Back to the Future

Revisiting Mixed Crop-Livestock Systems

Corporate Report 2009–2010

International Livestock Research Institute

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Foreword

A hitherto disregarded vast group of farmers—those mixing crops with livestock on 'in between' lands—neither high-potential farmlands nor low-potential rangelands—are heavyweights in global food security.

This year's corporate report by the International Livestock Research Institute (ILRI) looks 'back to the future'—to the thousand million farmers practicing small-scale mixed crop-and-livestock agriculture in poor countries—the kind of seemingly old-fashioned family farming systems that have become so fashionable in recent years among those wanting to reform the industrial food systems of rich countries.

Scientists at ILRI and seven other leading international agricultural research organizations around the world recently looked at the future of this form of farming and determined that it is 'mixed farms'—not breadbaskets or ricebowls—that will feed most people over the next two decades.

Their report shows that it is not big efficient farms on high potential lands but rather one billion small 'mixed' family farmers tending rice paddies or cultivating maize and beans while raising a few chickens and pigs, a herd of goats or a cow or two on relatively extensive rainfed lands who feed most of the world's poor people today. This same group, the report indicates, is likely to play the biggest role in global food security over the next several decades, as world population grows and peaks (at 9 billion or so) with the addition of another 3 billion people.

Remarkably, this is the first study ever to investigate the state of the world's most prevalent kind of farmers—those who keep animals as well as grow crops. A major implication of the new report is that governments and researchers are mistaken to continue looking to high-potential lands and single-commodity farming systems as the answer to world hunger. As the study shows, many highly intensive agricultural systems are reaching their peak capacity to produce food and should now focus on sustaining rather than increasing yields.

The authors of this multi-institutional and multi-disciplinary study, most belonging to centres of the Consultative Group on International Agricultural Research (CGIAR), agree with many other experts that we need to bring our focus back to small-scale farms. But this report goes further, distinguishing one particular kind of small-scale farmer that should be our focus: this is the mixed farmer growing crops and raising animals in the world's more extensive agricultural systems, which are described in detail on the next page.

These 'mixed extensive' farms make up the biggest, poorest and most environmentally sustainable agricultural system in the world. It is time we invested heavily in this particular kind of farming system. Here is where there remain the biggest yield gaps. Here is where we can make the biggest difference.

The billions of dollars promised by the international donor community to fund small-scale farming in developing countries are likely to fail unless policies are reoriented towards this particular, most ubiquitous, and till now most neglected, form of agriculture. What this 'extensive frontier' needs are the most basic forms of infrastructure and services. With these at hand, the world's extensive mixed farmers will be in good position to scale up their food production to meet future needs.

We recommend that interested readers read the full research report by the CGIAR Systemwide Livestock Programme, which you will find here: http://mahider.ilri.org/handle/10568/3020

Knut Hove
Chairman of the Board of Trustees

Carlos Seré
Director General


ARMY

Closing the yield gaps on the 'extensive frontier'

Important productivity gains could be made in the extensive mixed crop-livestock areas of developing countries. If we visualize the agricultural landscape as a dartboard, with the bull's-eye representing the most productive, intensively farmed, systems—those with the largest concentrations of mixed crop-livestock farms today—and the outermost rings representing pastoral areas that are the least productive and populated, and most marginal and sizable, of agricultural lands, we would view the rings in between these two extremes as the extensive mixed farming systems. While imperfect—these 'in-between' lands typically lack the soil quality and infrastructure, for example, of the intensively farmed regions—this is where the biggest growth in agriculture is likely to occur over the next several decades; these lands have considerable as yet untapped production potential.

Significant contributions to future food security could be made in the medium term by focusing on these extensive mixed crop-livestock systems of developing countries, where pressure on the land is less than in intensive areas and the gap between potential and current crop yields is large. It is estimated, for example, that with the right management and inputs, yields of sorghum, millet, groundnut, cowpea and other dryland crops could easily be increased by a factor of three. What these extensive mixed systems need are policies and investments to create incentives, reduce transaction costs and better manage risks.

Boosting production on this 'extensive frontier' will require a considerable shift in mindset as well as support. The extensive mixed farmlands are the forgotten farmlands in much of the developing world. Many of the resources currently invested in intensively farmed 'bull's-eyes' could be shifted to these lands further out. With better roads, markets, health facilities and other infrastructure and services for these extensively farmed lands, rural-to-urban migration rates could be slowed, and a new generation of food producers nurtured.

CONCLUSIONS

Making hard trade offs: We are in transition from an 'empty world' of unused resources to a world where water, energy, land and other natural resources are increasingly scarce and efficiency gains are key to meeting increasing food demands. The trade-offs in this modern 'full world' are becoming increasingly hard and difficult to manage. Mixed agricultural systems allow us to intensify food production in sustainable ways. As resources get scarcer while food demands grow, decision-makers will increasingly rely on agricultural sciences to make more equitable as well as judicious trade offs.

Addressing biomass scarcity: In addition to increasing scarcity of land and water, biomass itself will be in increasingly short supply. The challenge to find sufficient biomass to feed the increasing numbers of farm animals as well as poor people is an issue not yet on the world's radar.

Enhancing resilience: Mixed agricultural systems are particularly enabling in terms of

helping communities rebound from the seasonal disturbances (droughts, floods) and external shocks (market failures, civil unrest) that disproportionately affect the developing world's agricultural communities.

Paying for ecosystem services: In key agro-ecosystems, we shall have to protect the products and services of functioning ecosystems by providing payments to communities providing stewardship over these.

Coping with climate change: Climate change will be a further inexorable driver of change in smallholder agriculture worldwide, demanding on-going options for both adapting to these changes and mitigating the greenhouse gases that cause climate change.

Exploiting the extensive frontier: While we continue to invest in the short term in high-potential intensive farming systems, an opportunity exists over the medium term to make greater investments in the extensive frontier so as to exploit large yield gaps that still exist there.

Taking systems approaches: This synthesis makes the case for mixed crop-livestock production systems as being at the heart of global food security—now and in the future. As such, these mixed systems need to be addressed by researchers as whole systems. Such systems approaches to the development of small-scale agriculture worldwide are those most likely to lead to efficiencies not only in food production but also in such related fundamental areas as recycling nutrients and managing biomass. In addition, policymakers will increasingly require analyses transcending the traditional agricultural sector and incorporating issues of food security and systems, human health and employment, migrations and political stability, and global trade and energy.

Back to the future: Revisiting mixed crop-livestock systems

This chapter synthesizes results of a study, 'Drivers of change in crop-livestock systems and their potential impacts on agro-ecosystem services and human well-being to 2030,' being published in book form in 2011. The study was a collaborative endeavour conducted by a group of scientists in centres belonging to the Consultative Group on International Agricultural Research (CGIAR). The study was funded and coordinated by the CGIAR's Systemwide Livestock Programme and led by Mario Herrero, a livestock systems analyst at the International Livestock Research Institute.

Perhaps no global challenge facing us today is as daunting as the need to produce much more food, and do so in ways that are environmentally, socially and economically sustainable, for our fast-growing human population, which is predicted to rise from nearly 6.9 billion today to more than 9 billion in the next four decades, after which the world population is expected to stabilize and in some regions decline. (The global population growth rate has been declining since the 1960s.) Almost all population growth is occurring in the developing world, predominantly in Africa and Asia. Africa's population alone is on track to double in the first three decades of this century.

We need to find ways to feed the growing numbers of people until world population stabilizes. We need to help the 'bottom' billions of poor people, including the estimated two billion people today who are living on less than US$2 a day, to lift themselves out of poverty through agriculture and other means. We need to invent agricultural systems that both mitigate global warming and help small-scale farmers adapt to climate change. And we need to develop global food systems that conserve rather than deplete our land, water, forests, biodiversity and other natural resources.

Those are all, individually as well as together, tall orders. To meet these food challenges, we shall have to gain much more solid, refined and local understandings of the various agricultural systems we are relying on and the different pressures these systems are facing in different parts of the world. Such pressures include rapidly rising demand for animal products and a fierce competition for resources—chiefly land, water and biomass.

What follows is a summary of a study funded by the Systemwide Livestock Programme of the Consultative Group on International Agriculture Research (CGIAR) and led by ILRI. It was conducted by a group of CGIAR centres and partner institutions expert in widely varied commodities and representing widely varied scientific disciplines (Table 1). These researchers came together in this project to determine the forces most likely to drive change and shape our food production over the next two decades.

Mario Herrero	International Livestock Research Institute (lead coordinating author) (ILRI)
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John Dixon	International Maize and Wheat Improvement Center (CIMMYT)
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Russ Kruska	International Livestock Research Institute (ILRI)
John Lynam	Independent agricultural consultant
Siwa Msangi	International Food Policy Research Institute (IFPRI)
An Notenbaert	International Livestock Research Institute (ILRI)
Michael Peters	International Center from Tropical Agriculture (CIAT)
P Parthasarathy Rao	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
Philip Thornton	International Livestock Research Institute (ILRI)
Jeannette van de Steeg	International Livestock Research Institute (ILRI)
Stanley Wood	International Food Policy Research Institute (IFPRI)

***Table 1**. Researchers who participated in this study conducted by the Systemwide Livestock Programme on the drivers of change in crop-livestock systems to 2030.*

Framework for the study

The framework for the study was based on that developed for the *Millennium Ecosystem Assessment: Ecosystems, Economic Choices and Human Well-Being* (2005) and subsequently used for other major assessments, such as the *Global Environment Outlook 4* (United Nations Environment Programme 2007) and the *International Assessment of Agricultural Knowledge, Science and Technology for Development* (IAASTD 2008). This framework shares features with others for the *Intergovernmental Panel on Climate Change Fourth Assessment Report* (2007) and the *Comprehensive Assessment of Water Management in Agriculture* (2007).

The framework is based on the idea that a set of drivers, both direct and indirect, changes a system over time. The local development context determines which direct and indirect drivers play important roles in a given system and location. Different drivers of change exert different kinds of pressures on agro-ecosystems. Different kinds of drivers, such as land-use changes, resource and input use and competition for biomass for food, feed or energy, impact different kinds of services provided by agro-ecosystems, with consequences that can hurt fundamental human well-being in terms of income, health, food security, vulnerability and so on. To address such problems, we can either regulate the drivers so as to minimize the pressures they generate or we can develop ways to adapt our agro-ecosystems services to the changes they are undergoing.

The authors of this study coupled an IMPACT-Water model (Rosegrant et al. 2009) with a farming systems classification and a range of spatial disaggregation methods for looking at alternative scenarios of change in mixed crop-livestock systems to 2030. The scientists built upon the results of the IAASTD (2009) and used a reference scenario that was designed to mimic 'business-as-usual' conditions of growth in agriculture, incomes, population and other relevant factors. The research group also investigated the probable consequences of an increased demand for biofuels and an increased expansion of irrigation to produce more food and feed.

Rationale for the study

Developing-country demand is increasing for meat, milk and eggs, especially as incomes rise in many formerly very poor countries and people become newly able to afford more nourishing foods (Table 2). Demand in these countries is also increasing for better quality meat, milk and eggs, particularly among urban consumers who purchase their perishable foods from supermarkets. The environmental consequences of these two trends could be enormous, given that these increases in animal-source foods will need to be made from basically the same land and water resources we have today.

It appears that the increasing demand for meat will be met mostly by increased monogastric (chicken and pig) production, which has large consequences for cereal production, which will also have to increase to feed these monogastrics. It is predicted that by 2050, people and animals will be consuming roughly the same amount of grains (Figure 1). Populations of cattle, sheep, goats and other animals are likely also to increase substantially.

Consumption		Annual per capita		Total	
	year	Meat (kg)	Milk (kg)	Meat (Mt)	Milk (Mt)
Developing	2002	28	44	137	222
	2050	44	78	326	585
Developed	2002	78	208	102	265
	2050	94	216	126	295

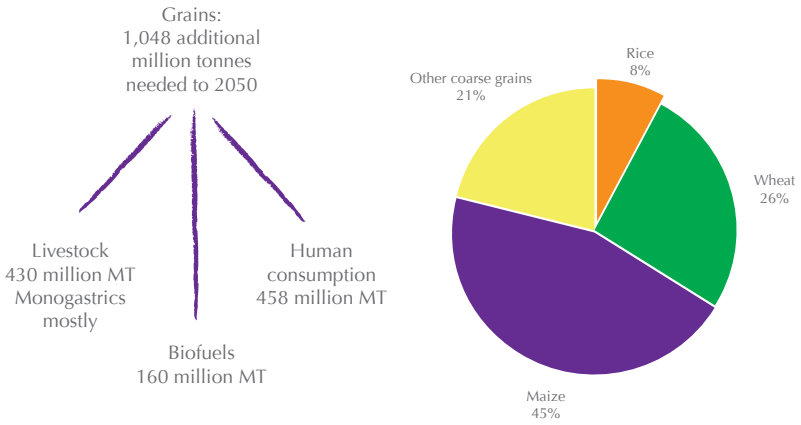
Table 2. *Demand for livestock products to 2050 is expected to rise. Source: Rosegrant et al. 2009.*

Other factors determining the viability of developing-country agricultural systems in the coming years are the level of development in a particular region, how much water and energy resources are available for farming there, and how much competition exists for non-agricultural uses of land. The impacts on farming of any given driver of change depend on the type and size of farming system and its location—whether, for example, the system comprises heavily irrigated plots in South Asia, rain-fed fields in sub-Saharan Africa or large-scale ranches in South America.

Where, and what, are the breadbaskets of the world today and tomorrow?

In the developing world, which is the epicentre of both rising populations and rising food demands, the predominant form of farming is

Figure 1. Additional cereal grains needed to 2050 and share of the projected contributions of different staples
The world will require 1 billion tonnes of additional cereal grains to 2050 to meet (human) food and (animal) feed demands (IAASTD 2009).



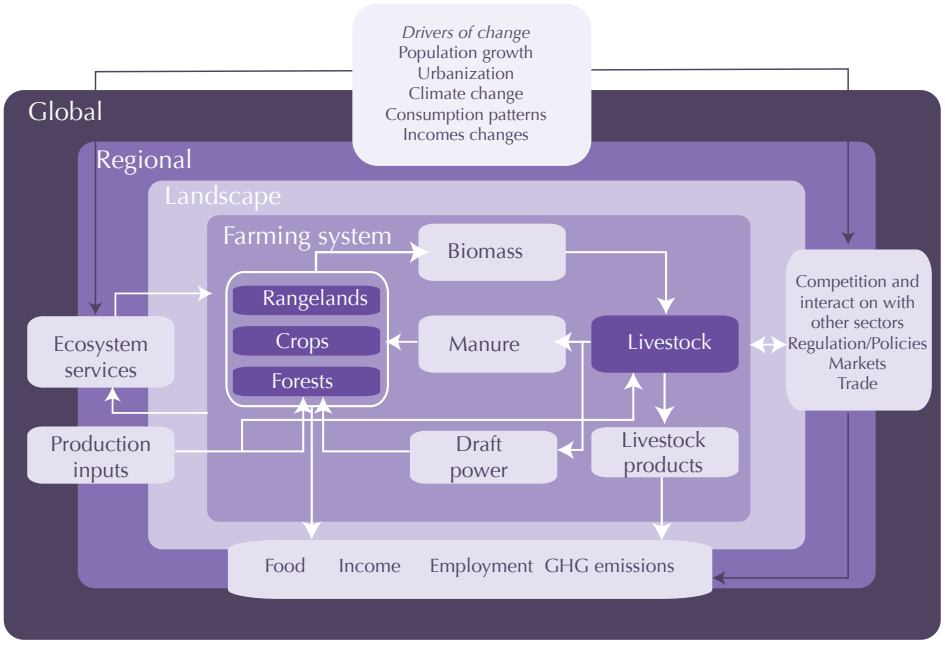
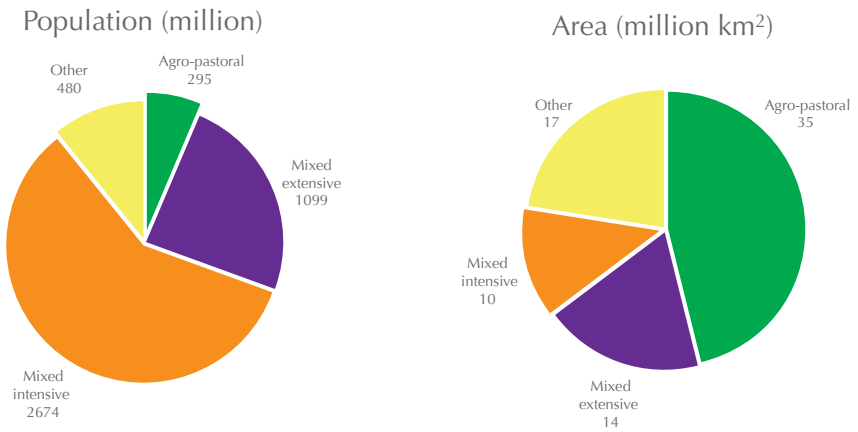


Figure 2. Main interactions in mixed crop-livestock systems in the developing world
*Source: Herrero et al. 2010 (*Science *327: 822–825).*

a traditional kind that combines crop growing and livestock keeping. Such farming is generally known as 'mixed crop-and-livestock', or just 'mixed', production systems. The farms in these systems are small in size—typically less than a few hectares—with millet, maize, rice and other staple food crops cultivated along with the raising of a mix of cattle, buffalo, sheep, goats, pigs, poultry or other kinds of domestic livestock. The synergies of crop and animal components of these mixed production systems are as old as agriculture itself: the stover and other wastes from the crops help to feed the animals while the animal traction helps to plough the lands and the animal manure to fertilize them (Figure 2). In addition, regular sales of milk, meat and eggs as well as surplus animal stock help to smooth household incomes and consumption and to sustain the poorest family farms through lean dry seasons or to manage the risk of droughts, floods, crop failures and other disasters.

These mixed crop-and-livestock agricultural systems remain the bedrock of developing-world agriculture—and developing-world agriculture, this study argues, is itself the bedrock of global food security. Fully two-thirds of the people in the world live in regions where these mixed farming systems supply most of the food available

Figure 3. Human populations and mixed systems
Globally, most people are (and will be) living in regions where mixed crop-livestock systems predominate. Source: Herrero et al. 2009.



Why livestock matter to the world's one billion small-scale farmers

Farms that simultaneously grow crops and raise livestock are found everywhere in the developing world because they offer small farmers optimal ways to integrate different production enterprises and to diversify livelihood strategies, thus reducing their risks. Regular income generated by sales of milk, meat and eggs, for example, or occasional sales of surplus stock, helps protect households against crop failure and other shocks and helps families get through the annual 'hungry season' that arrives in the weeks leading up to harvest-time, when the stocks of the last harvest are depleted and the new harvest has not yet been brought it.

(Figure 3). It is these mixed smallholdings in poor countries—not, as many people believe, the breadbaskets of rich countries—that most of the world's 2 billion poor rely on for their food today. Even greater numbers of marginalized people will rely on these smallholdings in future. We need to make greater investments in these mixed smallholder food systems of the developing world, which we are so greatly relying on for global food security.

What are 'mixed' systems?

There are two main kinds of mixed crop-livestock systems. *Extensive* mixed crop-livestock farming tends to be rainfed, to occur in regions with medium population densities, and to have moderate agro-ecological potential and weak links to markets. Farmers in these extensive systems make little use of chemical fertilizers and other purchased inputs. *Intensive* mixed crop-livestock farming is characterized by irrigation, high population densities, high agro-ecological potential and good links to markets. Farmers in these intensive systems make intensive use of purchased inputs. The other two main agricultural systems that incorporate livestock are (1) agro-pastoral and pastoral systems, which are characterized by low population densities, low agro-ecological potential and weak links to markets; crop production in these areas is marginal and people rely mostly on livestock production for their livelihoods; and (2) industrial systems, which occur mostly in peri-urban areas and are characterized by large 'vertically integrated' production units that make use of feed, genetic and health inputs in highly controlled environments. Such industrial systems account for the largest share of the volume of pig and poultry production (Bruinsma 2003).

Despite the ubiquity of mixed farms throughout the developing world, research and development efforts to increase food security typically still focus on just one component of these systems, such as a crop (e.g., maize or rice) or a form of livestock production (e.g., poultry keeping or cattle herding), in isolation. Most food and agricultural experts thus fail to address crop-and-livestock farming, the most predominant form of agriculture today, as the complex, interwoven production system that it is.

Another fact often overlooked by development workers is that smallholders keep and use livestock for many purposes other than income.

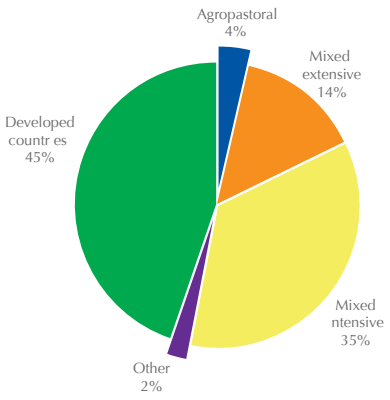


Figure 4. Smallholder mixed systems and world cereal production in 2000

Mixed systems produce almost 50 per cent of the cereals of the world today and this share will increase to over 60 per cent by 2030. Most production currently comes from intensive systems but in the future the greatest potential to increase yields is likely to be in the more extensive areas. Source: Herrero et al. 2009.

What these farmers need, therefore, are livestock practices that will best allow them to meet their multiple objectives, typically including food, income, insurance, savings, manure and traction. Researchers in livestock for development thus need to look carefully at the trade-offs and efficiencies inherent in various livestock practices, tools and policies to help determine which of these are appropriate interventions in which circumstances and—because these circumstances are continuously changing—to determine when interventions are appropriate and when they need to be modified. With such approaches, the synergies generated by producing both crops and animals should offer researchers, development experts and farmers alike many new opportunities for raising farm productivity and human well-being while better protecting the environment.

The poor feed the poor

The Systemwide Livestock Programme study makes it clear that mixed crop-livestock farming in the world's developing countries is key to future global food security.

There are four main reasons for this.

(1) First, the study reveals that smallholder crop and livestock farmers already produce 50 per cent of the world's cereals (Figure 4).

Mixed farmers also produce most of the staples consumed by the world's poor: 41 per cent of maize, 86 per cent of rice, 66 per cent of sorghum and 74 per cent of millet production (Figure 5).

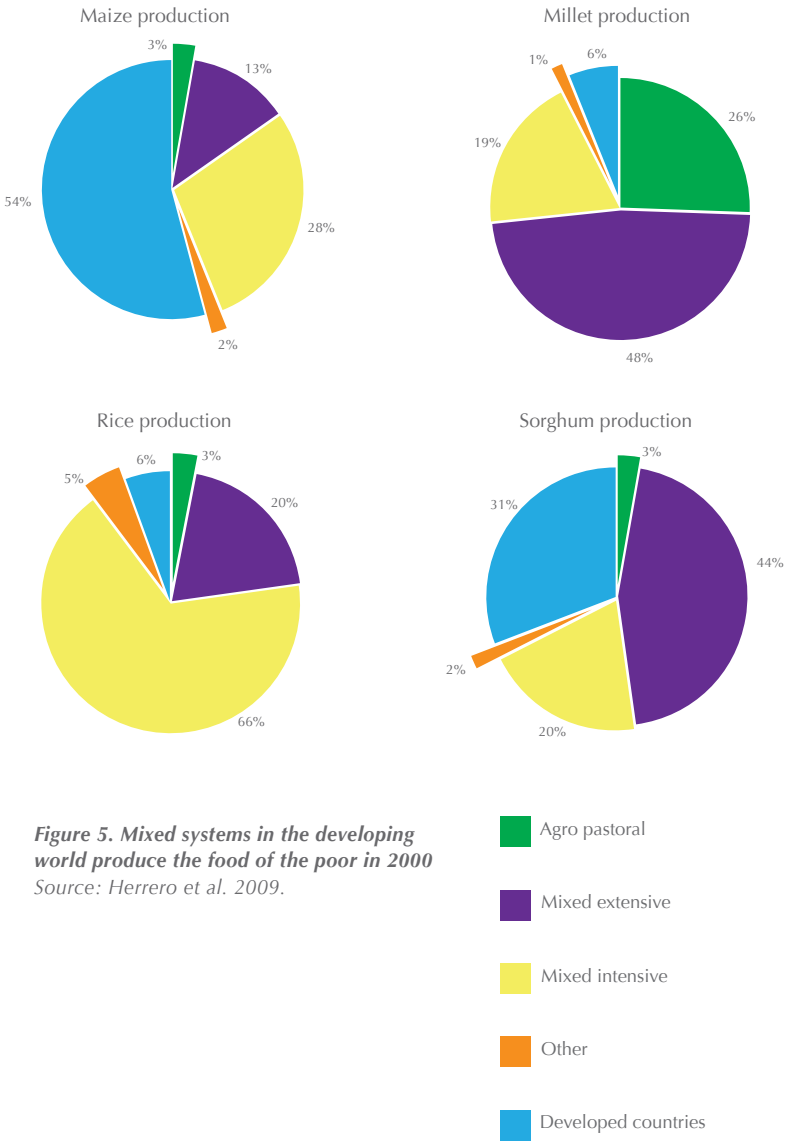


Figure 5. Mixed systems in the developing world produce the food of the poor in 2000
Source: Herrero et al. 2009.

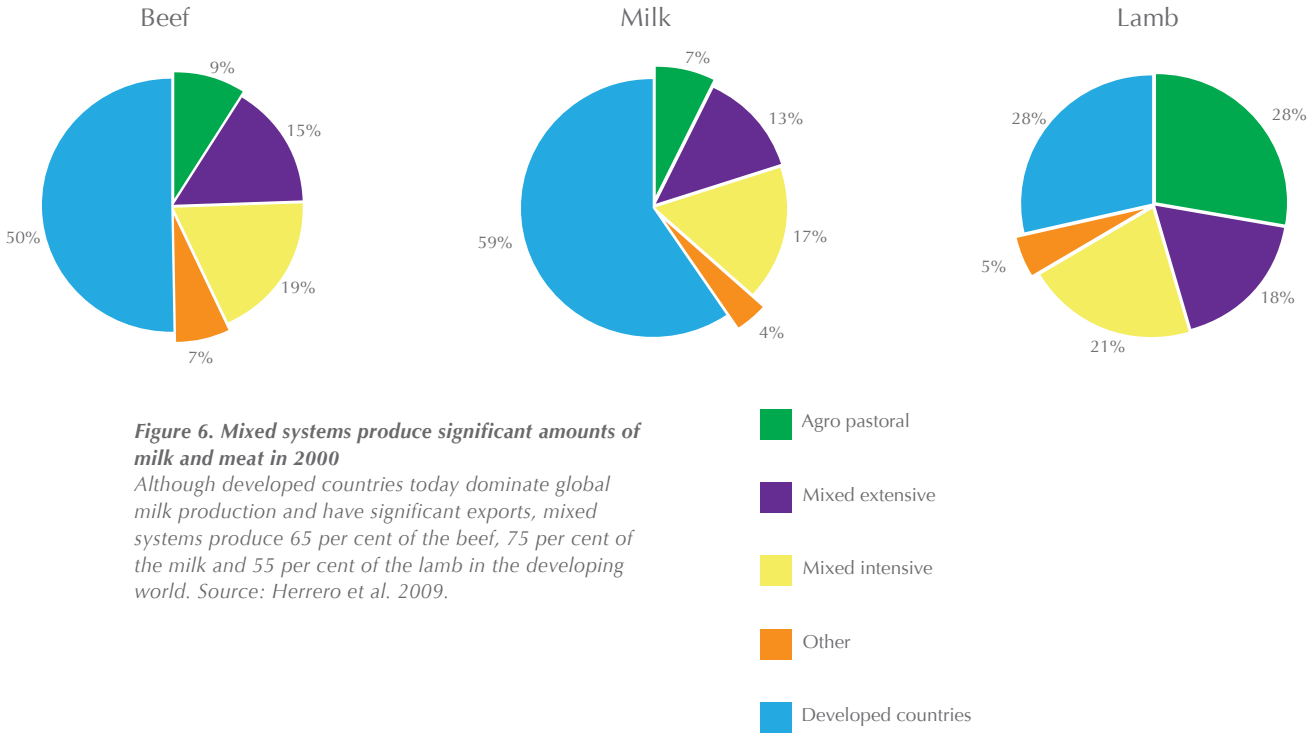


Figure 6. Mixed systems produce significant amounts of milk and meat in 2000
Although developed countries today dominate global milk production and have significant exports, mixed systems produce 65 per cent of the beef, 75 per cent of the milk and 55 per cent of the lamb in the developing world. Source: Herrero et al. 2009.

Mixed farms also produce the bulk of livestock products in the developing world—75 per cent of the milk and 60 per cent of the meat (Figures 6 and 7).

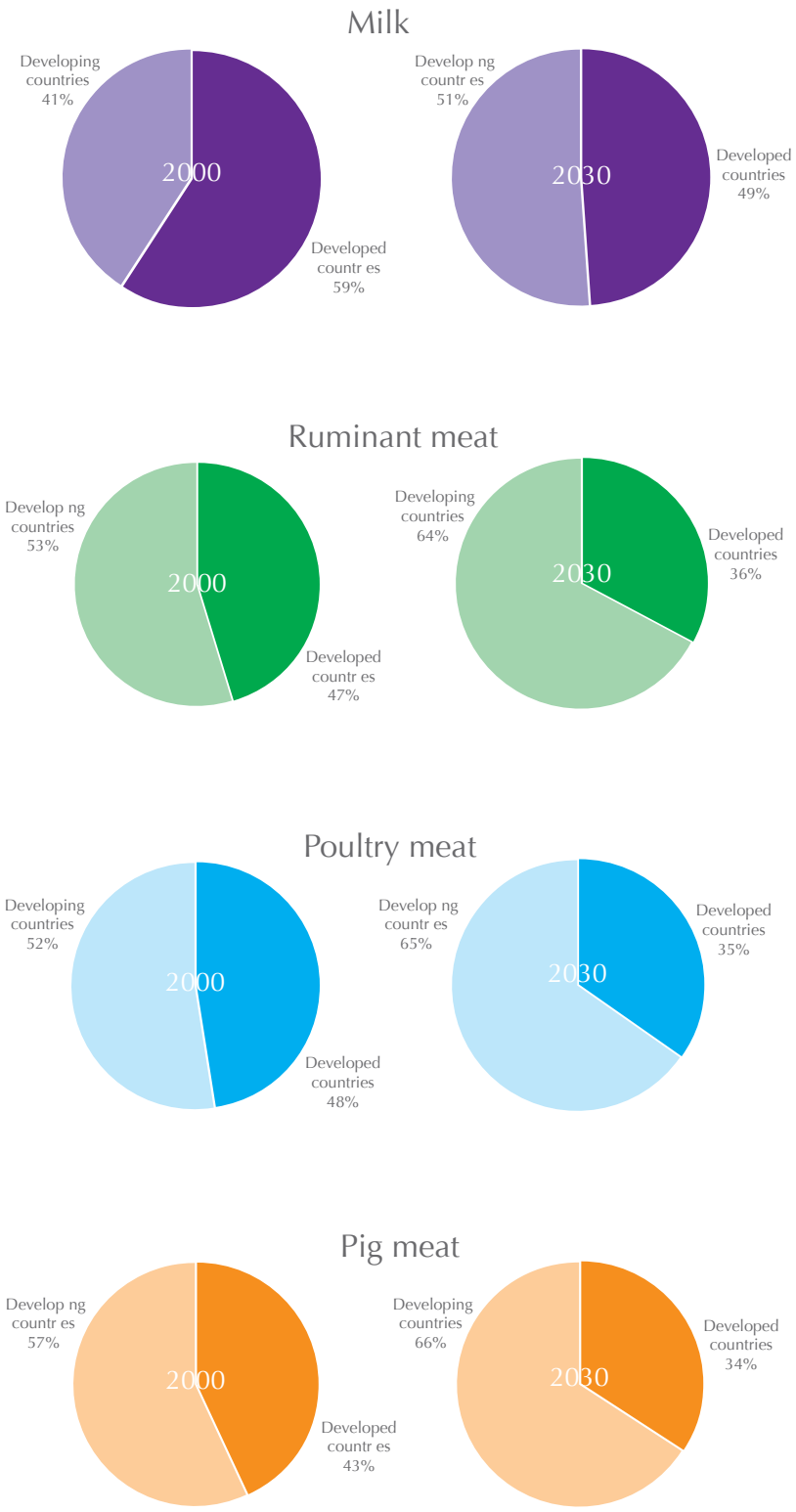
(2) The second reason mixed farming is key to food security is that mixed farms employ many hundreds of millions of people along the whole chain of activities needed to produce, harvest, store, transport, sell and consume foods.

(3) Third, only 5–10 per cent of even the most heavily traded livestock commodities are ever traded internationally; the rest is produced and consumed locally. Surpluses produced in rich countries provide at the most no more than 10 per cent of milk, meat and eggs to the world. Local food systems, then, are where most of the action is in global food security—and must be given much greater attention and support.

(4) Fourth, the study data indicate that by 2030 the mixed crop-livestock systems of the developing world will surpass farms in the developed world in their production of cereals and some livestock products as their production growth rates are significantly higher than growth rates in the developed world (Figure 8).

But even these substantial increases in production of cereals and livestock products will be insufficient to stay abreast of population growth. If these mixed farms are to provide enough food to feed the swelling numbers of people in the developing world, and do so largely in sustainable ways, agricultural policy must be reoriented, first to embrace the centrality of mixed crop-livestock systems to food security, second to resolve major problems affecting these systems in particular, and third to find ways to further refine the integration of crop and livestock production so that each can better sustain the other.

Figure 7. Growth of milk and ruminant meat, poultry meat and pig meat in developing countries
The percentages of these livestock foods now produced by developing countries are all projected to increase significantly over the next two decades. Source: Herrero et al. 2009.



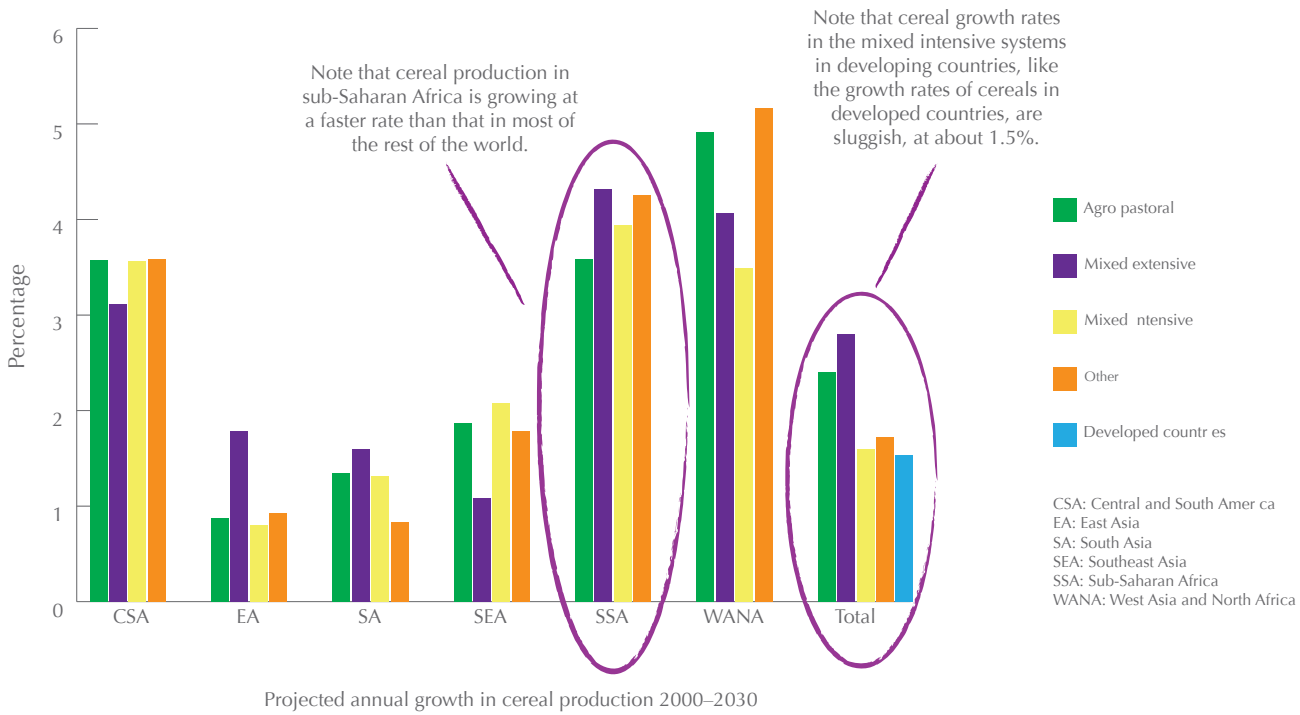


Figure 8. Projected cereal growth in mixed systems to 2030
Projected rates of growth of cereal production in mixed systems of developing countries are higher than those in developed countries. Source: Herrero et al. 2009.

Many mixed intensive systems are already at or nearing peak capacity

In many regions of the developing world, farmlands long viewed as having the highest potential for production—the intensively cultivated areas where farmers concentrate both crops and livestock—are either already maxed out or are nearing their peak capacity (IAASTD 2009 and MA 2005).

Essentially, the resource pressures faced by these intensively farmed lands are retarding, and in some cases ending, the substantial food growth rates of recent decades. The pressures are larger in some systems than in others, but all are caused by the increasing demands of fast-growing human populations, with their rising incomes and urbanization.

Water, for example, is becoming a severe constraint in the rice and wheat belts of South Asia at a time when livestock numbers are expected to increase significantly there over the next two decades. The numbers of cattle and buffalo are projected to rise from 150 to 200 million and the number of pigs and poultry by 40 per cent or more by 2030. This will push up the water requirements of livestock farmers wanting to grow fodder for their animals several fold and place livestock farmers in direct competition with crop farmers wanting to irrigate their lands.

Similar limits on the availability of natural resources can be found in the East African highlands and other high-potential agricultural areas of Africa. Already, many farming regions in Africa are weakened by infertile soils, degraded lands, depleted water sources, carbon losses, shrinking farm sizes and decreasing farm productivity. Recent research suggests that some

of these areas will not respond to traditional ways of increasing productivity, such as applying more fertilizer to restore soil health, but will need a closer integration of livestock and crop production to improve overall food security (Tittonel et al. 2009).

Prices will rise sharply for food and feed crops and (less so) for livestock products

In sub-Saharan Africa, a rise in hunger in children and other vulnerable groups is anticipated in the mixed intensive regions because such regions are likely to attract more people than their available resources can support. Competing demands for land, fuel and natural resources could, if today's trends continue, also drive up the prices of crops dramatically. The largest price increases are projected to occur in cereals, some oil crops and tubers such as sweet potato, which are, in addition to food, used for animal feed and to produce biofuels. The prices of maize, wheat, sorghum, sweet potato and oil grains are all likely to more than double by 2030.

The price of animal products is also expected to increase, though less so, because meat, milk and eggs, which are consumed in quantity by the more affluent members of developing-country societies, are already priced relatively high there. The rate of livestock price increases could be slowed by the adoption of intensification practices that make livestock production more efficient. Efficiency gains are especially likely for poultry, pigs and milk—all of which can be produced in larger volumes by relatively modest modifications made to increase the quality of the diets of the animals. And an increased supply of small ruminant products from pastoral and mixed systems is expected to slow price increases for goats and sheep relative to pigs and chickens.

Yet prices will continue to rise for livestock products, even if not at the pace of crops. Higher costs for animal products will make it harder for poor people to meet their dietary requirements for protein through meat and milk.

The livestock revolution will sharply increase production of all types of farm animals

The demand for livestock products is rising globally and will increase significantly in the coming decades in developing countries because of income shifts, population growth, urbanization and changes in dietary preferences in these countries. This increased demand will vary across regions.

Animal numbers

Marked differences, for example, occur in the projected growth of cattle populations in different regions. The head of cattle in East Asia is predicted roughly to double by 2030 due to sharply rising demand from increasing numbers of people there that are no longer poor. Large increases in cattle numbers are also expected in Latin America.

Animal products

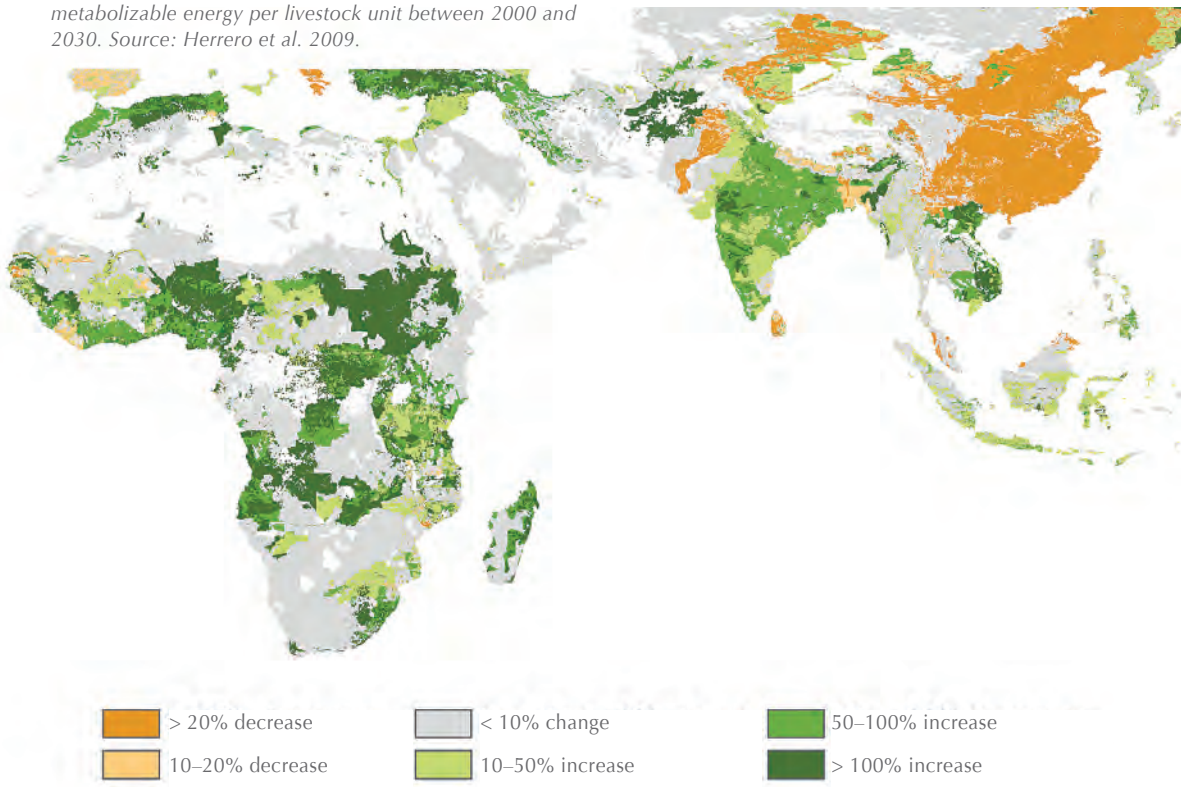
Milk and beef: Projected growth rates in milk and beef production outpace the projected growth rates in animal numbers, indicating that technical efficiencies will need to be made in dairy and beef systems. Nevertheless, most production increases are still mainly due to an increase in overall animal numbers. Intensive crop-livestock systems stand out because milk production on these types of farms, given current conditions, could rise by 64 per cent by 2030 and more than double if irrigation is expanded. Sharp increases in milk and beef production are projected across Asia, with less dramatic increases in Latin America and the West Asia and North Africa region.

Pork: Pig numbers are highest in the most intensive systems and in East Asia. The efficiency with which pigs convert feed to meat can be improved through better feeding, which reduces the number of animals and amounts of grain needed per kilo of output, to satisfy the increasing global demand for pork. For cultural and dietary reasons, some regions will not experience large growth in pig numbers and production, while in others, such as Southeast Asia, pig production will more than double.

Feeding more farm animals will challenge agricultural systems

If farmers in the developing world are to satisfy (and benefit from) rising demand for animal products, new strategies and policies will need to be developed to ensure there is enough feed to sustain a scale-up of livestock operations. In the mixed crop and livestock farms of the developing world, for example, cattle, goats, sheep and other ruminant livestock get more than half of their feed from crop residues—the crop material that remains after the grain has been harvested, such as maize stover or cowpea leaves and other green matter. The viability of this type of livestock production is thus directly linked to the viability of crop production. In many regions, the projected increases in ruminant numbers outpace projected rates of growth in available stover per

Figure 9. Projected availability of cereal stover
Feed from cereal stover: The percentage change of metabolizable energy per livestock unit between 2000 and 2030. Source: Herrero et al. 2009.



animal. The result will be feed deficits. To feed the greater number of ruminant animals, crop yields will have to increase and crop stover be further amended for greater livestock intake.

Changes in stover production are expected to vary widely from region to region over the next two decades (Figure 9). In Africa, predicted increases in maize, sorghum and millet production due to an expansion of croplands can be expected to increase the amount of stover available for animals. But the availability of stover per animal will decrease in other areas, such as much of East Asia, with high growth rates in ruminant production.

Where animals can no longer be maintained on leftover crop materials available on the farm, farmers will have to purchase feed. While in some areas animal feed can be obtained relatively easily and locally, there is reason to be alarmed about how this feed shortage will play out in parts of Asia, where animal and human needs for feed and food appear to be on a collision course, with

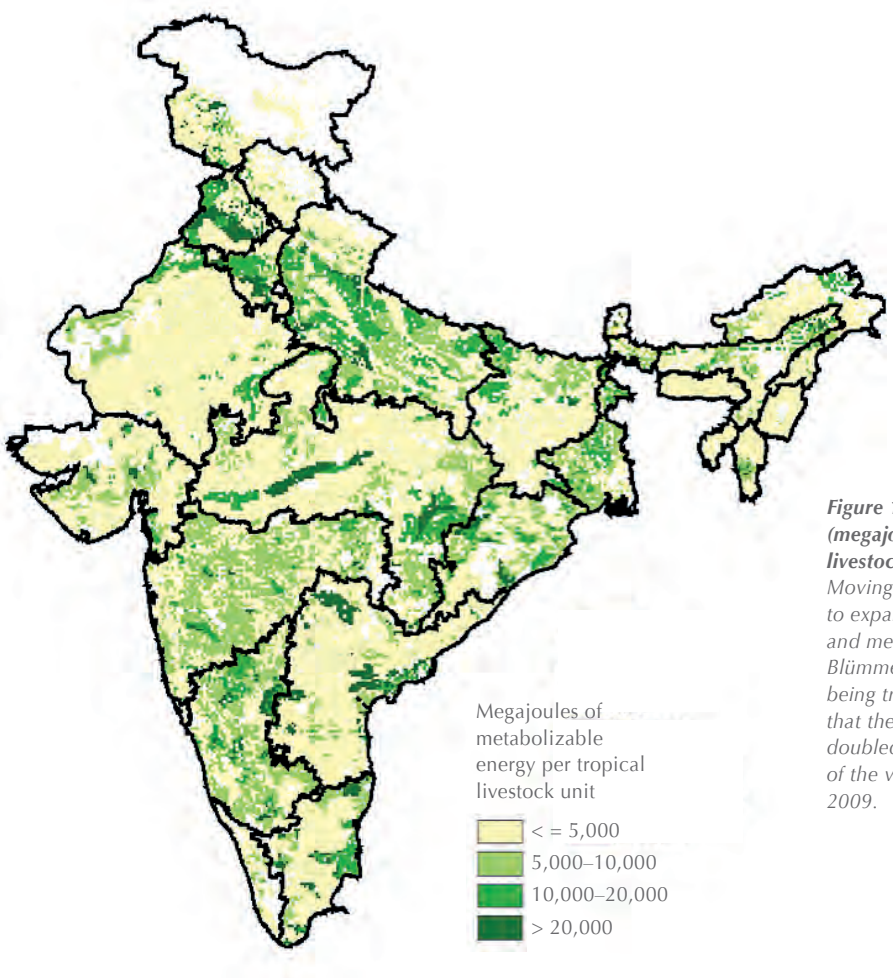


Figure 10. Feed availability in India in 2000 (megajoules of metabolizable energy per tropical livestock unit)
Moving megajoules: Local fodder markets are likely to expand in areas of feed deficits as demand for milk and meat increases. ILRI animal nutritionist Michael Blümmel reports that in parts of India stovers are now being transported more than 400 km to be sold and that the price per kilogramme of sorghum stover has doubled in 5 years and now equals up to two-thirds of the value of sorghum grain. Source: Herrero et al. 2009.

both competing for a limited amount of water and land.

Grains can also be used for ruminant animal feed, but they drive up the costs of both ruminant products and grains, making both unaffordable for the poor. If farmers are forced to use grain to maintain their ruminant as well as monogastic animals, the poor could lose out on dietary benefits of the livestock revolution, or at least the benefits of consuming products derived from both ruminants and monogastrics.

Fodder available for ruminants can be increased in several ways, such as by breeding better grasses and crops, sourcing forages from adjacent areas and making better use of farm by-products. Another way to deal with an anticipated shortage of feed for animals is to increase trade in animal fodders and stovers. Stovers already are being traded in India over vast distances and are being priced according to quality. With the right incentives and reductions in transaction costs, as fodder prices increase, areas of surplus can trade with areas of deficits (Figure 10).

Expansion of biofuels could reduce food consumption in poor households

Under mounting pressure to improve national energy security and combat global climate change, countries are now turning to ethanol and biodiesel to meet rising transportation fuel demands. The main biofuel feedstocks are maize, wheat, sugarcane, cassava and sweet sorghum for bioethanol and rapeseed, oil palm, soybean and sunflower seed for biodiesel. Cassava and

BOX 25

Smallholder farm plots will get smaller still

Although there will be an increasing percentage of people living in cities in the future (already, about half the world's population inhabits urban areas), there will still be a huge increase in the coming decades in the numbers of people living in the rural areas. We should thus not expect to have more land per capita for developing-country farmers in the future. Farm plots are bound to get smaller in most regions, not larger.

sweet potato are other key biofuel crops and will experience large increases in area and production, mostly in sub-Saharan Africa. The expansion of biofuels will likely reduce household food consumption in the developing world, particularly among poor urban households and the many rural households that are net buyers of food.

Growing demand for food crops as biofuel feedstock is already pushing up the price of livestock feed. Developing technology that will allow other plant materials to serve as feedstock for biofuels is often touted as a solution to the conflict between food and fuel production. But that solution could make the problem worse, with biofuel production also competing with livestock for pasture lands, stover and fodder.

Improving the efficiency of intensive mixed farms of the developing world

In the near future, many of the breadbaskets and ricebowls of the developing world will require significant efficiency gains to produce more food without using more land, water and other inputs. When it comes to producing more meat and milk, there are considerable opportunities to increase efficiencies and yields. Over the last 30 years, for example, researchers have doubled the efficiency with which chickens and pigs convert grain into meat, thereby reducing the amount of grain needed to produce a unit of poultry and pig meat.

In some regions, making more efficient use of existing resources will require farmers to change the breeds or even species they keep. Switching from cattle to chickens and other such species shifts are already occurring in South Asia's intensive mixed crop-livestock systems. Areas that adopt intensive industrial livestock production to satisfy food demands will require environmental and trade regulations to manage the environmental costs often attending high concentrations of animals, such as polluted drinking water and disease outbreaks among both livestock and people. For example, while growth in the monogastric sector has reduced global poultry and pork prices significantly, a by-product has been an increase in cereal prices and greater

deforestation in the neo-tropics. New policies, technologies and practices are needed to address these problems.

While it's possible to get more production out of some intensive systems, others, particularly in parts of Asia, have reached or exceeded their limits. These need either to stop growing or to reduce their production levels to remain viable. Regulatory frameworks for sustainable food production should define the limits of agricultural intensification. A set of agreed-upon intensification thresholds is needed to avoid causing irreparable environmental harm that, among other things, can lead to a crash in food production.

Appendices

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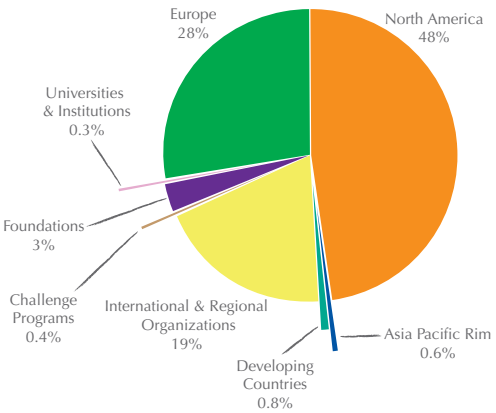
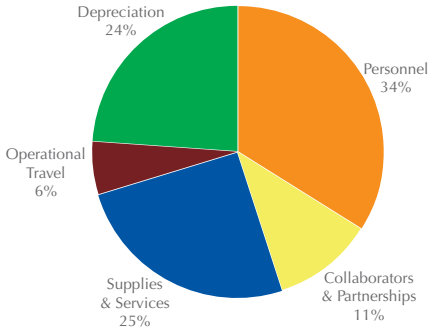
Financial highlights 2009

ILRI funding by type of donor



ILRI expenditure by object



ILRI's revenue in 2009 amounted to USD57.7 million, an increase of 32% over revenue in 2008. Expenditure for the year was USD56.5 million, an increase of 35% over expenditure in 2008. The increase in both income and expenditure is greatly attributable to the finalization of construction of BecA facilities. Unrestricted grant revenue made up 27% of ILRI's total revenue in 2009. The share of restricted revenue (including funds restricted to Challenge Programs) increased to 66% of total revenue in 2009. Centre income declined from 10% of total revenue in 2008 to 7% of total revenue in 2009. Programmatic expenditure represented 77% of all expenses in 2009. The institute's net assets amounted to USD26.39 million as of 31 December 2009, with liquidity and long-term stability indicators above CGIAR recommended ranges. Financial indicators show the institute's financial health continues to be sound. For the full financial report, go to http://mahider.ilri.org/handle/10568/2087

UNRESTRICTED GRANTS

Australia
Belgium
Canada
China
Denmark
Finland
France
Germany
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Netherlands
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Sweden
Switzerland
United Kingdom
United States of America
World Bank

PROGRAM GRANTS

Program restricted

Canada
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Ireland
Italy
Norway
Portugal
Switzerland
United States Agency for International Development (USAID)
World Bank

Project restricted

African Development Bank (ADB)
African Wildlife Foundation (AWF)
Alliance for a Green Revolution in Africa (AGRA)
Armenia
Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA)
Australian Centre for International Agricultural Research (ACIAR)
Austria
Bill and Melinda Gates Foundation (BMGF), USA
Bioversity International (IPGRI)
Canadian International Development Agency (CIDA)
China
Comart Foundation (CMF)
Consultative Group on International Agricultural Research (CGIAR)
Department for International Development (DFID), UK

Empresa Brasileiria de Pesquisa Agropecuária (EMBRAPA), Brazil

European Development Fund (EDF)

Food and Agriculture Organization of the United Nations (FAO)

French Agricultural Research Centre for International Development (CIRAD)

German Academic Exchange Service (DAAD)

Gesellschaft für Technische Zusammenarbeit (GTZ), Germany

Global Alliance for Livestock Veterinary Medicines (GALVmed), UK

Global Crop Diversity Trust

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Michigan State University, USA

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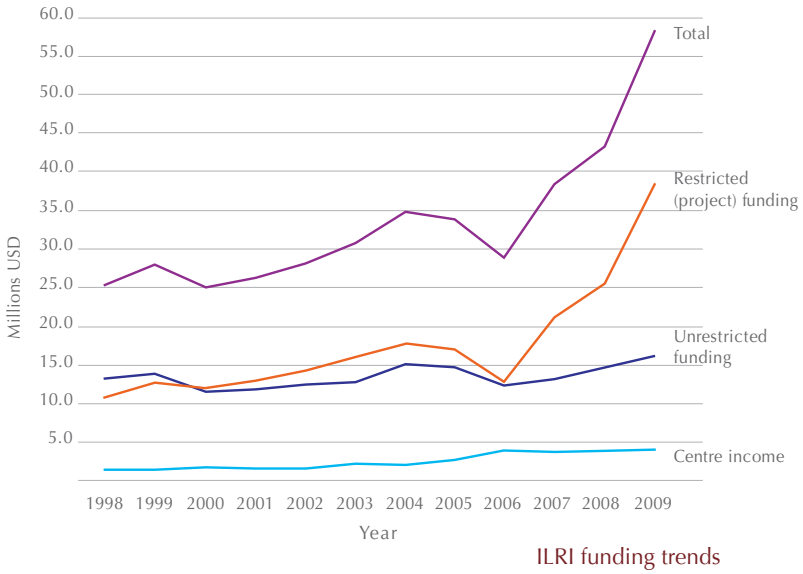
National Veterinary Institute (SVA), Sweden

Natural Resource International Limited (NR International), UK

Netherlands Foundation for the Advancement of Tropical Research (WOTRO)

OPEC Fund for International Development (OFID)

Pfizer Global Research and Development (GRD), USA



ILRI funding trends

Purdue University, USA

Rockefeller Foundation, USA

Sir Ratan Tata Trust (SRTT), India

Sweden

Swiss Agency for Development and Cooperation (SDC)

Swiss College of Agriculture

Swiss Federal Institute of Technology (ETH)-Swiss Centre for International Agriculture (ZIL)

Syngenta Foundation

Terra Nuova, Italy

Texas A & M University (TAMU), USA

University of Guelph, Canada

Training restricted

Makerere University, Uganda

United States Agency for International Development (USAID)

United States Civilian Research & Development Foundation (CRDF)

United States Department of Agriculture (USDA)

United States National Science Foundation (NSF)

University of Copenhagen, Denmark

University of Edinburgh, UK

University of Florida, USA

University of Glasgow, UK

University of Nairobi, Kenya

University of Syracuse, USA

Vétérinaires sans Frontières (VSF)

Wellcome Trust, UK

World Agroforestry Centre (ICRAF)

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Selected staff 2009

At the end of 2009, ILRI employed more than 700 staff, of whom about 10 per cent were leading research groups; these 68 scientific leaders at ILRI represented more than 30 scientific disciplines. In total, ILRI had 102 professional staff leading both research and research support groups at the end of 2009; these staff members are listed below, along with their scientific disciplines (where relevant) and nationalities. These 102 staff members came from a total of 28 countries, most of them developing (57 staff came from 16 developing countries [2 from Latin America, 7 from Asia and 48 from Africa] while 45 staff came from 12 developed countries [4 from Australia/New Zealand, 10 from North America, 31 from Europe]). A total of 35 per cent (36) of these staff members were women; 65 per cent (66) were men. Unless otherwise stated, all of these staff members were located in Nairobi, Kenya, or Addis Ababa, Ethiopia. For a full list of ILRI's current staff worldwide (excluding some staff managed by ILRI partner organizations in regions outside eastern Africa), please visit ILRI's website: www.ilri.org

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Linda Opati, Kenya	*legal and intellectual property officer*
Peter Getugi, Kenya	*internal audit manager*
Vivian Awuor, Kenya	*executive assistant to the director general*

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Fred Unger, Germany	*veterinary epidemiologist (based Thailand)*
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Ranjitha Puskur, India	*agricultural economist*
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Peter Ballantyne, UK	*head of knowledge management and information systems*
Ponniah Anandajayasekeram, Sri Lanka	*capacity strengthening manager*
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Lucy Macharia, Kenya	*compensations and benefits manager*

About ILRI and the CGIAR

ILRI works with partners worldwide to enhance livestock pathways out of poverty. Our products help poor people keep their farm animals alive and productive, improve their livestock and farm productivity, and sell their animal products in markets. ILRI has campuses in Kenya (headquarters) and Ethiopia, with other offices located in other regions of Africa (Mali, Mozambique, Nigeria) as well as in South Asia (India, Sri Lanka), Southeast Asia (Laos, Thailand, Vietnam) and East Asia (China). For more information, visit www.ilri.org or sign up for alerts from our News (http://www.ilri.org/ilrinews), Clippings (http://ilriclippings.wordpress.com) or related blogs (http://www.ilri.org/NewsFeeds).

ILRI is one of 15 centres belonging to a Consortium of International Agricultural Research Centers (CGIAR), which works to reduce hunger, illness, poverty and environmental degradation in developing countries by generating and sharing new knowledge, technologies and policies. The centres are funded by a multi-donor trust fund supported by more than 60 governments, foundations and international and regional organizations.

The CGIAR is completing a restructuring for greater impacts. In December 2009, it adopted a new institutional model consisting of a balanced partnership between donors and researchers established in the course of 2010. The new CGIAR Fund works to improve the quality and quantity of funding by harmonizing donor contributions, while a new Consortium of CGIAR Centers is uniting the centres under a legal entity that provides the Fund with a single entry point for contracting centres and other partners to conduct research. Shifting to a more programmatic approach, the CGIAR centres will operate within a Strategy and Results Framework aimed at strengthening collaboration for greater efficiency and development impact. A portfolio of CGIAR Research Programs is being developed to deliver international public goods that address major global issues in development. An Independent Science and Partnership Council provides the CGIAR with critical advice and expertise.

For more on the CGIAR, see websites of the:
CGIAR: http://www.cgiar.org
Change management process: http://cgiar.org/changemanagement/index.html
Fund Office: http://www.cgiarfund.org/cgiarfund
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website updates: feed://cgiar.org/cgiarweb.xml
'CGIAR in Action' blog: http://cgiarinaction.wordpress.com

Picture captions

All pictures by ILRI/Stevie Mann.

FRONT COVER
India: A farmer and her calf in the foothills of the Himalayas in Uttarakhand.

PAGE 2
India: A mixed farmer in West Bengal carries his wooden plough to his fields.

PAGE 4
Niger: A woman gathers forages for her sheep in Fakara Village.

PAGE 6
India: A youth is employed in the small-scale dairy business in Nagaland.

PAGE 9
India: A chicken and manure drying for household fuel under a traditional farm cart in West Bengal.

PAGE 10
Laos: A rice farmer and his grazing buffalo.

PAGE 15
Kenya: (Box: 'Why livestock matter to the world's one billion small-scale farmers') Goat being fed by hand in Embu.

PAGE 25
Mozambique: (Box: 'Smallholder farm plots will get smaller still'): A domestic pig in the compound of a typical dryland mixed-farming household.

PAGE 27
Mozambique: A woman feeds her household pigs.

PAGE 28
Kenya: A mixed farmer feeds her goat forages she has gathered.

PAGE 34
Niger: A woman feeds one of two sheep she is fattening to sell for profit.

PAGE 36
India: A girl in Rajasthan carries cow manure to be used to replaster her family's home.

INSIDE BACK COVER
Nigeria: A farmer holding a hoe stands before his cattle in a mixed farming humid region of Oyo State.

BACK COVER
Niger: A farmer holding a weeding implement corrals his cattle on his millet fields overnight to fertilize his soils.

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