Williams (1998) covered common property issues in semi-arid West Africa, specifically the problems created by
population growth, land pressure on water and grazing, the lack of participation in governance by resource users, and the role of the state in resolving non-market conflicts.

**Land tenure and fodder trees**

The International Institute for Tropical Agriculture (IITA) had for many years studied alley farming, a system in which leguminous trees were planted between rows of food crops, such as maize or cassava. Nitrogen fixed by the trees could be returned to the soil as mulch for uptake by crops, or the leaves could be cut and fed to livestock. Long-term collaboration among IITA, ILCA/ILRI and national programmes in West Africa investigated agro-economic and economic aspects of leguminous tree farming.

Given the long-term character of tree investments, adequate land tenure was thought to be needed to provide incentives to plant and maintain trees. One study included results from a sample of 248 farms in southern Nigeria between 1984 and 1991. While that study did not collect tenure data, it did show that high turnover in plot ownership had no effect on tree farming (Lawry et al., 1994, p. 3).

A wider study in humid West and Central Africa tested the land tenure argument. This work characterized land and tree tenure practices and their implications for tree management in Cameroon, Nigeria and Togo. The review found that 66%, 50% and 56% of the land, respectively, in Cameroon, Nigeria, and Togo was under tenure that provided long-term security and was, therefore, favourable for adoption of alley farming (Lawry and Stienbarger, 1991, p. 62). Tenure had a significant role in the adoption, continuation and discontinuation of alley farming. Because a significant proportion of the land in the three countries was under a favourable tenure system, it was concluded that land tenure was not a major constraint to the adoption of alley farming, if other favourable factors were present (Lawry and Stienbarger, 1991; Lawry et al., 1994). In a study of southwest Cameroon, Adesina et al. (2000) found no statistically significant effect of land tenure security on the probability of adopting alley farming. An aggressive policy of tenure reform would therefore not be generally necessary to promote alley farming in the West and Central African land markets studied, though Adesina et al. (2000) showed that relieving the specific land tenure constraints faced by women farmers would be necessary to raise their share of benefits from alley farming or from other fallow substitutes.

**Livestock and poverty**

Poverty was not a theme of ILCA/ILRAD/ILRI research before the mid-1990s and the words ‘poor’ or ‘poverty’ as keywords in published work rarely appear before 2000. There was some analysis of wealth disparities in Maasailand in the 1980s by King et al. (1984) and Grandin (1988) but no systematic or even sporadic effort to relate ILRI’s work to poverty in Africa, or anywhere else, before 2000.

ILRI adopted the theme of livestock as a ‘pathway out of poverty’ for its 2002–2010 strategy (ILRI, 2002). Two landmark studies – Perry et al. (2002) and Thornton et al. (2002) – examined welfare among livestock keepers and paths by which they might escape poverty. Subsequent work identified three paths along which research might assist by: (i) securing the assets of the poor; (ii) improving the productivity of assets; and (iii) encouraging market participation by the poor.

Thornton et al. (2002) produced the first set of maps to locate poor livestock keepers by country, region and production system. They estimated that out of nearly 1 billion poor people living in the developing world, about 550 million depended on livestock for their livelihoods, most of them located in sub-Saharan Africa and South Asia. Some 366 million and 103 million livestock-dependent poor people live, respectively, in rain-fed and irrigated mixed systems, another 30 million in rangelands, and the remaining 50 million or so in highlands and other areas.

Subsequent microeconomic studies assessed poverty dynamics and its relation to livestock. Kristjanson et al. (2004) followed over 1700 households in 20 communities in western Kenya. The communities differed in population density, farm size, agricultural potential, poverty rate and human immunodeficiency virus
prevalence. As they emerged from poverty, households typically first acquired food, then clothes, shelter, primary education and small animals, including chickens, sheep and goats. The results showed movement by households into and out of poverty over the 25-year period. Of the households that had escaped poverty, 73% mentioned diversifying income into cash crops and/or selling food crops when a household member obtained an off-farm job, 57% mentioned cash crop production and 42% mentioned that they diversified their on-farm incomes through livestock, ranging from poultry to dairy. On-farm diversification of income sources away from a sole reliance on crops through investment in chickens, sheep, goats and/or cattle helped many of the households in the study to escape poverty. Poor health, health-related expenses and funerals were the principal reasons cited by households for having fallen into poverty. The slaughter of livestock to meet emergency needs was mentioned by 63% of households as a reason for falling into poverty.

Kristjanson et al. (2007) replicated the community approach in some 3800 households in two regions of highland Peru, based on 10-year and 25-year recall. The reasons for movements into or out of poverty were identified at community and household levels, as was the role of livestock in the different paths. Diversification of income through livestock and intensification of livestock activities through improved breeds helped many households escape poverty, but these results varied across households.

Ouma et al. (2003), in a study in Kenya, used data from a survey of cattle-keeping households in intensive, semi-intensive and extensive systems. This work assessed the contribution of non-market benefits of cattle to the competitiveness and survival of smallholder enterprises. Some 50–70% of the benefits from smallholder cattle are non-cash and smallholder cattle production systems are relatively competitive and efficient in the utilization of household production factors when non-market benefits are taken into consideration. This is especially so for extensive systems, which are non-market-oriented. The study concluded by emphasizing the importance of the non-market roles of cattle in evaluations of smallholder cattle production systems, as this will have a bearing on any policy-related interventions whose target are households that are wholly or partially dependent on the livestock economy.

Little et al. (2008) examined poverty among Kenya pastoralists. They argued that external observers tended to ‘homogenize’ the concept of ‘pastoralist’ by failing to acknowledge the diverse livelihoods, wealth and income in pastoral areas. The study concludes that what is not needed is another development label (stereotype) that equates pastoralism with poverty, thereby empowering outside interests to transform rather than strengthen pastoral livelihoods.

Radeny et al. (2007) showed that education among Tanzanian pastoralists influenced livelihood choices and improved the viability of pastoralism by diversifying it with crop production.

Food security and nutrition

A fundamental policy question under the heading of ‘livestock and poverty’ is how the benefits of technical change accrue to the rich and the poor and between women and men. The question is especially relevant when technical change involves a cash good such as milk or meat, commodities not consumed in large quantities by most poor households, raising the possibility that producing cash goods can worsen the nutrition of the poor (Pinstrup-Andersen, 2000). Studies in Ethiopia on which ILRI collaborated tended to reject that adverse possibility.

A study was started in 1997 in collaboration with national institutions near Holetta in the highlands of Ethiopia. The work involved an on-farm trial of cross-bred dairy cows and animal draught power to assess the nutritional impacts of market-oriented dairying. A first analysis evaluated the nutritional and health status of women and children in households with and without cross-bred cows (Shapiro et al., 2000; Ahmed et al., 2000). Malnutrition, as measured in pre-school children by stunting, wasting and underweight, and as measured by body mass index in adult women, was lower in households with cross-bred cows than in those with local cows. Calorie, protein and nutrient intake were significantly higher in the cross-bred cow group.

The analysis further assessed the effects of milk and income on decision making (Haider
et al., 2000). Women in households with cross-bred cows contributed over 80% of household expenditure on food. A second extension of the study revealed that steady increases in income from dairy in Ethiopia translated directly into increases in expenditure on purchased food, non-food and farm inputs (Ahmed et al., 2000, 2003).

Tangka et al. (2002) analysed the food security and supply effects of smallholder dairying in peri-urban Ethiopia. Econometric analysis of panel data was used to evaluate the effects of dairying on food consumption, calorie intake and marketed surplus in a treatment group of households in contrast to a control group without the dairy technology. There were substantive and statistically significant improvements in food security and marketed surplus with improved cattle. These impacts were reflected mainly through the effects of income and wealth, measured by animal value and land area. Household income had a positive and significant effect on food consumption. Regression estimates show that elasticity of expenditure on food with respect to income, animal value and cropland area at the mean levels was respectively 0.29, 0.18 and 0.26. The largest share (63%) of the difference in calorie intake between the cross-bred and local-breed cattle households was attributed to differences in the explanatory variables, while the estimated parameter differences between the two groups accounted for 37% of the difference. The value of animal assets had a positive and statistically significant impact on calorie intake in both the combined and cross-bred cattle regressions. The increase in animal values for the cross-bred cattle households was estimated to increase their caloric intake by 12.7% relative to the local-breed cattle households. The value of food marketed by the cross-bred cattle group was 82% higher than that in the local-breed cattle group. A total of 76% of the increase in the value of marketed surplus food for the cross-bred cattle over the local-breed cattle groups was accounted for by the difference in household characteristics, while only 24% of the increase could be attributed to differences in the estimated parameters. Households in market-oriented dairying increased their income and animal values significantly compared with households in traditional dairying.

Nutritional status of children under 5 years of age is often a good indicator of community health and nutrition. Anthropometrical indicators – stunting (height for age), underweight (weight for age) and wasting (weight for height) – are generally used as means of assessing prevalence of malnutrition among pre-school children or children under 5 years. A study in highland Ethiopia tested the hypothesis that access to animal-source foods affected nutrition in pre-school children (Okike et al., 2005). A child’s nutritional and health status are jointly determined by dietary intake, maternal wellbeing and the state of the physical environment as it influenced agricultural production and health status. Presence of dairy cows in the household significantly contributed to the health of children. The findings implied the need for multi- or transdisciplinary approaches to research and development incorporating heath, nutrition, sanitation, and farming practices for improving the health and nutrition of rural households.

A study in Selale District, in the Ethiopian highlands, examined the relationship between smallholder dairying, time allocation by gender and income receipts by gender (Lenjiso et al., 2016). In market participant households, income from milk was higher because of higher output and marketed surplus, but control of income shifted from women to men compared with non-participant households. Policy lessons from this work were inconclusive.

**IBLI in the arid rangelands of Kenya and Ethiopia**

An IBLI project developed a market tool for risk management by pastoralists in arid and semi-arid Kenya. Following the inception of household surveys in Marsabit, Kenya, in 2009 and the launch of the IBLI’s insurance product in January 2010 (Jensen et al., 2015), the IBLI model has combined biological, economic and institutional research involving scientists, herders, private firms and regulators to: (i) protect pastoralists from livestock losses by assessing forage availability during the rainy season(s), as an index of production risk among a sample of 924 herding households in Marsabit county of arid northern Kenya; (ii) measure household demography, income and wealth in that sample over a survey period of 5 years; (iii) define and sell
insurance policies against covariate risks caused by drought; (iv) measure an index of vegetation to define a trigger for insurance payments, using remote sensing data; (v) analyse the consumption and investment behaviour of pastoralists of varying herd sizes to estimate the impact of insurance on sales, income, consumption and herd viability; (vi) identify effective institutional and extension models for the uptake of the product; and (vii) work with herders and private brokers to monitor demand for index insurance, to continue adaptive testing of the insurance instruments and to analyse the development impacts of IBLI (a recent summary of IBLI is given by Fava and Jensen, 2020).

Impact

There was widespread adoption of index insurance in Marsabit, although many herders did not renew their policies after seasons of low pay-outs (Jensen et al., 2015, p. 3). Insurance had three broad impacts in Kenya. First, insurance, whether payments were triggered or not, had a positive impact in maintaining consumption and in preserving livestock wealth (Janzen and Carter, 2019), through IBLI’s generation of roughly US$10 million in pay-outs to Kenya herders. During the drought of 2011, households in Marsabit county with IBLI coverage had higher incomes and milk production; (Jensen et al., 2015), were 27–36% less likely to skip meals and were 22–36% less likely to make distress sales of livestock (Janzen and Carter, 2019). Jensen et al. (2017) found, over 3 years of IBLI coverage, that average veterinary expenditures doubled and livestock sales in non-drought years increased by an average of 46% of the mean.

Impact on the wider policy environment in Kenya is a second category in which the programme had a strong effect measure through the expansion of IBLI by the government of Kenya as the Kenya Livestock Insurance Project (KLIP). KLIP now provides subsidized insurance to 18,000 pastoral households, representing over 80,000 beneficiaries, across eight counties of northern Kenya, and plans to serve 100,000 households across 16 counties by 2021. The 2016/17 drought was among the worst in Kenya in the past 20 years, and KLIP paid out $7 million to pastoralists. One indicator of the policy impact of IBLI was that the insurance product had a favourable benefit-cost ratio compared with other social protection programmes in Kenya (Janzen and Carter, 2019).

IBLI expanded into southern Ethiopia in 2012 and has since generated pay-outs to herders of approximately US$370,000 (Matsuda et al., 2019). A major finding from the studies of IBLI in Ethiopia is that index insurance is a complement, not a substitute, to traditional risk-sharing mechanisms (Takahashi et al., 2019). Since 2019, an IBLI product has been integrated into the Africa Risk Capacity (ARC) to offer index insurance to national partners targeting pastoral regions. To date, more than 86,000 policies have been sold with the ARC micro-insurance scheme and more than 25,000 pastoralists are protected through the macro-level programmes.

Policy lessons

Successful policy is impossible without a base of data collection and analysis

Index insurance for livestock leaves substantial idiosyncratic risks (Jensen et al., 2016), with roughly 60–75% of risk uncovered. These idiosyncratic risks have to be managed by traditional risk-sharing mechanisms or by associated public policies such as social funds.

The arid and semi-arid counties of Kenya are poor enough and risky enough that commercial livestock insurance will need public financial support for some time.

Market agents – insurance brokers, regulators, and extension and research collaborators – had insufficient capacity at the onset of IBLI. The commercial and regulatory capacities of Kenya have grown since the inception of IBLI, but international research support will be needed for some time to maintain a flow of information and analysis on programme operations and outcomes.

Livestock sector analyses and master plans as part of development policies

ILRI has pioneered the use of system dynamics models in agri-food and livestock value chains. One application was in Rich et al. (2009) who assessed the viability of a two-stage export certification system in Ethiopia using quarantine
stations and feedlots to ensure disease-free and higher-quality beef for export to Middle Eastern markets. The model found that the costs of complying with SPS regulations did not constrain competitiveness but that high feed costs would do so. Later models at ILRI evaluated sheep and goat marketing in Mozambique (Hamza et al., 2014), reforms to improve competitiveness in the beef sector in Botswana (Dizyee et al., 2017) and assessments of animal disease and food safety (Grace et al., 2017; Rich et al., 2018).

Lie et al. (2017, 2018) used spatial techniques in a model of the dairy value chain in Nicaragua to quantify the market effects of feed quality.

A growing area of ILRI policy support has been the development of ‘livestock master plans’. Such plans set priorities within livestock development strategies to generate public and private investments. The government of Ethiopia has developed a Growth and Transformation Plan II 2015–2020, which prioritizes agriculture and livestock investments to reduce poverty, to raise national income, to increase exports and to improve food and nutritional security. The Growth and Transformation Plan includes a livestock master plan, based on an analytical tool known as the Livestock Sector Investment Policy Toolkit (www.au-ibar.org/2012-10-01-13-08-42/news/171-au-ibar/451-the-alive-livestock-sector-investment-policy-toolkit-lispt; accessed 9 March 2020).

The Ethiopia livestock master plan (Shapiro et al., 2015) was based on a 15-year sectoral model of potential outcomes of livestock investments in terms of increased production and value added for technology and service investments under associated policy scenarios. The modelling incorporated the red meat and dairy value chains subject to constraints in animal health, feeds and genetics. The livestock master plan, as derived from the sector model, comprises a 5-year investment roadmap and assessments of potential medium-term impacts of combined technology and policy interventions, and informed the Ethiopian government’s Growth and Transformation Plan II livestock targets for 2015–2020.

Since 2016, the plan has served as the basis for new funding and projects for the country’s livestock sector. This includes livestock investments of US$132 million by the World Bank (http://projects.worldbank.org/P159382?lang=en; accessed 8 March 2020), new donor project financing of US$75 million and new private-sector investments of US$200 million. The higher livestock productivity and income levels resulting from the plan’s investment interventions are projected to lift more than 2.3 million of Ethiopia’s 11 million livestock-keeping households out of poverty.

The Future

The goal of ILCA/ILRAD/ILRI policy research was to increase smallholder returns by: (i) improving the productivity of technologies through technical, economic and financial analysis; (ii) identifying policy barriers that lower farm prices, raise input costs or increase the financial, information and risk costs of new methods; and (iii) building institutions to raise productivity, create assets and reduce the external costs of animal agriculture.

We are unable to estimate most of the development benefits of policy research at ILRI and partners, for several reasons. One is that many policy studies made little or no effort to calculate impact research on the policy process or on outcomes of policy changes. This pattern began with early ILCA work, such as Addis Amente (1983, 1984, 1985, 1991) and the dairy policy studies of Brokken and Senait Seyoum (1992), continuing with McCarthy et al. (1999) and the contemporary livestock and poverty (Thornton et al., 2002), animal health (Perry et al., 2002), and climate change investigations (Thornton and Herrero, 2010). One recent innovation is the preparation of ‘livestock master plans’ (e.g. Shapiro et al., 2015, for Ethiopia, which developed benefit–cost results for specific policy measures). The book of Herrero et al. (2014) on African livestock futures proposed specific policy measures, but there has been no effort to cost those recommendations and to see if they have been implemented.

A second reason is broader – the international system has neglected the assessment of policy research with the exception of IPPRI’s work. The reasons for this failure include the time lag between research output and policy changes, the difficulty of attributing policy changes to
research products, and the futile and counterproductive demands by donors for simple answers to complex questions in unrealistically short periods, which leads to hasty and inconclusive studies. Exceptions to these generalizations were ILRI’s research on the Kenyan dairy policy, which had significant economic and capacity development benefits (Kaitibie et al., 2010a; Leksmono et al., 2006), development of the East Coast fever vaccine (see Chapter 6, this volume) and the public–private partnerships in Latin America that led to the planting of large areas of the forage grass *Brachiaria* spp.

There is an important contrast between the extended data collection and analysis done as part of the ICRISAT village-level studies (Walker and Ryan, 1990) in semi-arid central India and the work at ILRI and other centres. The ICRISAT village-level studies had the greatest scientific impact of economics and policy work across the international agricultural research institutions because the work was sustained for many years and was specifically linked to technology generation. Future field investigations of livestock systems should renew the ICRISAT village-level studies model over a sufficiently long period in African and in other developing country situations.

### Acknowledgements

The authors thank Iain Wright and Isabelle Baltenweck for comments.

### Notes

1 These were the same classes of measures recommended by Schiff and Valdés (1992) in a global review of agricultural incentives.

2 There are several versions of the Kaitibie et al. (2010b) paper. The version published in a major policy journal had only 37 citations to May, 2020.

3 Gallais was a member of the 1981 Quinquennial Review of ILCA (CGIAR/TAC, 1982). His deep knowledge of Sahelian pastoralism and land tenure is only faintly apparent in the findings of that Review.

### References

Adesina, A.A., Mbila, D., Nkamleu, G.B. and Endamana, D. (2000) Econometric analysis of the determinants of adoption of alley farming by farmers in the forest zone of southwest Cameroon. *Agriculture, Ecosystems & Environment* 80, 255–265.

Addis Anteneh. (1983) Financing animal health services in some African countries. *Livestock Policy Unit Working Paper No. 1*. ILCA, Addis Ababa.

Addis Anteneh. (1984) *Trends in sub-Saharan Africa’s livestock industries*. ILCA Bulletin No. 18. ILCA, Addis Ababa.

Addis Anteneh, A. (1985) Financing livestock services: do Directors of Veterinary Services have a distinct role? ALPAN network paper No. 6. ILCA, Addis Ababa.

Addis Anteneh. (1991) *The financing and staffing of livestock services in sub-Saharan Africa: a cross-country analysis. Livestock Economics Division*. Working Document No. 16. ILCA, Addis Ababa.

Agyemang, K., Dwinger, R.H., Little, D.A. and Rowlands, G.J. (1997) Village N’Dama cattle production in West Africa: Six years of research in The Gambia. ILRI, Nairobi.

Ahmed, M.M., Jabbar, M. and Ehui, S. (2000) Household-level economic and nutritional impacts of market-oriented dairy production in the Ethiopian highlands. *Food and Nutrition Bulletin* 21, 460–465.

Ahmed, M.M., Berhanu Gebremehdin, Benin, S. and Ehui, S. (2002) Measurement and sources of technical efficiency of land tenure contracts in Ethiopia. *Environment and Development Economics* 7, 507–527.

Ahmed, M.A., Emana, B., Jabbar, M.A., Tangka, F. and Ehui, S. (2003) Economic and nutritional impacts of market-oriented dairy production in the Ethiopian highlands. ILRI Socio-Economics and Policy Research Working Paper 51. ILRI, Nairobi.

Akter, S., Jabbar, M., Ehui, S. and Goletti, F. (2004) Competitiveness of poultry and pig production in Vietnam: an application of policy analysis matrix. *Quarterly Journal of International Agriculture* 43, 1962–1979.
Asfaw Negassa and Jabbar, M A (2008) Livestock ownership, commercial off take and related reasons in Ethiopia. ILRI Research Report No. 8. ILRI, Nairobi.

Asfaw Negassa, Costalgi, R., Metete, G., Jabbar, M., Oyieke, S.O., et al. (2008) Towards improving livestock export marketing support services in the Somali context: survey findings and implications. ILRI, Nairobi.

Ayele Solomon, Assegid Workalemahu, Jabbar, M.A., Ahmed, M.A. and Belachew Hurissa (2003) Livestock marketing in Ethiopia: a review of structure, performance and development initiatives. Socio-economics and Policy Research Working Paper 52. ILRI, Nairobi.

Bahta, S. and Malope, P. (2014) Measurement of competitiveness in smallholder livestock systems and emerging policy advocacy: an application to Botswana. Food Policy 49, 408–417.

Baker, D. and Enahoro, D. (2014) Policy analysis and advocacy for livestock-based development: the gap between household-level analysis and higher-level models. Food Policy 49, 361–364.

Baltenweck, I. and Staal, S. (2007) Beyond one-size-fits-all: differentiating market access measures for commodities in the Kenyan highlands. Journal of Agricultural Economics 58, 536–548.

Behnke, R.H. (1986) The implications of spontaneous range enclosure for African livestock development policy. African Livestock Policy Analysis Network Paper No. 12. ILCA, Addis Ababa.

Benin, S. and Pender, J. (2001) Impacts of land redistribution on land management and productivity in the Ethiopian highlands. Land Degradation and Development 12, 555–568.

Benin, S., Ahmed, M., Pender, J. and Ehui, S. (2005) Development of land rental markets and agricultural productivity growth: the case of northern Ethiopia. Journal of African Economies 14, 21–54.

Benin, S., Ehui, S. and Pender, J. (2003a) Policies for livestock development in the Ethiopian highlands. Environment, Development and Sustainability 5, 491–510.

Benin, S., Jabbar, M. and Ehui, S. (2003b) Livestock marketing in the Ethiopian highlands: changes in structure and conduct since market liberalization in 1991. Presented at the Workshop on Harnessing Markets for Agricultural Growth in Ethiopia: Bridging the Opportunities and Challenges, 7–8 July, ILRI, Addis Ababa, Ethiopia.

Berhanu Gebremedhin and Swinton, S. (2001) Reconciling food-for-work, project feasibility with food aid targeting in Tigray, Ethiopia. Food Policy 26, 85–95.

Berhanu Gebremedhin and Swinton, S. (2003) Investment in soil conservation in northern Ethiopia: The role of land tenure security and public programmes. Agricultural Economics 29, 69–84.

Berhanu Gebremedhin, Pender, J. and Tesfaye, G. (2003) Community natural resource management: the case of woodlots in Northern Ethiopia. Environment and Development Economics 8, 129–148.

Berhanu Gebremedhin, Pender, J. and Tesfaye, G. (2004) Collective action for grazing land management in crop–livestock mixed systems in the highlands of northern Ethiopia. Agricultural Systems 82, 273–290.

Brokken, R.F. and Senait Seyoum, eds (1992) Dairy Marketing in Sub-Saharan Africa. Proceedings of a Symposium Held at ILCA, Addis Ababa, Ethiopia, 26–30 November 1990. ILCA, Addis Ababa.

Cartwright, T.C., Anderson, F.M., Buck, N.G., Nelsen, T.C., Trail, J.C.M., et al. (1982) Systems modelling in cattle production—an application in Botswana. World Animal Review 41, 40–45.

CGIAR/TAC (1982) Report of the TAC quinquennial review of the International Livestock Centre for Africa (ILCA). TAC Secretariat, FAO, Rome.

CIAT (1975) Beef production systems: reprint from Annual Report of CIAT, 1975. CIAT, Cali, Colombia.

Coppock, D.L. (1994) The Borana plateau of southern Ethiopia: synthesis of pastoral research, development and change, 1980–91. Systems Study No. 5. ILCA, Addis Ababa.

Costales, A., Delgado, C.L., Catelo, M.A., Lapar, M., Tiongco, M., et al. (2006) Scale and access issues affecting smallholder hog producers in an expanding peri-urban market: Southern Luzon, Philippines. IFPRI Research Report 151. IFPRI, Washington, D.C.

Coughenor, M.B., Ellis, J.E., Swift, D.M., Coppock, D.L., Galvin, K.M., et al. (1985) Energy extraction and use in a nomadic pastoral ecosystem. Science 230, 619–625.

Deininger, K. and Jin, S. (2006) Tenure security and land-related investment: evidence from Ethiopia. European Economic Review 50, 1245–1277.

Delgado, C.L., Rosegrant, M., Steinfield, H., Ehui, S. and Courbois, B. (1999) Livestock to 2020: the next food revolution. IFPRI, Washington, DC, FAO, Rome and ILRI, Nairobi.

Delgado, C.L., Rosegrant, M.W. and Meijer, S. (2001) Livestock to 2020: the livestock revolution continues. Paper presented at the annual meeting of the International Agricultural Trade Research Consortium (IATRC), 18–19 January Auckland, New Zealand.

Dizyee, K., Baker, A.D. and Rich, K.M. (2017) A quantitative value chain analysis of policy options for the beef sector in Botswana. Agricultural Systems 156, 13–24.
Ehui S.K., Ahmed M.M., Berhanu Gebremehdin, Benin S.E., Nin-Pratt, A. and Lapar, M.L. (2003) 10 Years of Livestock Policy Analysis. Policies for improving productivity, competitiveness and sustainable livelihoods of smallholder livestock producers. ILRI, Nairobi.

El Dirani, O.H., Jabbar, M. A., and Babikar, B. I. (2009) Constraints in the market chains for export of Sudanese sheep and sheep meat to the Middle East. ILRI Research Report No. 16. ILRI, Nairobi.

Elbasha, E., Thornton, P.K., and Tarawali, G. (1999) An ex post economic impact assessment of planted forages in West Africa. ILRI Impact Assessment Series No. 2. ILRI, Nairobi.

Fafchamps, M. and Gavian, S. (1996) The spatial integration of livestock markets in Niger. *Journal of African Economics* 5, 366–405.

Fava, F. and Jensen, N. (2020) Lessons learnt from the implementation of index-insurance in the African drylands: toward early response and regional scaling. Available at: https://cgspace.cgiar.org/bitstream/handle/10568/107356/PosterAGU2019.pdf?sequence=1&isAllowed=y (accessed 13 May 2020).

Franzel, S. and Wambugu, C. (2007) The uptake of fodder shrubs among smallholders in East Africa: Key elements that facilitate widespread adoption. In: Hare, M.D. and Wongpichet, K. (eds) *Forages: A Pathway to Prosperity for Smallholder Farmers*. Proceedings of an International Symposium, Faculty of Agriculture, Ubon Ratchathani University, Thailand, pp. 203–222.

Freeman, H.A., Ehui, S.K. and Jabbar, M.A. (1998) Credit constraints and smallholder dairy production in the East African highlands: application of a switching regression model. *Agricultural Economics* 19, 33–44.

Fritz, S., See, L., McCallum, I., You, L., Bun, A., et al. (2015) Mapping global cropland and field size. *Global Change Biology* 21, 1980–1992.

Gallais, J. (1967) *Le Delta Intérieur du Niger: Étude de Géographie Régionale*. IFAN, Dakar.

Gallais, J. and Boudet, G. (1980) Projet de code pastoral concerned plus spécialement la région du Delta Central du Niger au Mali. GERDAT-IEMVT, Maisons-Alfort, France.

Gaspart, F., Jabbar, M., Mélard, C. and Platteau, J.-P. (1998) Participation in the construction of a local public good with indivisibilities: an application to watershed development in Ethiopia. *Journal of African Economics* 7, 157–184.

Gavian, S. and Amare Teklu (1996) Land tenure and farming practices: The Case of Tiyo Woreda, Arsi, Ethiopia. In: Mulat, D., Wolday, G., Tesfaye, Z., Solomon, B. and Ehui, S. (eds) *Sustainable Intensification of Agriculture in Ethiopia*. Proceedings of the second annual conference of the Ethiopian Agricultural Economics Society, 3–4 October, Addis Ababa, Ethiopia, pp. 74–97.

Gavian, S. and Ehui, S. (1999) Measuring the production efficiency of alternative land tenure contracts in a mixed crop–livestock system in Ethiopia. *Agricultural Economics* 20, 37–49.

Gillian, K.E., Tittonell, P., Rufino, M.C., van Wijk, M.T., Zingore, S., et al. (2011) Communicating complexity: integrated assessment of trade-offs concerning soil fertility management within African farming systems to support innovation and development. *Agricultural Systems* 104, 191–203.

Gryseels, G. (1988) Role of livestock on mixed smallholder farms in the Ethiopian highlands. PhD thesis, *State Agricultural University*, Wageningen, The Netherlands.

Gryseels, G. and Anderson, F.M. (1983) Research on farm and livestock productivity in the central Ethiopian highlands: initial results, 1977–1980. ILCA Research Report No. 4. ILCA, Addis Ababa.

Haider, J., Shapiro, B.I., Tsegaye, D., and G/Wold, A. (2000) The nutritional and health status of women and children in households with and without cross-bred cows in Holetta, Wereda, Ethiopia. In: Jabbar, M.A., Peden, D.G., Mohamed Saleem, M.A. and Li Pun, H. (eds) *Agro-ecosystem, Natural Resource Management and Human Health Related Research in East Africa*. Proceedings of an IDRC/ILRI international workshop held at ILRI, Addis Ababa, Ethiopia, 11–15 May 1998, pp. 124–136.

Hall, D.C., Ehui, S.K. and Shapiro, B.I. (2004) Economic analysis of the impact of adopting herd health control programs on smallholder dairy farms in Central Thailand. *Agricultural Economics* 31, 335–342.

Hamza, K., Rich, K.M., Baker, D. and Hendrickx, S. (2014) Commercializing smallholder value chains for goats in Mozambique: a system dynamics approach. In: *Proceedings in System Dynamics and
Herrero, M., Thornton, P. K., Notenbaert, A. M., Wood, S., Freeman, H. A., et al. (2014) African livestock futures: realizing the potential of livestock for food security, poverty reduction and the environment in sub-Saharan Africa. Office of the Special Representative of the UN Secretary General for Food Security and Nutrition and the United Nations System Influenza Coordination, Geneva, Switzerland.

Herrero, M., Thornton, P. K., McIntire, J., Palazzo, A. and Valin, H. (2014) Smart Investments in Sustainable Food Production: Revisiting Mixed Crop-Livestock Systems. Science 327, 822–825.

Holloway, G. J. and Ehui, S. K. (2001) Demand, supply and willingness-to-pay for extension services in an emerging-market setting. American Journal of Agricultural Economics 83, 764–768.

Holloway, G., Nicholson, C., Delgado, C., Staal, S. and Ehui, S. (2000a) How to make a milk market: a case study from the Ethiopian highlands. Working Paper. ILRI, Addis Ababa.

Holloway, G. J., Barrett, C. B. and Ehui, S. (2000b) Crossbred-cow adoption and milk-market participation in a multivariate count data framework. In: Bayesian Methods with Applications to Science, Policy and Official Statistics: Eurostat Special Issue. Eurostat, Luxembourg, pp. 233–242.

ILCA, Jabbar, M.A. (1998) Market niches for increased small ruminant production in southern Nigeria. Oxford Agrarian Studies 23, 85–96.

Jabbar, M.A. (1998) Buyer preferences for sheep and goats in southern Nigeria: a hedonic price analysis. Agricultural Economics 18, 21–30.

Jabbar, M.A. and Akter, S. (2006) Market and other factors affecting farm-specific production efficiency in poultry production in Vietnam. Journal of Food Products Marketing 12, 99–113.

Jabbar, M.A. and Akter, S. (2008) Market and other factors affecting farm specific production efficiency in pig production in Vietnam. Journal of International Food & Agribusiness Marketing 20, 29–53.

Jabbar, M.A. and Diedhiou, M. L. (2001) Does breed matter to cattle farmers and buyers? Evidence from West Africa. Ecological Economics 45, 461–472.

Jabbar, M.A. and di Domenico, C. (1990) Dairy consumption patterns in southern Nigeria. In: Dairy Marketing in sub-Saharan Africa. Proceedings of a Symposium, 26–30 November, ILCA, Addis Ababa, Ethiopia, pp. 185–202.

Jabbar, M.A. and di Domenico, C. (1993) Demand for dairy products among the indigenous population of southern Nigeria. Indian Journal of Dairy Science 46, 363–370.

Jabbar, M.A., Benin, S., Eleni Gabremedhin and Paulos, Z. (2008) Market institutions and transaction costs influencing trader performance in live animal marketing in rural Ethiopian markets. Journal of African Economies 17, 747–764.

Jabbar, M.A., Swallow, B.M. and d’Ieteren, G.D.M. (1995) The demand for trypanotolerant cattle: Evidence on farmers breed preferences and breeding practices in southern Nigeria. Presented at the 23rd meeting of the International Scientific Council for Trypanosomiasis Research and Control, 11–15 September, Banjul, The Gambia.

Jabbar, M.A., Swallow, B.M., d’Ieteren, G.D. and Busari, A. A. (1997) Farmer preferences and market values of cattle breeds of West and Central Africa. Socioeconomic and Policy Research Working Paper No 21. LPAP, ILRI, Addis Ababa.
Jabbar, M., Swallow, B. and Rege, E. (1999) Incorporation of farmer knowledge and preferences in designing breeding policy and conservation strategy for domestic animals. *Outlook on Agriculture* 28, 239–243.

Jabbar, M.A., Islam, S.M.F., Delgado, C., Ehui, S., Akanada, M.A.I., *et al.* (2005) Policy and scale factors influencing efficiency in dairy and poultry production in Bangladesh. ILRI, Nairobi.

Jabbar, M.A., Rahman, M.H., Talukder, R.K. and Raha, S.K. (2007) Alternative institutional arrangements for contract farming in poultry production in Bangladesh and their impacts on equity. ILRI Research Report 7. ILRI, Nairobi.

Jabbar, M.A., Baker, D. and Fadiga, M. (2010) Demand for livestock products in developing countries with a focus on quality and safety attributes: evidence from Asia and Africa. ILRI Research Report 24. ILRI, Addis Ababa.

Jahnke, H.E. (1982) *Livestock Production Systems and Livestock Development in Tropical Africa*. Kieler Wissenschaftsverlag Vauk, Kiel, Germany.

Jansen, H.G. (1992) Dairy consumption in northern Nigeria: implications for development policies. *Food Policy* 17, 214–226.

Jansen, S.A., and Carter, M.R. (2019) After the drought: the impact of microinsurance on consumption smoothing and asset protection. *American Journal of Agricultural Economics* 101, 651–671.

Jensen, N.D., Barrett, C.B. and Mude, A.G. (2015) The favourable impacts of index-based livestock insurance: evaluation results from Ethiopia and Kenya. ILRI Research Brief No. 52. ILRI, Nairobi.

Jensen, N.D., Barrett, C.B. and Mude, A.G. (2016) Index insurance quality and basis risk: evidence from northern Kenya. *American Journal of Agricultural Economics* 98, 1450–1469.

Jensen, N.D., Barrett, C.B. and Mude, A.G. (2017) Cash transfers and index insurance: a comparative impact analysis from northern Kenya. *Journal of Development Economics* 129, 14–28.

Jones, P.G. and Thornton, P.K. (2009) Croppers to livestock keepers: livelihood transitions to 2050 in Africa due to climate change. *Environmental Science and Policy* 12, 427–437.

Kaitibie, S., Omore, A., Rich, K. and Kristjanson, P. (2010a) Kenya dairy policy change: influence pathways and economic impacts. *World Development* 38, 1494–1505.

Kaitibie, S., Omore, A., Rich, K., Salayasa, B., Hooton, N., *et al.* (2010b) Influence pathways and economic impacts of policy change in the Kenyan dairy sector. ILRI Research Report. ILRI, Nairobi.

Kamara, A. (2000) Ethiopian case study. In: McCarthy, N., Swallow, B., Kirk, M. and Hazell, P. (eds) *Property Rights, Risk and Livestock Development in Africa*. ILRI, Nairobi, and IFPRI, Washington, D.C., pp. 396–426.

Kamara, A.B. (2001) Property rights, risk and livestock development in Ethiopia. Socioeconomic Studies on Rural Development 123. Kieler Wissenschaftsverlag Vauk, Kiel, Germany.

Kebede Andargachew and Brokken, R.F. (1993) Intra-annual sheep price patterns and factors underlying price variations in the central highlands of Ethiopia. *Agricultural Economics* 8, 125–138.

Kimani, T., Schelling, E., Bett, B., Ngigi, M., Randolph, T. and Fuhrimann, S. (2016) Public health benefits from livestock Rift Valley fever control: a simulation of two epidemics in Kenya. *EcoHealth* 13, 729–742.

King, J.M., Sayers, A.R., Peacock, C.P. and Kontrohr, E. (1984) Maasai herd and flock structures in relation to livestock wealth. *Climate and Development* 13, 21–56.

Konandreas, P.A., Anderson, F.M. and Trail, J.C.M. (1983) Economic trade-offs between milk and meat production under various supplementation levels in Botswana. ILCA, Addis Ababa.

Kristjanson, P.M. and Zerbini, E. (1999) Genetic enhancement of sorghum and millet residues fed to ruminants. An ex ante assessment of returns to research. ILRI Impact Assessment Series No. 3. ILRI, Nairobi.

Kristjanson, P.M., Swallow, B.M., Rowlands, G.J., Kruska, R.L. and de Leeuw, P. (1999) Measuring the costs of African animal trypanosomosis, the potential benefits of control and returns to research. *Agricultural Systems* 59, 79–98.

Kristjanson, P.M., Tarawali, S., Okiki, I., Singh, B.B., Thornton, P.K., *et al.* (2001) Genetically improved dual-purpose cowpea: assessment of adoption and impact in the dry savanna regions of West Africa. ILRI Impact Assessment Series 9. ILRI, Nairobi.

Kristjanson, P., Krishna, A., Radeny, M. and Nindo, W. (2004) Pathways out of poverty in western Kenya and the role of livestock. Pro-Poor Livestock Policy Initiative Working Paper No. 14. FAO, Rome.

Kristjanson, P., Krishna, A., Radeny, M., Kuan, J., Quilca, G., *et al.* (2007) Poverty dynamics and the role of livestock in the Peruvian Andes. *Agricultural Systems* 94, 294–308.

Lenjiso, B., Smits, J. and Ruben, R. (2016) Transforming gender relations through the market: the impact of smallholder milk market participation on women’s intra-household bargaining position in Ethiopia. *Journal of Development Studies* 52, 1002–1018.

Lapar, M.L.A. and Ehui, S.K. (2004) Factors affecting adoption of dual-purpose forages in the Philippine uplands. *Agricultural Systems* 81, 95–114.
Lapar, M.L., Holloway, G. and Ehui, S. (2003a) Policy options promoting market participation of smallholder livestock producers: a case study from the Philippines. *Food Policy* 28, 187–211.

Lapar, M.L., Vu Trong Binh and Ehui, S. (2003b) Identifying barriers to entry to livestock input and output markets in South-East Asia: the case of Vietnam. Socio-economics and Policy Research Working Paper No. 56. ILRI, Nairobi.

Lawry, S.W. and Stienbarger, D.M. (1991) *Tenure and Alley Farming in the Humid Zone of West Africa: Final Report of Research in Cameroon, Nigeria and Togo.* LTC, Madison, Wisconsin.

Lawry, S., Stienbarger, D. and Jabbar, M.A. (1994) Land tenure and the potential for the adoption of alley farming in *West Africa.* *Outlook on Agriculture* 23, 183–187.

Leksmono, C., Young, J., Hooton, N., Muriuki, H. and Romney, D. (2006) Informal traders lock horns with the formal milk industry: the role of research in pro-poor dairy policy shift in Kenya. ODI Working Paper 266. ODI, London, and ILRI, Nairobi.

Lie, H., Rich, K.M. and Burkart, S. (2017) Participatory system dynamics modelling for dairy value chain development in Nicaragua. *Development in Practice* 27, 785–800.

Lie, H., Rich, K.M., van der Hoek, R. and Dizyee, K. (2018) Quantifying and evaluating policy options for inclusive dairy value chain development in Nicaragua: a system dynamics approach. *Agricultural Systems* 164, 193–222.

Lindahl, J., Deka, R.P. and Grace, D. (2017) Improving the traditional dairy sector in Assam: policy, practice and incentives. ILRI Research Brief 81. ILRI, Nairobi.

Little, P.D., McPeak, J., Barrett, C.B. and Kristjanson, P. (2008) Challenging orthodoxies: understanding poverty in pastoral areas of East Africa. *Development and Change* 39, 587–611.

Matsuda, A., Takahashi, K. and Ikegami, M. (2019) Direct and indirect impact of index-based livestock insurance in southern Ethiopia. *The Geneva Papers on Risk and Insurance – Issues and Practice* 44, 481–502.

Mbagoh, S.G. (1984) Dairy development and internal dairy marketing in sub-Saharan Africa: performance, policies and options. LPU Working Paper No. 5. ILCA, Addis Ababa.

Mbagoh, S.G. (1992) Marketing efficiency, pricing and policy implications: a case study of milk marketing in Addis Ababa, Ethiopia. In: Brokken, R.F. and Senait, S. (eds) *Dairy Marketing in sub-Saharan Africa.* Proceedings of a symposium, 26–30 November 1990, Addis Ababa. ILCA, Addis Ababa, pp. 239–256.

Mbagoh, S.G. and Ochuonyo, J.B. (1992) Kenya's dairy industry: the marketing system and the marketing and pricing policies for fresh milk. In: Brokken, R.F. and Senait, S. (eds) *Dairy Marketing in sub-Saharan Africa.* Proceedings of a symposium, 26–30 November 1990, Addis Ababa. ILCA, Addis Ababa, pp. 269–278.

McCarthy, N., Swallow, B., Kirk, M. and Hazell, P. (eds) (1999) *Property Rights, Risk, and Livestock Development in Africa.* ILRI, Nairobi, and IPFRI, Washington, D.C.

McDermott, J.J. and Arimi, S. (2002) Brucellosis in sub-Saharan Africa: epidemiology, control and impact. *Veterinary Microbiology* 90, 111–134.

McDermott, J.J. and Coleman, P.G. (2001) Comparing apples and oranges – model-based assessment of different tsetse-transmitted trypanosomiasis control strategies. *International Journal for Parasitology* 31, 603–609.

McDermott, J., Grace, D. and Zinsstag, J. (2013) Economics of brucellosis impact and control in low-income countries. *Scientific and Technical Review* 32, 249–261.

McIntire, J., Bourzat, D. and Pingali, P. (1992) *Crop–Livestock Interaction in Sub-Saharan Africa.* World Bank, Washington, D.C.

Mohammed Mussa and Gavian, S. (1994) Privatization of animal health services: policy issues for Ethiopia. Paper prepared for the Fourth Annual Conference on the Ethiopian Economy, Hor Ras Hotel, Debret Zeit, Ethiopia.

Montgolfier-Kouevi, C. and Viavonou, A. (1981) Trends and prospects for livestock and crop production in Tropical Africa. ILCA Working Paper No. 5. ILCA, Addis Ababa.

Mugunieri, L., Costagli, R., Osman, I.O., Oyieke, S.O., Jabbar, M., et al. (2008) A rapid appraisal of institutions supporting Somali livestock export. Improvement and diversification of Somali livestock trade and marketing project. ILRI Discussion Paper No. 14. ILRI, Nairobi.

Mukhebi, A., Perry, B.D. and Kruska, R. (1992) Estimated economics of theileriosis control in Africa. *Preventive Veterinary Medicine* 12, 73–85.

Nicholson, C.F., Thornton, P.K., Mohammed, L., Muinha, R.W., Mwamachi, D.M., et al. (1999) Smallholder dairy technology in coastal Kenya. An adoption and impact study. ILRI Impact Assessment Series. ILRI, Nairobi.
Nin-Pratt, A., Hertel, T.W., Foster, K.A. and Rae, A.N. (2001) Productivity growth and catching-up: implications for China’s trade in livestock products. Paper presented at the 2001 AAEA Annual Meeting, 5–8 August, Chicago, Illinois.

Nin-Pratt, A., Bonnet, P., Ehiu, S., Jabbar, M. and de Haan, C. (2003a) Benefits and costs of compliance of SPS rules: the case of Rift Valley Fever in Ethiopia. ILRI, Nairobi.

Nin-Pratt, A., Lapar, M.L. and Ehui, S. (2003b) Globalization, trade liberalization and poverty alleviation in Southeast Asia: the case of the livestock sector in Vietnam. Paper presented at the Sixth Annual Conference on Global Economic Analysis, Scheveningen, Netherlands, 12–14 June. ILRI, Nairobi.

Nyangito, H.O., Richardson, J.W., Mukhebi, A.W., Zimmel, P., Namken, J. and Berry, B.P. (1996a) Whole farm simulation analysis of economic impacts of East Coast Fever immunization strategies on mixed crop–livestock farms in Kenya. *Agricultural Systems* 51, 1–27.

Nyangito, H.O., Richardson, J.W., Mundy, D.S., Mukhebi, A.W., Zimmel, P. and Namken, J. (1996b) Economic impacts of East Coast Fever immunization on smallholder farms, Kenya: a simulation analysis. *Agricultural Economics* 13, 163–177.

Okike, I, Jabbar, M.A, Gugsa Abate and Lema Ketema (2005) Household and environmental factors influencing anthropometric outcomes among pre-school children in a rural Ethiopian community. *Ecology of Food and Nutrition* 44, 167–187.

Okumu, B.N., Russell, N., Jabbar, M.A., Colman, D., Mohamed Saleem, M.A. and Pender, J. (2004) Economic impacts of technology, population growth and soil erosion at watershed level: the case of the Ginchi in Ethiopia. *Journal of Agricultural Economics* 53, 503–523.

Omiti, J.M., Parton, K.A., Sinden, J.A. and Ehui, S.K. (1999) Monitoring changes in land-use practices following agrarian de-collectivisation in Ethiopia. *Agriculture, Ecosystems and Environment* 72, 111–118.

Omiti, J.M., Parton, K.A., Ehui, S.K. and Sinden, J.A. (2000) Some policy implications of the resurfacing of rural factor markets following agrarian de-collectivization in Ethiopia. *Human Ecology* 28, 585–603.

Omore, A.O. (2004) Employment generation through small-scale dairy marketing and processing: experiences from Kenya, Bangladesh and Ghana. A Joint Study by the ILRI Market-oriented Smallholder Dairy Project and the FAO Animal Production and Health Division, FAO, Rome.

Ouma, E.A., Obare, G.A. and Staal, S.J. (2003) Cattle as assets: assessment of non-market benefits from cattle in smallholder Kenyan crop-livestock systems. In: *Proceedings of the 25th International Conference of Agricultural Economists (IAAE)*, 16–22 August 2003, Durban, South Africa, pp. 328–334.

Owango, M.O., Lukuyu, B., Staal, S.J., Kenyanjui, M., Njubi, D. and Thorpe, W. (1998) Dairy co-operatives and policy reform in Kenya: effects of livestock service and milk market liberalization. *Food Policy* 23, 173–185.

Pender, J., Berhanu Gebremedhin, Benin, S. and Ehui, S. (2001) Strategies for sustainable agricultural development in the Ethiopian highlands. *American Journal of Agricultural Economics* 83, 1231–1240.

Perry, B.D. and Randolph, T.F. (1999) Improving the assessment of the economic impact of parasitic diseases and of their control in production animals. *Veterinary Parasitology* 84, 145–168.

Perry, B.D., Randolph, T.F., McDermott, J., Sones, K. and Thornton, P. (2002) *Investing in Animal Health Research to Alleviate Poverty*. ILRI, Nairobi.

Pratt, D.J. and Gwynne, M.D. (1977) *Rangeland Ecology and Management in East Africa*. Robert E. Krieger, Huntington, New York.

Randall, T.F., Schelling, E., Grace, D., Nicholson, C.F., Leroy, J.L., et al. (2007) Invited review: role of livestock in human nutrition and health for poverty reduction in developing countries. *Journal of Animal Science* 85, 2788–2800.

Reid, R.S., Kruska, R.L., Deichmann, U., Thornton, P.K. and Leak, S.G.A. (2000a) Human population growth and the extinction of the tsetse fly. *Agriculture, Ecosystems and Environment* 77, 227–236.

Reid, R.S., Kruska, R.L., Muthui, N., Taye, A., Wotton, S., et al. (2000b) Land-use and land-cover dynamics in response to changes in climatic, biological and socio-political forces: The case of southwestern Ethiopia. *Landscape Ecology* 15, 339–355.
Rich, K.M. and Perry, B.D. (2009) The impact of changing global animal health trading standards on market access for livestock products by developing countries; assessment of commodity based trade. Commissioned report to the Department for International Development (DFID) of the Government of the UK.

Rich, K.M., Perry, B.D. and Kaitibie, S. (2009) Commodity-based trade and market access for developing country livestock products: the case of beef exports from Ethiopia. *International Food and Agribusiness Management Review* 12, 1–22.

Rich, K.M., Perry, B.D., Kaitibie, S., Gobana, M. and Tewolde, N. (2008) Enabling livestock product exports from Ethiopia: understanding the costs, sustainability and poverty reduction implications of sanitary and phytosanitary compliance. Final report for the Texas Agricultural Experiment Station, Texas A&M University Sanitary and Phytosanitary Livestock and Meat Marketing Program.

Rich, K.M., Rich, M. and Dizyee, K. (2018) Participatory system approaches for urban and peri-urban agriculture planning: the role of system dynamics and spatial group model building. *Agricultural Systems* 160, 110–123.

Robinson, T., Thornton, P., Franceschini, G., Kruska, R., Chiozza, F., et al. (2011) Global livestock production systems. FAO, Rome, and ILRI, Nairobi.

Rutherford, A. (2008) Broad bed maker technology package innovations in Ethiopian farming systems: an ex post impact assessment. ILRI Research Report No. 20. ILRI, Nairobi.

Sandford, S. (1983) *Management of Pastoral Development in the Third World*. Wiley, Chichester, UK.

Sandford, S. (1985) Better livestock policies for Africa. ALPAN Network paper No. 1. ILCA, Addis Ababa.

Sandford, S. (1988) *Management and Human Health Related Research in East Africa*. Proceedings of an IDRC/ILRI International Workshop, 11–15 May 1998. ILRI, Addis Ababa, Ethiopia. ILRI, Addis Ababa, pp. 109–123.

Shapiro, B.I., Getachew Gebru, Solomon Desta, Asfaw Negassa, Kidus Negussie, et al. (2015) Ethiopia livestock master plan. ILRI Project Report. ILRI, Nairobi.

Staal, S.J., Nin-Pratt, A. and Jabbar, M.A. (2008b) Dairy development for the resource poor. Part 2: Pakistan and India dairy development case studies. FAO/PPLPI Working Paper, No. 44-2. FAO, Rome.

Staal, S.J., Nin-Pratt, A. and Jabbar, M.A. (2008c) Dairy development for the resource poor. Part 3: Kenya and Ethiopia Dairy Development Case Studies. FAO/PPLPI Working Paper, No. 44-3. FAO, Rome.

Stienbarger, D.M. (1990) Tenure and alley farming: a literature review with particular reference to the West African Humid Zone. LTC Paper No. 138. Land Tenure Center, University of Wisconsin-Madison, Madison, Wisconsin.
Swallow, B.M. (1994) Evaluating the relationships between property rights, risk, technology and productivity in sub-Saharan Africa. Socio-economic and Policy Research Working Document No. 18. ILCA, Addis Ababa.

Swallow, B.M. and Bromley, D.W. (1994) Co-management or no management: the prospects for internal governance of common property regimes. *Oxford Agrarian Studies* 22, 3–16.

Swallow, B.M. and Bromley, D.W. (1995) Institutions, governance and incentives in common property regimes for African rangelands. *Environment and Resource Economics* 6, 99–118.

Swallow, B.M. and Woudyalew, M. (1994) Evaluating willingness to contribute to a local public good: application of contingent valuation to tsetse control in Ethiopia. *Ecological Economics* 11, 153–161.

Takahashi, K., Barrett, C.B. and Ikegami, M. (2019) Does index insurance crowd in or crowd out informal risk sharing? Evidence from rural Ethiopia. *American Journal of Agricultural Economics* 101, 672–691.

Tangka, F.K., Emerson, R.D. and Jabbar, M.A. (2002) Food security effects of intensified dairying: evidence from the Ethiopian highlands. ILRI, Nairobi.

Thornton, P.K. (1987) A beef production model for the savannas of Colombia: model description and user notes. CIAT, Cali, Colombia.

Thornton, P.K. (2010) Livestock production: recent trends, future prospects. *Philosophical Transactions of the Royal Society B: Biological Sciences* 365, 2853–2867.

Thornton, P.K. and Herrero, M. (2010) The potential for reduced methane and carbon dioxide emissions from livestock and pasture management in the tropics. *Proceedings of the National Academy of Sciences USA* 107, 19667–19672.

Thornton, P.K., Jones, P.G., Erickson, P.J. and Challinor, A.J. (2011) Agriculture and food systems in sub-Saharan Africa in a 4°C+ world. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 369, 117–136.

Tisdell, C.A. (2009) The survival of small-scale agricultural producers in Asia, particularly Vietnam: general issues illustrated by Vietnam's agricultural sector, especially its pig production. In: Salazar, A. and Rios, I. (eds) *Sustainable Agriculture: Technology Planning and Management*. Nova Science Publishers, Hauppauge, New York, pp. 315–328.

Valbuena, D., Erenstein, O., Homann-kee, T.S., Abdoulaye, T., Claessens, I., et al. (2012) Conservation agriculture in mixed crop–livestock systems: scoping crop residue trade-offs in sub-Saharan Africa and South Asia. *Field Crops Research* 132, 175–184.

Verburg, P.H., van de Steeg, J., Veldkamp, A. and Willemen, L. (2009) From land cover change to land function dynamics: a major challenge to improve land characterization. *Journal of Environmental Management* 90, 1327–1335.

von Massow, V.H. (1989) Dairy imports into sub-Saharan Africa: problems, policies and prospects. ILCA Research Report No. 17. ILCA, Addis Ababa.

Walker, T.S. and Ryan, J.G. (1990) *Village and Household Economics in India's Semi-arid Tropics*. Johns Hopkins University Press, Baltimore, Maryland.

Williams, T.O. (1993) Trade and pricing policies in the context of sustainable livestock production in sub-Saharan Africa. In: Ehui S.K. and Lipner M. (eds) *Livestock and Resource Management Policy: Issues and Priorities for Research*. Proceedings of the Research Planning Workshop, 24–27 March, ILCA, Addis Ababa, pp. 37–42.

Williams, T.O. (1998) Multiple uses of common pool resources in semi-arid West Africa: a survey of existing practices and options for sustainable resource management. ODI Natural Resource Perspectives No. 38. ODI, London.

Williams, T.O., de Rosa, D.A. and Badiane, O. (1995) Macroeconomic, international trade and sectoral policies in livestock development: an analysis with particular reference to low income countries. In: Wilson, R.T., Ehui S. and Mack, S. (eds) *Livestock development strategies for low income countries*. Proceedings of the joint FAO/ILRI round table on livestock development strategies for low income countries, 27 February–2 March, ILRI, Nairobi, pp. 47–69.

Zilberman, D. and Heiman, A. (2004) The value of economics research. In: Pardey, Philip G., and Smith, Vincent H. (eds) *What's Economics Worth? Valuing Policy Research*. IFPRI, Washington D.C., pp. 275–299.