Promising Technology Report: ILRI

Promising Interventions for Livestock Production and Productivity Improvement

in Smallholder Systems in Developing Countries

By

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[1] H. Kiara and A. Mude of ILRI provided information on vaccines and livestock insurance.

Background and outline of the report

In this report, we highlight the global importance of animal food sources, presenting measures of production, consumption and international trade of meat, milk and eggs, and emphasizing effects of these on developing countries. Our discussion points out the implications for smallholder producers, of a 'livestock revolution' that is evident in developing regions of the world. Next, we present candidate promising livestock systems interventions that hold much potential for improving livestock productivity and production in smallholder low input systems in developing countries. The technicalities, costs and timelines involved in the development of the interventions are presented in some detail, as well as the processes for transferring the new technologies to the end users. The mandate of the International Livestock Research Institute (ILRI) in the current Global Futures Project prioritizes modifying of the specification of the livestock sector in the IMPACT model. An 'IMPACT-livestock' quantification improvement exercise - that includes characterization of region and production system-specific global livestock production systems - is underway, so that cost benefit analysis and technology adoption runs cannot yet be implemented for livestock commodities in the IMPACT model. As such, a single promising livestock technology has not been identified based on uniform investment and returns analysis. For the same reasons, we in lieu of presenting IMPACT-generated results on the economic and social value of the promising technologies, discuss other results and present the progress made on the livestock systems characterization and other improvements of livestock sector quantification in IMPACT. The final section discusses important issues coming out of the current work.

Introduction

Livestock products play an important global role as food sources. Livestock production is also an important source of income and livelihood for millions of livestock owners and keepers, and others in the animal products food supply chain[2]. The global importance of livestock production for social – including ceremonial and religious, economic and financial, and environmental functions has been much emphasized, including in more recent times, the important links between livestock production and global climate change (e.g., Steinfeld, et al. 2006; Rowlinson, et al., 2008; Bouwman, et al., 2011). On average, livestock assets, products and activities contribute 40 percent of the total value of world agriculture – with gross domestic production (GDP) of livestock accounting for more than 50 percent of agricultural GDP in industrialized countries, and 33 percent and growing in developing regions (Bruinsma, 2003; Thornton, 2010). Further, livestock production is a major employer of labor, retaining up to 1.3 billion people globally – most of whom are associated with resource constrained farming or pastoralist systems in developing countries where livestock typically provide a variety of economic and financial, social, religious and environmental services (see e.g., Thornton, 2010; Staal, et al., 2009). Staal, et al. (2009) estimated that more than 600 million poor livestock keepers were to be found in South Asia, and 300 million in sub-Saharan Africa[3]. Livestock production however, is also known to have some negative implications for public health and the environment, amongst others (see e.g., Steinfeld, et al., 2006; Thornton, 2010).

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[2] In addition to their uses for food, income and employment, farm animals may confer additional benefits through their use of otherwise waste material (e.g., agricultural and industrial byproducts) as feed; and in providing draft power and manure nutrients for crop production in mixed crop livestock systems.
[3] Poor livestock keeper defined as living on less than 2 United States' dollars per day.

In terms of their importance as nutrient source for humans, it has long been established that introducing even minimal increases in animal source food in the diet offers huge potential for stemming nutrition-related poor health conditions that are prevalent in poor populations (Murphy and Allen, 2003). On average for individuals in developed regions, animal source foods make up 23 percent of the total calories. The corresponding number for developing regions is 10 percent (see Bruinsma, 2003). However, significant variations exist within developing regions, and for the different animal products. For example, animal food sources constitute about 19 percent of per capita total calorific intakes in Brazil, while meat, milk and all other animal source foods account for only 5 percent of the per capita calorie consumption in sub-Saharan Africa. Table 1 shows the food consumption of meat, milk and eggs for selected countries globally. Meat consumption is highest in Latin and Central America (up to 126 kilograms (kg) per person per year in Uruguay), the United States (125 kilograms per capita annually) and Europe (113 kg per person per year in Spain). It is lowest in parts of Africa and in Southeast Asia (FAO). In India, meat consumption per person per year is estimated to be 4.6 kg, comparing unfavorably with annual milk consumption per capita that stands at 47.6kg. These variations in consumption of animal source foods may be attributable to income and accessibility, as well as to social and religious factors[4]. Nonetheless, improved consumption of livestock products has in general been advocated as a tool for improving diets and nutrition, as well as physical and mental health in developing countries, particularly among children, the poor, and other vulnerable populations (e.g., Speedy, 2003; Murphy and Allen, 2003 and Dror and Allen, 2011).

A number of studies project unprecedented expansion in the global demand for livestock products, attributing the expected changes in demand to growth in population and incomes, increased globalization and urbanization, and changes in lifestyle and consumption patterns. Much of this global spurt in food demand would occur in developing regions, where livestock products demand is expected to nearly double by 2050 (see e.g., Delgado, et al., 1999; Steinfeld, et al., 2006; Thornton, 2010).

On the production side, livestock production is estimated to account for up to 30 percent of the planet's land surface not covered by ice, and directly or indirectly for 70 percent of available agricultural land (Steinfeld, et al., 2006). Currently, the highest productions of animal source foods in quantity terms occur in China (eggs and meat) and India (milk). The United States is the second largest producer of these commodities. Table 2 presents in some detail, the production of meat, milk and eggs in the countries that are the 5 largest producers. In addition to China, India and the United States, the industrialized countries of Japan, Russia and Germany also place within the top 5 producers of these livestock products. Brazil, Pakistan and Mexico are other developing countries on the (top 5) producers' list, for meat, milk and egg production, respectively. International trade in livestock products is dominated by the developed countries (see Table 3 and 4). While the United States leads total meat exports; New Zealand and the Netherlands top the lists for exports of milk and eggs. On the other hand, Japan and Germany import the largest quantities of meat, milk and eggs. In general, global livestock production has seen marked growth in recent decades, with total meat production in developing countries estimated to have expanded by more than three times from the early 1980s to year 2000 (FAO). Much of this growth has centered in the emerging giant economies in East and Southeast Asia. Opportunities may exist in these and other developing regions, for improved incomes and livelihoods for the livestock production sector, including for smallholder and poor livestock owners and keepers (see e.g., Herrero, et al., 2009; Staal, et al., 2009). Thornton (2010) however points out that while some smallholder mixed production systems may have the capacity to respond to growing food demand

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[4] Strong social and religious influences could limit the effects of population or income growth and urbanization on the demand for certain foods.

pressures by intensifying their input use, the future role of these systems in the coming decades is not certain. It seems that concerted intervention may be required to position low-input smallholder livestock systems to profitably and sustainably participate in the unfolding livestock 'revolution', in addition to addressing longstanding issues of food security in these regions.

The International Livestock Research Institute (ILRI) has since the 1970s played a leading role in research to improve incomes and livelihoods in smallholder livestock systems in developing countries[5]. Here, we present candidate promising approaches developed at ILRI for improving global livestock productivity and production, with a focus on low-input, livestock-oriented production systems in developing countries. The promising interventions are a) vaccine for control of cattle east coast fever in central, eastern and southern Africa; b) weather-index based livestock insurance to improve drought coping capacities of pastoralist systems in East and Central Africa; and c) feed trait improvement of crop cultivars for dairy production in smallholder crop-livestock systems in India.

Description of the promising livestock systems interventions *and* dissemination plans

a) Cattle East Coast fever vaccines

Vector borne diseases pose a significant threat to livestock production and productivity in much of the developing world. Estimated number of deaths from theleriosis or East Coast fever (ECF) in sub-Saharan Africa is placed at 1 million head of cattle yearly, with exotic breeds and young animals of indigenous and adapted breeds proving most susceptible (Di Giulio et al., 2009). ECF is endemic in 11 countries in east, central and southern Africa[6]. Up to 28 million, or 65 percent of the total cattle population in this region, are at risk (Mukhebi, et al., 1992). In pastoral systems in the region where vector controls are largely not practiced, calf losses of 30 to 60 percent have been attributed to the disease (Homewood, et al., 2006)[7]. Effective control of the disease should have direct implications for reduced livestock mortalities and for improved food security in the affected countries. Historically, ECF control has been by the use of toxin treatments (e.g., acaricides dips) to limit cattle infestation with the tick carrier of the disease (*Rhipicephalus appendiculatus*); but tick resistance to this form of treatment, financial difficulties on the part of poor farmers (e.g., in maintaining required facilities); and food safety and environmental concerns, have limited the potential for this form of control (Babo Martins, et al., 2010). Showing more promise is a vaccine-based control method which development has been the focus of a joint initiative of ILRI, the East African Community, and the Kenya Agricultural Research Institute. A multi-component vaccine holds much potential for sustained control of the vector-borne cattle disease theleriosis in endemic regions in sub-Saharan Africa.

Infection and treatment immunization (ITM) for ECF makes use of the scientific ability to harvest sporozoites of *Theileria parva,* i.e., the intercellular protozoan causing ECF; preserve the material as stabilates; and induce protective immunity in cattle by injecting combinations of the stabilate and long-acting antibiotics (Di Giulio et al., 2009). It involves inoculating cattle with an estimated 5.9×10^4 sporozoites of *T. parva* using a typical immunizing dilution of 1: 80 of the original stabilate, combined with a formulation of antibiotic oxytetracycline. According to Di Giulio et al. (2009), this ECF control method has been around for a while, having been developed for at least 15 years, although safety and

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[5] This includes the predecessors of ILRI - the International Laboratory for Research on Animal Diseases (ILRAD) and the International Livestock Center for Africa (ILCA).

[6] Burundi, Democratic Republic of Congo, Kenya, Malawi, Mozambique, Rwanda, Sudan, Tanzania, Uganda, Zambia and Zimbabwe are classified as endemic with ECF.

[7] In peri-urban dairy systems that use vector control, ECF-related calf losses are estimated to be 10 percent.

efficacy concerns have limited its adoption and use in affected countries. Technology for bulk production of the vaccine is also available[8]. While follow-up research continues, stocks of the vaccine such as the trivalent Muguga cocktail or ILRI08 have undergone successful trials in Eastern Zambia, Uganda, Tanzania and Zimbabwe. In the first large-scale trial of ILRI08, more than 250,000 indigenous zebu calves were vaccinated in Northern Tanzania[9]. Calf mortality rates were reduced in the trials by up to 95 percent, and vaccinated animals showed increased resilience to other tick-borne diseases present in the region. There is potential for widespread use of the ITM technology in unreached regions in the adoption countries, as well as in other ECF-endemic countries and South Sudan, where *T. parva* prevalence has only recently been established. It is also envisaged that a multi-component recombinant vaccine will be developed that has enhanced protection against all known strains of the ECF disease[10]. To this end, the development of commercial and other partnerships to ensure farmer access and vaccine availability and use has been outlined as priorities.

Dissemination of ECF vaccines to pastoralists and smallholder livestock keepers
The activities involved in transferring this technology to the end users are in form of dissemination of information on usefulness of the vaccine, as well as mass-production and distribution in the affected regions. Target end-users of the vaccines are pastoralists and commercial dairy operators in Tanzania and other parts of East and Southern Africa. Potential of the vaccine could also be explored for smallholder mixed crop livestock systems. The roles of a commercial partner in product development and commercialization of the vaccine include patent acquisition, product reformulation for commercial use, commercial trials, vaccine registration, and sales logistics and implementation. Further, partnership with local extension and veterinary officials is necessary to provide farmers with education on the ECF disease, vaccine availability, and proper vaccine administration. McLeod and Randolph estimated a bill to commercial partners of 4.6 million United States' dollars (USD) to cover market research and extension, and marketing costs (See McLeod and Randoph, 2000). They also estimated a timeline of 6 years from the time of delivery of the vaccine from research efforts, to the launch of a market product (see Table 5). However, involvement of the commercial developer is also expected in the stages prior to delivery of the vaccine by ILRI (i.e., in the research development stage).

   b) **Index-based livestock insurance (IBLI) for pastoralists in the horn of Africa**
In pastoralist systems in the arid and semi-arid regions of sub-Saharan Africa, livestock form the bulk of household wealth, and are the major source of food, income and livelihoods (e.g., from milk, meat, hides and manure). Rainfed pastures are the primary input, providing biomass for use as livestock feed. Toumlin in 1985 summarized the direct effects of droughts on pastoral areas in sub-Saharan Africa as: severe shortfall in fodder availability to support livestock; and associated reductions in herd productivity, including declines in animal liveweight and meat and milk production, reduced fertility of the herd, and livestock deaths. With severe droughts, mortalities of 60 percent or more of total livestock numbers may be recorded. These livestock losses are a major source of vulnerability in the pastoral regions of east and central Africa, where up to 13 million people may be affected (van de Steeg, et al., 2009; Zwaagstra, et al., 2009)[11]. The region has experienced up to four major droughts in the past decade alone, with high livestock mortalities and devastating consequences for families. In northern Kenya, up to three million pastoralist households face threats of severe drought yearly (Mude, 2010). Heightened risks of increased drought frequencies in the pastoral areas may exist with increased global

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[8] The first batch of 600,000 vaccine doses was developed by ILRI in 1997; second batch of 1 million doses in 2008.
[9] For example, the exact mechanism by which the antibiotic treatment works to control infection and enhance immunity is not yet known (Di Giulio, et al., 2009).
[10] See McLeod and Randolph, 2000.
[11] Reference regions are in Sudan, northern Uganda, and the lowlands of Kenya and Ethiopia.

climate change and variability (see e.g., van de Steeg, et al., 2009). To equip livestock owners with more effective options for managing weather and climate-induced risks to their livestock production, ILRI and technical partners from Cornell University, Syracuse University and the University of Wisconsin – Madison have conceptualized and designed a weather-related index-based insurance product for pastoralist livestock keepers in Kenya (www.ilri.org/ibli).

The unique feature of a weather-based insurance product is that the contract is written against a specific, widely observed and often natural event (e.g., flood), and payments are 'automatically' triggered by pre-specified patterns of an easily monitored measure that is highly correlated with the loss. Usually, a large number of policy holders are covered in the region facing the risk and collective (and not individual) exposure to the risk is assessed. As such, payouts within the index-based framework can be administered without the need for claim filing by individual policy holders, potentially reducing the costs to insurers and the insured. ILRI's index-based livestock insurance (IBLI) which uses an index directly linked to drought-related livestock deaths, is targeted to pastoralists in northern Kenya. Predictions of livestock losses due to drought are made based on forage availability in the area - which in turn is measured using the normalized difference vegetative index (NDVI), an indicator of photosynthetic activity of vegetation in the area under observation. The NDVI is regularly monitored using satellite imagery technology. Forage availability and predicted livestock mortalities is monitored and reported by ILRI – which is generally accepted as independent of influence by the insuring and insured parties alike[12]. Insurance payouts are triggered when the estimates of livestock deaths exceed 15 percent of the beginning-of-season stock. Policy holders in a specific region receive equivalent rate of insurance payment when the policy trigger level is exceeded. A pilot phase of the project has been successfully completed in Marsabit district in Northern Kenya[13]. Future research is focused on improving the NDVI index currently being used, and on assessing the need and developing tools for similar regions in Kenya, southern Ethiopia, and other pastoralist systems in east and central Africa that face threats of drought. Development of the insurance intervention (for Kenya) is estimated at 1.89 million USD, with research development spanning six years.

Dissemination of livestock insurance technology for pastoralists[14]
The activities involved in transferring this technology to pastoralist systems in other regions and the expected timelines follow. Total estimated dissemination cost is 1.6 million USD per country, excluding costs to commercial partners of the actual insurance product.

i)   Initial studies to identify sources and extents of vulnerability, as well as available coping strategies.
ii)   Design of region-specific index-based livestock insurance product.
iii)   Market testing of product including testing of appropriate pricing mechanisms.
iv)   Building stakeholder partnerships.
v)   Marketing studies.
vi)   Farmer education and extension services.

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[12]Insurance is administered by commercial partners such as banks and insurance companies ILRI is only acting as a temporary index announcement and verification authority as an independent and trusted local institution to do the job is sourced.
[13] The Marsabit pilot project recently made payments to insured pastoralists following the 2011 severe drought and livestock deaths that triggered IBLI insurance payouts.
[14] Adapted from personal communication with A. Mude.

c) Improved feed traits of dual purpose crop cultivars[15]

Livestock feed scarcity has been identified as a major constraint to improving livestock productivity in smallholder livestock production systems, in India, and elsewhere (e.g., Birthal and Jha, 2005; Herrero, et al., 2007). Herrero, *et al.*, (2009) for example, showed that feed supplies were not available year-round to support livestock production in low input mixed systems in the tropics. As such, existing livestock feed supply systems in these regions may have limited capacity to support growth in the livestock sector, limiting potential for smallholder farmer participation in the growing 'livestock revolution'. Further, failure on the part of low input smallholder crop farmers to return nutrients to the soil could lead to heavy soil degradation, which could be expected in resource-constrained mixed systems where crop residues and other available plant material would be mostly allocated to livestock feed. Global climate change and variability effects could compound these complexities, heightening threats to the sustainability of smallholder mixed crop livestock systems, and to incomes, livelihoods and food security in the affected regions. An important approach to addressing the feed constraint problem in low-input smallholder livestock systems is the improving of feed traits for regionally-grown dual purpose or food-feed crop cultivars[16].

With food-feed crops, the "main" product of the cultivated plant, e.g., grain is harvested for human food while "secondary" products such as the leaf, stalk and vines become available for use as soil cover for conservation purposes, or as livestock feed. These dual-purpose crops have the potential to reduce the land pressure from the livestock industry. Current crop development at the International Crops Research Institute for the Semi Arid Tropics (ICRISAT), in collaboration with livestock scientists at ILRI, is exploring options for developing food crop (e.g., sorghum, millet) varieties with higher fodder quality for smallholder mixed systems in India (see e.g., Blümmel et al., 2010a; Blümmel and Rao, 2006)[17]. There is potential for transfer of this technology to low-input systems in other arid, semi-arid tropical and sub-tropical regions.

The grain-residue improvement of sorghum and millet is not only to increase the residue availability, but to enhance the quality of the stover produced. Blümmel, et al., (2010a) reported that new sorghum varieties under trial in India showed superior grain and stover yield and stover quality traits over traditional varieties. Other studies reported four-fold sorghum grain yield advantages over traditional varieties, as well as stover yield improvements of 37 percent and crop residue digestibility improvements of 12 percent (see Blümmel, et al., 2010b). There are other advantages for food grain production and land use management. For example, optimal plant spacing can be maintained to obtain more crop residue production per fixed land area, important for maintaining crop grain yield and quality integrity. However, potential soil quality issues could arise when available crop residues are used up as feed rather than returned to the soil to provide nutrients (Herrero, *et al.*, 2009).

Development of and dissemination of information to the farmers on the appropriate field management practices would be required, as well as the distribution of seeds and required inputs such as fertilizers. Market and institutional support is also needed for food-fodder crop cultivar improvements.

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[15] Technicalities of developing improved dual-purpose crops should be discussed in more detail in the relevant crop centre reports. The focus here is on emphasizing the relevance of these technologies to livestock production in smallholder mixed crop livestock systems in developing countries.

[16] Other approaches not discussed here include growing improved varieties of fodder grasses and legumes; and developing feed processing technologies to improve the uptake and utilization of livestock feeds by reducing bulk and increasing nutritive value and digestibility.

[17] Similar crop development are on for are maize in East and Southern Africa, and cowpea in West Africa (see Romney *et al.*, 2003; Tarawali, *et al.*, 2002).

Economic and social value of the improved technologies

The proposed promising livestock systems interventions are expected to have varied levels of impacts within and beyond the livestock production systems for which they are developed. For example, McLeod and Randolph (2000) estimate a 22 percent return on investments to a commercial partner in ECF vaccine development, with potential retail sales value of 6.4 million USD for the vaccine in countries in East and Central Africa affected by the cattle disease. Other studies suggest that preventing ECF-related deaths could stem economic losses of up to 170 million USD per year in affected countries in sub-Saharan Africa (Di Giulio). International trade in live animals and livestock products could experience a boost as cross-border ECF-related policies in the affected countries are revisited. On the part of livestock keepers, ECF vaccine use in Tanzania trials resulted in livestock owners receiving 50 percent or more in payments for the sale of vaccinated animals, following liveweight gains of these over unimmunized animals. The increased unit sale prices, combined with the significant reductions in disease-related animal deaths, would likely compensate for the costs to the livestock keepers of getting their animals vaccinated[18]. Measurable gains are also to be expected in protein and kilocalorie availability and food security in the relevant countries.

One of the explicit objectives of the technical group developing the Index-based livestock insurance tool for pastoralists in arid regions of northern Kenya is to reduce by half the income or welfare impacts on target households losing livestock to drought. With the region serving as home to more than 3 million livestock-dependent households, the insurance intervention should have important implications for regional food consumption and food security[19].

On their part, improved dual purpose crop cultivars are expected to have significant implications for mixed crop livestock production systems in the regions for which they are being developed. Projections for India place crop residue contributions to total livestock feeds at nearly 70 percent in 2020, a 25 percent increase from current levels (see Blümmel, et al., 2010b). This expansion in residue production (a sizeable proportion of which is envisaged to come from dual purpose crop cultivars) should have interesting effects on sub-national, national and regional dynamics of livestock feed trade, input prices, incomes and livelihoods, as well as other food security-related factors.

Economic analysis of the global effects of the candidate promising livestock interventions is planned using the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT). Preceding this analysis however, is a list of outlined activities aimed at improving the characterization of the global livestock sector in IMPACT.

i) Characterize food production unit-based global livestock production systems (LPS).
ii) Obtain simulation production data accounting for various combinations of feed sources.
iii) Develop new LPS-based production functions for livestock production in IMPACT.
iv) Develop framework for livestock feed supplies by system and region.
v) Incorporate improved livestock components into IMPACT.
vi) Extend cost-benefits and adoption pathway framework for new crop technologies to the IMPACT with the improved livestock quantification.

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[18] Smallholder livestock keepers in the Tanzania trials paid the equivalent of 12-14 USD per animal for vaccines. Pastoralists, due to their larger herds per household/unit and economies of scale, paid 6 -7 USD.
[19] 13 million pastoralist/agro-pastoralist households in the wider region for which the intervention is relevant.

Livestock quantification improvement in IMPACT and progress made[20]
Since its inception in the early 1990s, IMPACT has undergone various modifications to improve its usefulness for policy analysis and projections. While the number of crops, and uses for these crops, has been greatly expanded in the model in recent years, the treatment of livestock production and feed demand has not received much attention. One reason for this has been a lack of system-specific livestock quantity and production data on a global level. Recent work by Mario Herrero and others at ILRI and the International Institute for Applied Systems Analysis (IIASA) is making it possible to move the IMPACT model towards system-level livestock production and feed demand. This is the foundation of ongoing improvements to the livestock sector within IMPACT.

The traditional IMPACT models livestock production as homogenous across systems within each country. As such, it does not account for important sub-national system differences in production and feed demand. It is also not possible to explicitly model how shifts within systems, (e.g., extensive grazing to more intensive), will affect livestock production outcomes, or even crop production. Using new data developed by ILRI/IIASA on animal numbers and production, M. Herrero (ILRI) and S. Msangi (IFPRI) have disaggregated country livestock numbers by livestock production systems within countries (following an adaptation of Kruska *et al*., 2003; and Sere and Steinfeld, 1996). A set of simulation data from an animal herd model developed at ILRI has also been developed, that would inform feed demand equations specific to each LPS in each country. Whereas livestock production in IMPACT is currently a function of feed grain prices, we will be able with the new production data, to add to the model other sources of livestock feeds such as crop residues and pastures (that are particularly important for livestock production in smallholder mixed and pastoralist livestock production systems).

At the time of this report activities (i) through (iv) of the (outlined) major steps for improving livestock characterization in IMPACT are mostly completed, while (v) is underway. Box 1 provides additional details on the activities.

Limitations and next steps

Issues so far encountered in the assessment of promising livestock systems interventions includes challenges with obtaining consistency between available data and the forms required for meaningful analysis with the available tools. For example, while livestock data is available in disaggregated form, i.e., at (IMPACT) food production unit based – livestock production system levels, sub-national crop production information is only available for the food production units. This poses constraints to tracking local biomass availability for livestock feeds. As the model is currently being specified, the assumptions on livestock feed supplies would allow for local feed availability from feed trade and production covering much wider geographical areas than may be observed in practice (so that for example, feed grains and residues grown in any parts of Kenya may be available to cattle raised in any other parts of the country, a situation that is clearly not feasible). A related issue with data consistency is that dataset developed and available from ILRI/IIASA may be aggregated differently from IMPACT specifications. Issues such as this, however, are being addressed by adapting standardized protocols for model calibration (e.g., S. Msangi applied numerical optimization methods to obtain applicable forms of FPU-level distributions of system-specific animal numbers and production for the livestock categories within the IMPACT model, as in Msangi, 2011).

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[20] Based on 'Incorporating improved quantification of livestock sectors in IMPACT', unpublished document developed for the Global Futures Project by D. Enahoro and N. Magnan, 2011.

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A more serious challenge, however, has been that of obtaining the necessary quantitative data or other information at all. In some cases where the required information does exist or could be generated, increased interest in the GF project and its relevance/urgency may be needed, particularly for new or potential partners in the project.

There also exist challenges arising from inherent differences in the way crop and livestock systems are configured, and evolve. For example, technology pathways for improved production and productivity may be radically different in the systems, so that intervention approaches (as well as modeling requirements and the assessment of technology impacts) are not closely aligned. This makes assessment of livestock technologies somewhat challenging in the current (GF) context. Further, lifecycle and other dynamics may be of particular significance in livestock production systems, particularly of the kinds to which research at ILRI is geared. This aspect of the systems is ignored in the current analysis. A practical way to address this going forward, could be the incorporation of other forms of modeling and analysis (e.g., allowing for animal herd dynamics) into the Global Futures project or its successors.

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Appendix

Table 1: Consumption of meat, milk and eggs in
selected countries/regions (Kg/capita/year)

Country/Region	Meat	Milk	Eggs
World	37.9	46.4	8
Uruguay	126.5	131.6	9.3
United States	124	117.3	14.5
Spain	113.1	108.1	13.9
Brazil	73	118.7	6.7
China	48.1	6.4	15.6
Japan	42.4	43.5	19.2
Mali	18.6	42.6	0.7
Kenya	13.7	76.7	1.3
Pakistan	12.4	87.2	2
India	4.6	47.5	1.5

FAO, 2001. Adapted from Speedy, 2003

Table 2: Meat milk, and egg production in the 5 highest production countries ('000 tonnes)

Meat		Milk		Eggs	
Country	Production	Country	Production	Country	Production
China	78,118	India	110,936	China	27,773
United States	41,643	United States	85,880	United States	5,349
Brazil	20,100	China	40,385	India	3,324
Germany	7,884	Pakistan	34,362	Japan	2,508
Russia	6,570	Russia	32,565	Mexico	2,360

FAO, 2009.

Table 3: Meat, milk and egg total imports for the 10 largest importers ('000 tonnes)[1]

Meat		Milk		Eggs	
Country	Production	Country	Production	Country	Production
Japan	2,782	Germany	7,633	Germany	429
Russia	2,506	Netherlands	7,341	France	148
Germany	2,296	Italy	6,034	Netherlands	122
United Kingdom	2,229	China	5,025	Iraq	106
Italy	1,673	Belgium	4,694	Hong Kong	92
United States	1,661	France	4,552	United Kingdom	49
Hong Kong	1,575	United Kingdom	3,965	Belgium	44
Netherlands	1,574	Spain	2,803	Switzerland	34
Mexico	1,538	Mexico	2,724	Poland	28
France	1,466	Algeria	2,392	Canada	28

FAO, 2009.
[1] Note the figures are total and not net imports.

Table 4: Meat, milk and egg total exports for the 10 largest exporters ('000 tonnes)[1]

Meat		Milk		Eggs	
Country	Production	Country	Production	Country	Production
United States	6,254	New Zealand	14,235	Netherlands	397
Brazil	6,062	Germany	13,625	Poland	142
Germany	2,877	France	9,086	China	135
Netherlands	2,706	Netherlands	8,280	Spain	125
Australia	1,666	United States	5,496	Germany	106
Canada	1,652	Belgium	4,735	Malaysia	98
Denmark	1,554	Australia	4,180	Turkey	90
France	1,473	Denmark	2,989	United States	85
Belgium	1,423	Poland	2,952	Belgium	70
Spain	1,312	Ireland	2,835	France	59

FAO, 2009.
[1] Note the figures are total and not net exports.

Table 5: Timetable for ECF vaccine research and commercial product development

Year	0	1	2	3	4	5	6	7	8	9	10	11	12
ILRI Research													
Identify schizont antigens	█	█	█	█									
Develop delivery systems	█	█	█	█									
Evaluation of antigens	█	█	█	█	█								
Process development				█	█	█							
Commercial Partner													
Concept support	█	█	█	█	█	█							
Define formulation				█	█								
Manufacture					█	█	█						
Commerical field trials						█	█	█					
Product registration							█	█	█				
Product launch									█	█	█	█	
Donor Support													
Product delivery support									█	█	█	█	
Infrastructure development	█	█	█	█	█	█	█	█	█	█	█	█	
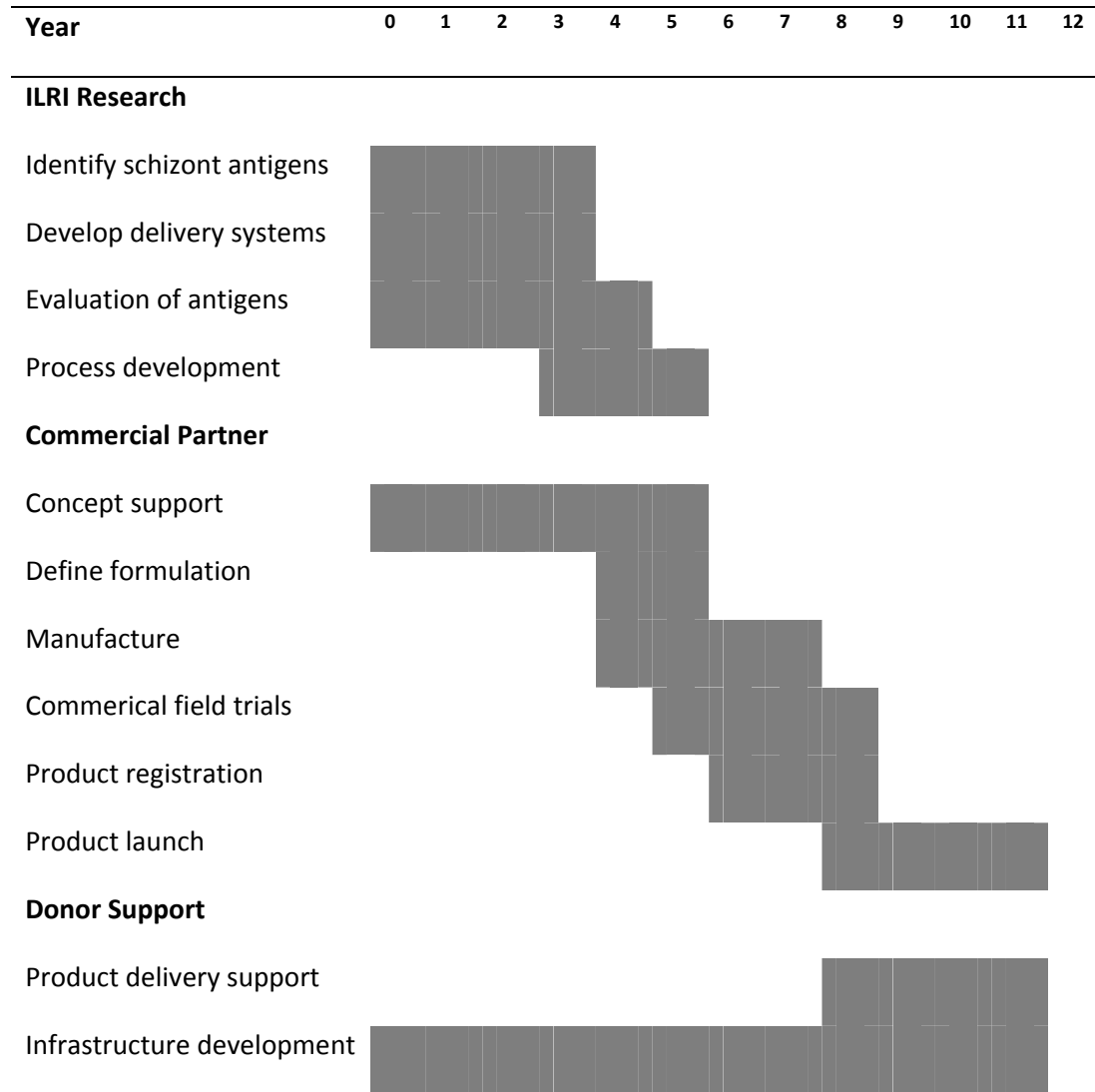
Source: McLeod and Randolph, 2000

Box 1: Activities involved in improving livestock quantification in IMPACT

1. Define global livestock production systems
    - Country-level data (FAOstat) on animal numbers and production are disaggregated into eight Food Production Unit (FPU) based livestock production systems (following adaptation of Kruska *et al*., 2002; and Sere and Steinfeld, 1996).
    - Baseline (year 2000) data for animal numbers and production (by region and LPS) are generated from models developed at ILRI and IIASA.
2. Develop region-system based simulations of livestock product outputs and feed inputs using a process-based animal herd model (RUMINANT).
3. Develop new LPS-based livestock production functions
    - Define new LPS and FPU-specific livestock production functions and parameterize using econometric or relevant estimates from process based simulation data.
      Account for factors like environment as exogenous shifters.
    - Expand feed demand to include pasture, various fodder, crop residues, and occasional feed sources (that include concentrates and supplements).
    - Simulate projections of herd size using exogenous growth parameters.
4. Livestock feed supplies by system and region
    - Incorporate appropriate feed pricing in the existing crop supply functions.
    - Determine feed cereal byproduct availability.
    - Model supplies of fodder from pastures in collaboration with others working on land use (IFPRI) and forage (ICRAF) improvement activities in IMPACT.
5. Incorporate improved livestock component into IMPACT
    - Develop module with important features of the livestock sector.
    - Test functioning module to IMPACT.
6. Adapt cost benefit analysis in IMPACT to livestock systems