Targeting strategic investment in livestock development as a vehicle for rural livelihoods

BMGF-ILRI project on Livestock Knowledge Generation

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Introduction

The purpose of this report is first to provide evidence of the role of livestock in rural livelihoods in Sub-Saharan Africa and South Asia[1]. Further, the report aims to identify opportunities for investments that build on that evidence and hold promise for improving and sustaining the livelihoods of smallholder livestock producers and their rural communities in developing countries. This analysis is presented in order to support the decision making of those public and private development investors, and policy makers, for whom improved rural livelihoods is a key objective.

The report is presented in two parts. Part 1 comprises summaries of in-depth analysis of key issues central to the role of livestock and rural livelihoods, each of which brings together a wide range of available data to inform the topic. Part 2 then uses the information generated and presented in Part 1 and through a conceptual framework for guiding pro-poor livestock investment, identifies the key value chains or livestock systems and regions that are demonstrated by the evidence to offer livelihood opportunities, and some initial description of best bet types of interventions.

Part 1: Key Elements of Livestock Livelihoods

Background

The ongoing Livestock Revolution (Delgado et al. 1999, 2001) has been characterized by acceleration in demand for livestock products in developing countries due to increasing incomes, creating new opportunities for rural producers to participate in income-generating livestock enterprises, thereby building improved livelihoods. Strategic investment has the potential to greatly assist this process.

Targeting such investment is difficult, given the great heterogeneity in the production systems delivering livestock products, in the natural resource base on which they depend, and in the political, market and technology environments in which they operate. Therefore, investment in livestock-mediated livelihood opportunities should be guided by the best knowledge available, applied strategically. The knowledge required for that targeting revolves around several central issues:

- Where are the rural poor located, particularly those who depend on livestock for livelihoods?
- How important is livestock to their livelihoods and communities, including human nutrition?
- What is the value of production by smallholders of livestock, and what are the main constraints to that production?

[1] For the purposes of this analysis coverage of South Asia is limited to India and Bangladesh

- Where are the greatest market demand opportunities to drive increased livestock production and incomes?

This part of the report presents, in summary form, the findings of six separate studies that address these questions, focusing on the regions which many donors and development agents regard as the most critical for reaching the poorest, sub-Saharan Africa and South Asia. In each case, a range of data are used to address the issues at hand: national-level statistics such as that available from FAOSTAT and other sources, spatial data from public GIS databases, and case study or survey data. In line with the questions above, the report is accordingly laid out as follows[2]:

A. Poor livestock keepers in sub-Saharan Africa and South Asia (Kariuki and Notenbart)

B. Contribution of livestock to household incomes (Nzuma and Baltenweck)

C. Role of livestock in human nutrition (Nzuma and Randolph)

D. Value of livestock production (Omolo and Notenbaert)

E. Productivity gaps in livestock production (Mwacharo et al)

F. Livestock value chains and market opportunities (Njoroge et al)

[2] For each of these topics a detailed study report is available. Contact s.staal@cgiar.org for a copy.

Poor livestock keepers in sub-Saharan Africa and South Asia

Central to any pro-poor investment in livestock development is to actually target the poor, particularly those that depend on livestock for livelihood, identifying where and in what types of systems they and their communities are found. This analysis was designed to provide that targeting. The study (Kariuki and Notenbaert) sought answers to three questions:

- How many livestock keepers are living on less than US$ 2 per day in sub-Saharan Africa and South Asia (here considered as India and Bangladesh)?[3]
- Where are they living (by region and by production system)?
- What percentage of the poor do they represent within the production system?

The livestock production system classification used was that developed by ILRI (Kruska et al. 2003, based on Seré and Steinfeld 1996), simplified into four main types:

- Arid/semi-arid pastoral systems;
- Mixed humid/subhumid, including rainfed and irrigated systems in those zones;
- Mixed temperate/tropical highland, including rainfed and irrigated systems in those zones;
- Other, including sparsely populated forest and coastal areas, and urban areas.

The populations living within those production systems were extracted from regional population density datasets (Deichmann 1996; Hyman et al. 2000), and income data were obtained from World Bank statistics. Estimates from an internal ILRI expert consultation were used to set the proportion of poor people in each system who were livestock keepers.

Figure 1 and Figure 2 show the geographical spread of poor livestock keepers, for all types of livestock,[4] in sub-Saharan Africa and South Asia, respectively (blue, low density; red, highest density).

[3] The study considered poverty data for both US$ 1 and US$ 2 per day, but for simplicity only the latter criterion is presented here.

[4] While eight categories of livestock keepers were recognized in the initial study, this broad analysis aggregates all categories.

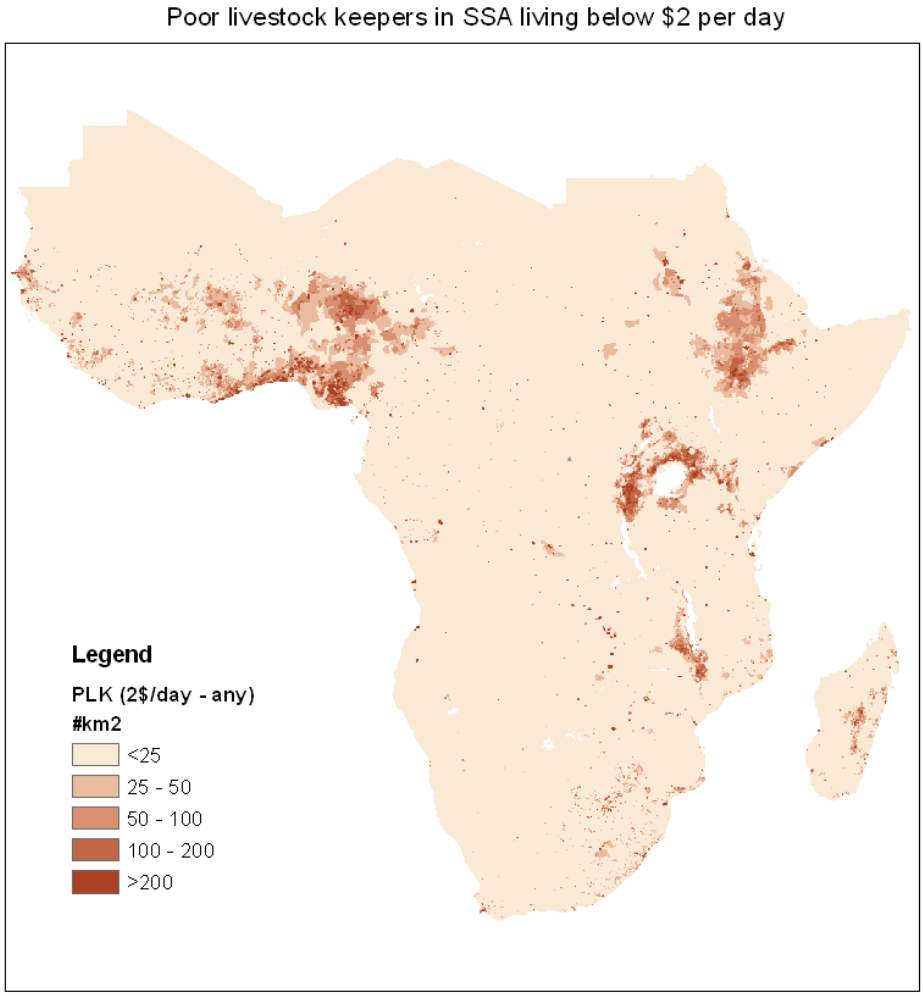


Figure 1: Poor livestock keepers in sub-Saharan Africa living below US$ 2 per day (all livestock). Source: (Kariuki and Notenbaert 2008)

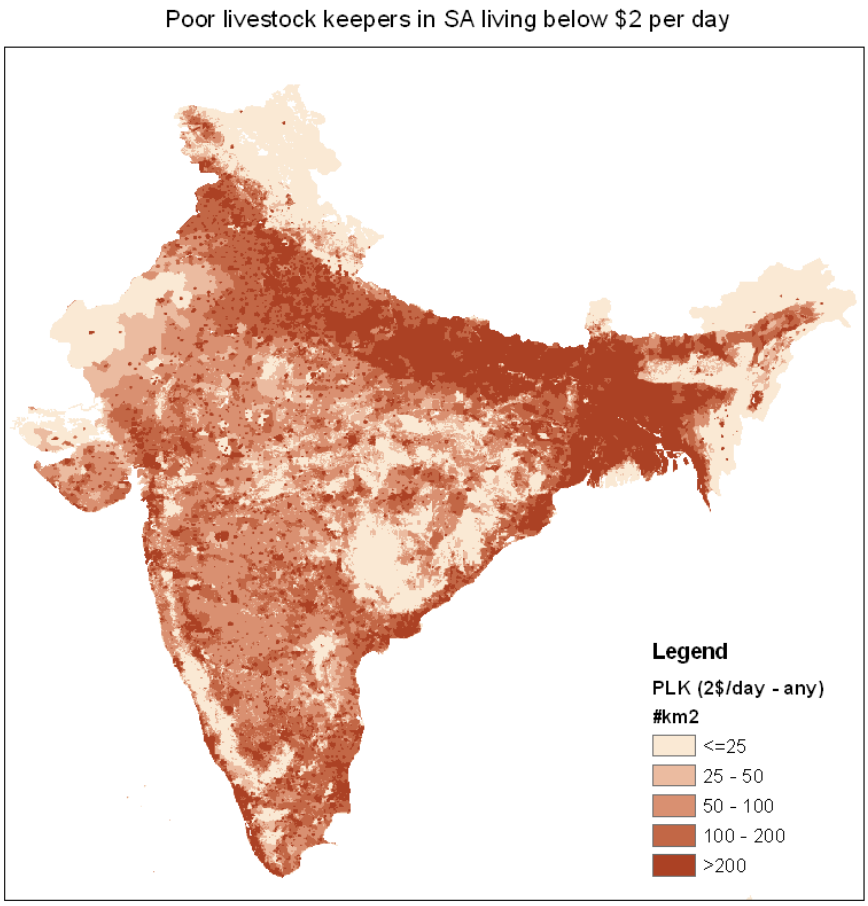


Figure 2: Poor livestock keepers in South Asia living below US$ 2 per day (all livestock).

Table 1 shows the absolute number of livestock keepers living below US$ 2 per day, by region and subregion. The figures show that of over 900 million poor livestock keepers, over 600 million are found in South Asia, mostly in India. Sub-Saharan Africa has over 300 million poor livestock keepers, concentrated in East and West Africa, with fewer in Southern and Central. Table 2 and Table 3 present data for each system in sub-Saharan Africa and South Asia, respectively, disaggregated by subregion. Table 4 and Table 5 show the percentage of the poor keeping various livestock types, by production system.

Table 1: Number of livestock keepers living below US$ 2 per day (region, subregion)

Region	Number of Poor Livestock Keepers	Percentage of regions total
South Asia	643,519,374	67.55
India	*578,924,462*	*60.77*
Bangladesh	*64,594,913*	*6.78*
SSA	309,167,069	32.45
Central Africa	*30,450,902*	*3.20*
Western Africa	*133,174,213*	*13.98*
East Africa	*95,210,085*	*9.99*
Southern Africa	*50,331,870*	*5.28*
Total	952,686,444	100

Table 2: Sub-Saharan Africa: Livestock keepers living on less than US$ 2 per day, by system

	SSA	*Central Africa*	*% of regional system total*	*% of regional total*	*Western Africa*	*% of regional system total*	*% of regional total*	*East Africa*	*% of regional system total*	*% of regional total*	*Southern Africa*	*% of regional system total*	*% of regional total*
Arid-semiarid	36,149,668	*3,196,499*	*8.8*	*1.0*	*9,841,515*	*27.2*	*3.2*	*15,172,487*	*42.0*	*4.9*	*7,939,166*	*22.0*	*2.6*
Mixed Humid	218,654,066	*21,105,176*	*9.7*	*6.8*	*120,976,220*	*55.3*	*39.1*	*44,141,626*	*20.2*	*14.3*	*32,431,045*	*14.8*	*10.5*
Mixed Temparate	45,358,090	*3,820,562*	*8.4*	*1.2*	*59,839*	*0.1*	*0.0*	*33,175,752*	*73.1*	*10.7*	*8,301,938*	*18.3*	*2.7*
Other	9,005,245	*2,328,666*	*25.9*	*0.8*	*2,296,639*	*25.5*	*0.7*	*2,720,220*	*30.2*	*0.9*	*1,659,721*	*18.4*	*0.5*
TOTAL	309,167,069	30,450,902	*9.85*	*9.85*	133,174,213	*43.08*	*43.08*	95,210,085	*30.80*	*30.80*	50,331,870	*16.28*	*16.28*

Table 3: South Asia: Livestock keepers living on less than US$ 2 per day, by system

	South Asia	India	*% of regional system total*	*% of regional total*	Bangladesh	*% of regional system total*	*% of regional total*
Arid-semiarid	1,883,302	1,841,273	*97.8*	*0.3*	42,028	*2.2*	*0.0*
Mixed Humid	632,062,922	568,533,627	*89.9*	*88.3*	63,529,295	*10.1*	*9.9*
Mixed Temparate	2,934,646	2,934,646	*100.0*	*0.5*	0	*0.0*	*0.0*
Other	6,638,505	5,614,915	*84.6*	*0.9*	1,023,589	*15.4*	*0.2*
TOTAL	643,519,374	578,924,462	*89.96*	*89.96*	64,594,913	*10.04*	*10.04*

Table 4: Percentage of the poor keeping livestock in SSA (by production system)

	Arid/Semi-Arid (agro-)Pastoral	Mixed Humid/Sub-humid	Mixed temperate/tropical highland	Other
Any livestock	80	80	70	10
Beef cattle	65	50	45	5
Dairy cattle	0.1<1	3	30	1
Commercial Eggs	0.1<1	0.1<1	0.5 <1	0.5 <1
Broilers	0.1<1	0.1<1	0.5 <1	0.1 <1
Local Chicken	20	50	60	5
Goat Meat	70	50	10	3
Dairy Goat	0	0	0.1 <1	0
Sheep	65	15	15	0.5 <1

Table 5: Percentage of the poor keeping livestock in SA (by production system)

	Arid/Semi-arid (pastoral/ semi pastoral)	Mixed crop livestock system in humid* zone	Mixed crop livestock system in temperate (highlands)	Industrial/urban
Any livestock	65	70	40	12
Beef cattle	35	40	5	10
Dairy cattle	25	29	30	10
Commercial-egg poultry	0	0.01	0.1	0.001
Broilers	0	0.1	0.5	0.001
Local poultry	15	30	40	10
Goat Meat	50	50	10	3
Dairy goats	0.01	0.1	0.5	0
Sheep	20	50	10	3

The data indicate that mixed humid systems contain relatively more poor livestock keepers than other systems, in both South Asia and sub-Saharan Africa. However, Table 4 shows the high relative importance of livestock to the poor in all rural systems. Which criterion should be used, then, when targeting investment – absolute numbers of poor, or system-based poverty rates? What other criteria should be considered? Further data are needed on spatial and temporal distribution of crops and livestock and on the numbers, location and characteristics of vulnerable poor livestock keepers in order to enable finer geographical targeting of livestock interventions.

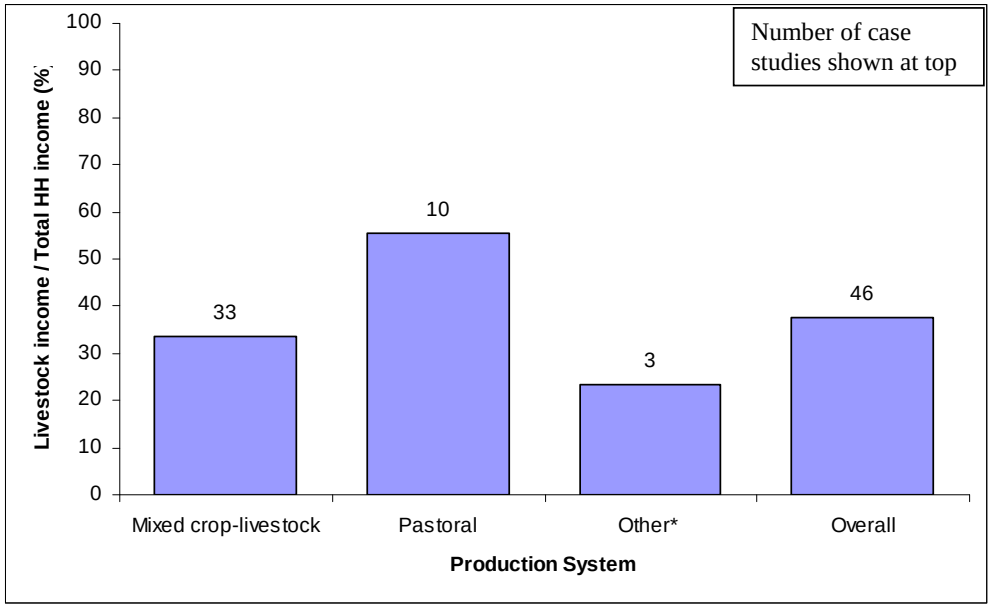
The next section looks more specifically at how livestock can contribute to household incomes in resource-poor communities.

Contribution of livestock to household incomes

Livestock contribute to the livelihood strategies of the poor and the food insecure in many ways (Roland-Holst et al. 2007) and their products and services can be a significant component of national output. However, there is a dearth of knowledge about the relative contribution of livestock to total household incomes across regions, species and production systems. The study (Nzuma and Baltenweck) therefore aimed, using a review of individual case studies in sub-Saharan Africa and South Asia, to answer a number of related questions, including:

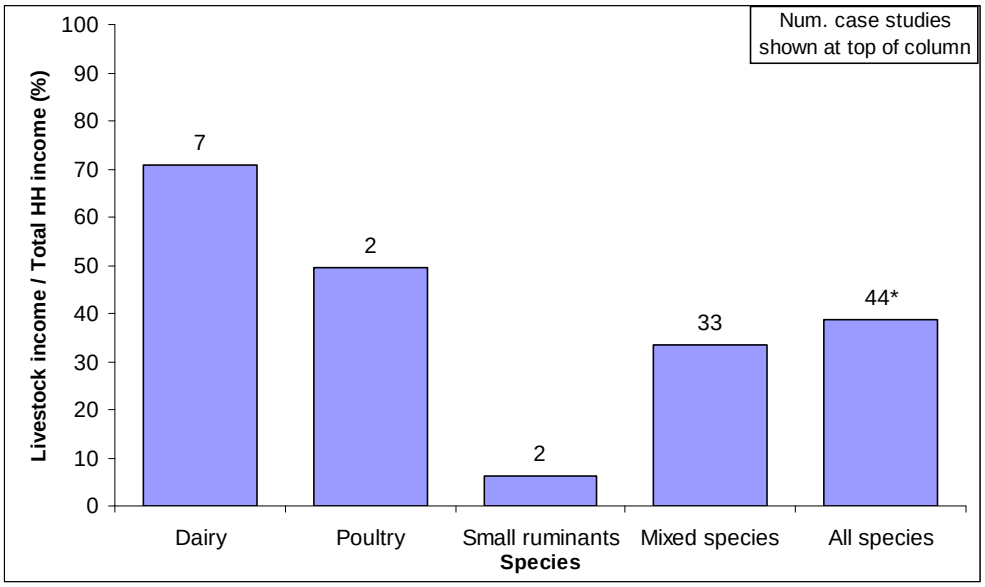
- What is the total household income for livestock keepers (US$/year)?
- What is the share of income from livestock production in total household income?
- What variations exist according to type of production system and species kept?

The study of 92 cases considered the contributions to incomes of dairy cattle, small ruminants and poultry in three broad system categories – mixed crop/livestock, pastoral and other. On average, livestock production accounted for close to 40% of total household income across all livestock production systems (Figure 3), species (Figure 4) and regions.



* "Other" comprises one exotic poultry study from Bangladesh and two local goat/sheep studies from India.

Figure 3: Share of livestock income in total household income, by production system.



* Two case studies not included as species description missing.

Figure 4: Percentage of livestock income in total household income, by species.

Pastoral production systems showed the highest contribution of livestock to household incomes (55%, Figure 3) (Otte and Chilonda 2002). Livestock production generates roughly half of the household income in the pastoral areas of Kenya (Barrett et al. 2003), and pastoral communities in Ethiopia, Niger and Burkina Faso derive over 80% of their incomes from livestock. The 33% average contribution of livestock to household incomes for mixed crop/livestock systems (Figure 3) masks a wide variation according to the type of livestock kept and the extent of market participation of different categories of livestock keepers. On the whole, however, household incomes were higher in the pastoral systems case studies (average US$ 2,315) than in the mixed crop/livestock systems (average US$ 984).

With regard to species, dairy, as a component of mixed crop/livestock systems, contributed the highest share of household income at 70% (Figure 4), with an average income of US$ 958. Poultry was the next highest proportion of income at 50%, but gave the highest household income (range US$ 2,207 to US$ 6,837). Though from only two case studies, the results show the potential contribution that poultry can make to reducing rural poverty if a commercial system can be maintained. By contrast, the two small ruminant studies in India (local breed sheep and goats) showed the lowest contribution to household income (1% and 13%), although the small sample size from both these and the poultry cases renders inferences difficult.

The next section considers another important role of livestock in poor communities – as a vital element of human nutrition.

The role of livestock in human nutrition

Livestock keeping is critical for many of the poor in the developing world, often contributing to multiple livelihood objectives (Randolph et al. 2007), including improved household food security. The study (Nzuma and Randolph) evaluated the role of livestock in human nutrition, using data[5] for sub-Saharan Africa and South Asia for various livestock product categories, through consideration of the following questions:

- What is the per capita consumption of livestock products in the study areas?
- How much energy (calories) and protein do livestock products contribute to human diets?
- What is the relative importance of various livestock products in human diets?
- How much malnutrition exists in the study areas?
- What are the nutritional benefits of animal-source foods?

Per capita consumption of livestock products (dairy, beef, poultry meat and eggs, small ruminant meat) in the study areas is shown in Figure 5, with Bangladesh and Central Africa consuming the least, and India and East and Southern Africa the most. Overall, consumption is low (compare with the United States, 404 kg/person/year consumption of livestock products). Figure 6 and Figure 7 show energy and protein intake from livestock products in the study areas. As Table 6 shows, most energy is derived from crop products, with livestock products constituting a smaller source of energy per unit consumption. However, and importantly, they are rich in protein (right column, Table 6) and other micronutrients.

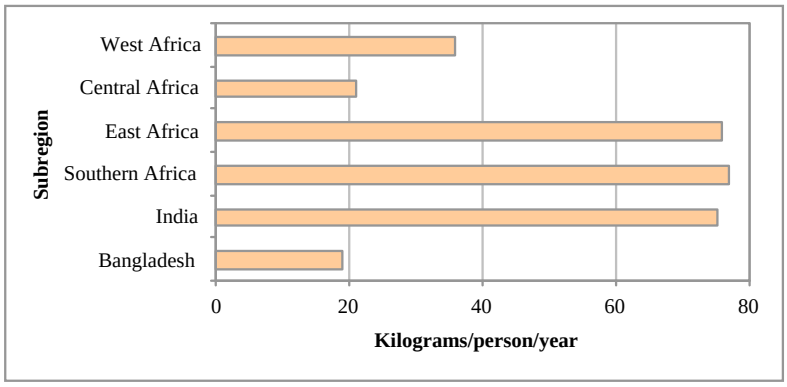


Figure 5: Annual consumption of livestock products (kg/person per year) by subregion.

[5] The main source of data was the FAOSTAT database of the Food and Agriculture Organization of the United Nations (http://faostat.fao.org).

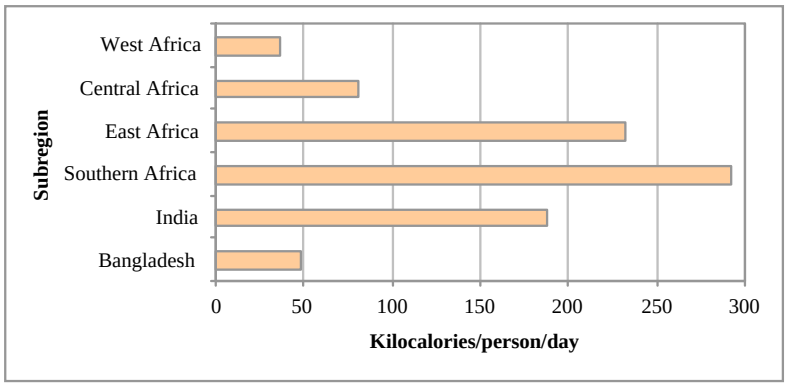


Figure 6: Daily energy intake from livestock products (kcal/person per day) by subregion.

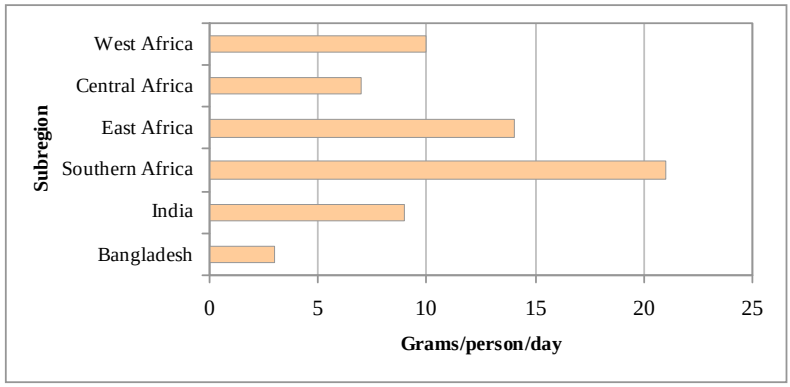


Figure 7: Daily protein intake from livestock products (grams/per person) by subregion.

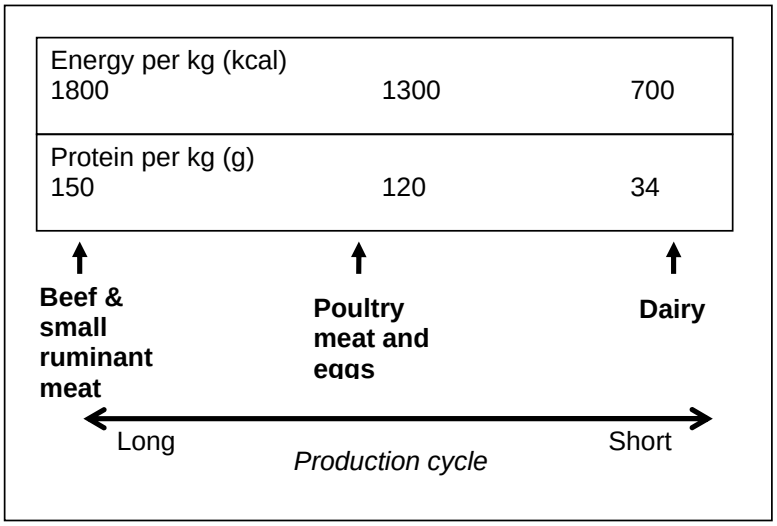
Table 6: Energy and protein sources, by subregion

Region	% of energy from cereals, roots, tubers	% of energy from livestock	% of protein from livestock
West Africa	66	5	16
Central Africa	69	4	19
East Africa	63	11	26
Southern Africa	72	12	36
India	64	8	16
Bangladesh	54	2	6

Source: FAOSTAT data

When considering the contribution of livestock products to human diets, it is important to bear in mind the nutritional characteristics of the various products (Figure 8). Beef and small ruminants provide most energy and protein per kilogram

consumed, but also involve a longer production cycle and so are generally less frequently available for consumption (from own production) compared to poultry (meat and eggs) and dairy products.



Source: FAOSTAT data.

Figure 8: Nutritional characteristics of livestock product categories.

Looking next at consumption patterns in the subregions under consideration, two broad categories emerge. In Eastern Africa and South Asia dairy products alone account for the large majority of the livestock products consumed. In the other African subregions dairy products represent less than half the total, and fall behind "other" products (pork and bush meat etc.) in Central Africa. Small ruminant meat makes a minor contribution in all subregions. Figure 9 shows the considerable variations by country. Those countries in which consumption of livestock (especially dairy) products is high are often those with dry climates and less potential for crop production.

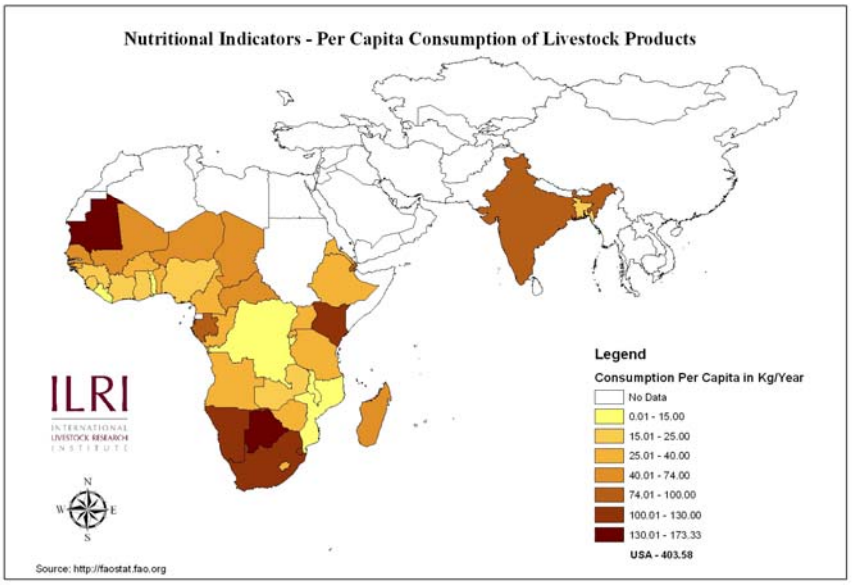


Figure 9: Per capita consumption of all livestock products, by country.

While there is again considerable variation between countries, undernutrition is widespread throughout the study areas.[6] An estimated 461 million were undernourished in sub-Saharan Africa and South Asia in 2001–2003, 25% of the population (FAO 2006).

Animal-source foods are able to combat a range of nutritional deficiencies, particularly when consumed as a component of a diverse diet that includes plant-source foods (Randolph et al. 2007). They are energy dense and are good sources of protein and micronutrients, and therefore moderate increases in their consumption in undernourished populations can provide critical nutritional benefits without crossing the threshold of significant risk for chronic disease. Animal-source foods are excellent sources of essential micronutrients such as iron, zinc, calcium, riboflavin, iodine, vitamin A and vitamin B_{12}, and many nutrients are better absorbed from animal-source than from plant-source foods. Addressing micronutrient deficiencies in children is particularly important, as the impact of undernutrition on physical capacity and cognitive development is established early in life, with substantial long-term effects on human capital development and productivity (Leroy et al. 2007).

Livestock keeping and production can therefore be a key component of food-based strategies that allow people to take responsibility for the quality of their own diet through the production and consumption decisions that they make, thereby contributing to human well-being and sustainable development (Leroy and Frongillo 2007).

[6] Undernutrition refers to the condition of people whose dietary energy consumption is continuously below a minimum dietary energy requirement for maintaining a healthy life and carrying out light physical activity (FAO indicators).

Having considered the prevalence of smallholder livestock keepers across the developing world, and the roles that livestock can play in household income and well-being, the next section analyses value of production as a factor in investment targeting.

The value of livestock production

The relative importance of different livestock species varies by country and production system. Alongside other types of information, a better understanding of the value of production (and therefore importance) of livestock products would help target investments, both in terms of species and regions. The study (Omolo and Notenbaert) sought to contribute to the understanding of the economic potential of different species by calculating the value of production of selected species (cattle, poultry and small ruminants) across different regions and production systems.

For the four production systems considered, differential productivities were assumed, with the mixed humid/subhumid as a reference (100%):

- Arid/semi-arid pastoral systems: 70%;
- Mixed humid/subhumid, including rainfed and irrigated systems in those zones: 100%;
- Mixed temperate/tropical highland, including rainfed and irrigated systems in those zones: 120%;
- Other, including urban: 70%.

The first step in this broad-brush analysis was to use a geographic information system (GIS) to calculate numbers of animals per country and production system (FAO 2007; Kruska et al. 2003). Country-level productivity estimates were extracted from FAOSTAT and weighed by the above productivity figures. In a second step, the animal numbers were multiplied with the resulting productivity estimates (per system per country) and prices to come up with a value of production of the animals present.[7]

Figure 10 and Figure 11 show livestock densities for the species under consideration in sub-Saharan Africa and South Asia, respectively. Figure 12, Figure 13 and Figure 14 show spatial variations in value of production for cattle, small ruminants and poultry, respectively, in South Asia and sub-Saharan Africa. Table 7 gives values of production for each system and species in each region.

[7] Using FAOSTAT database (http://faostat.fao.org).

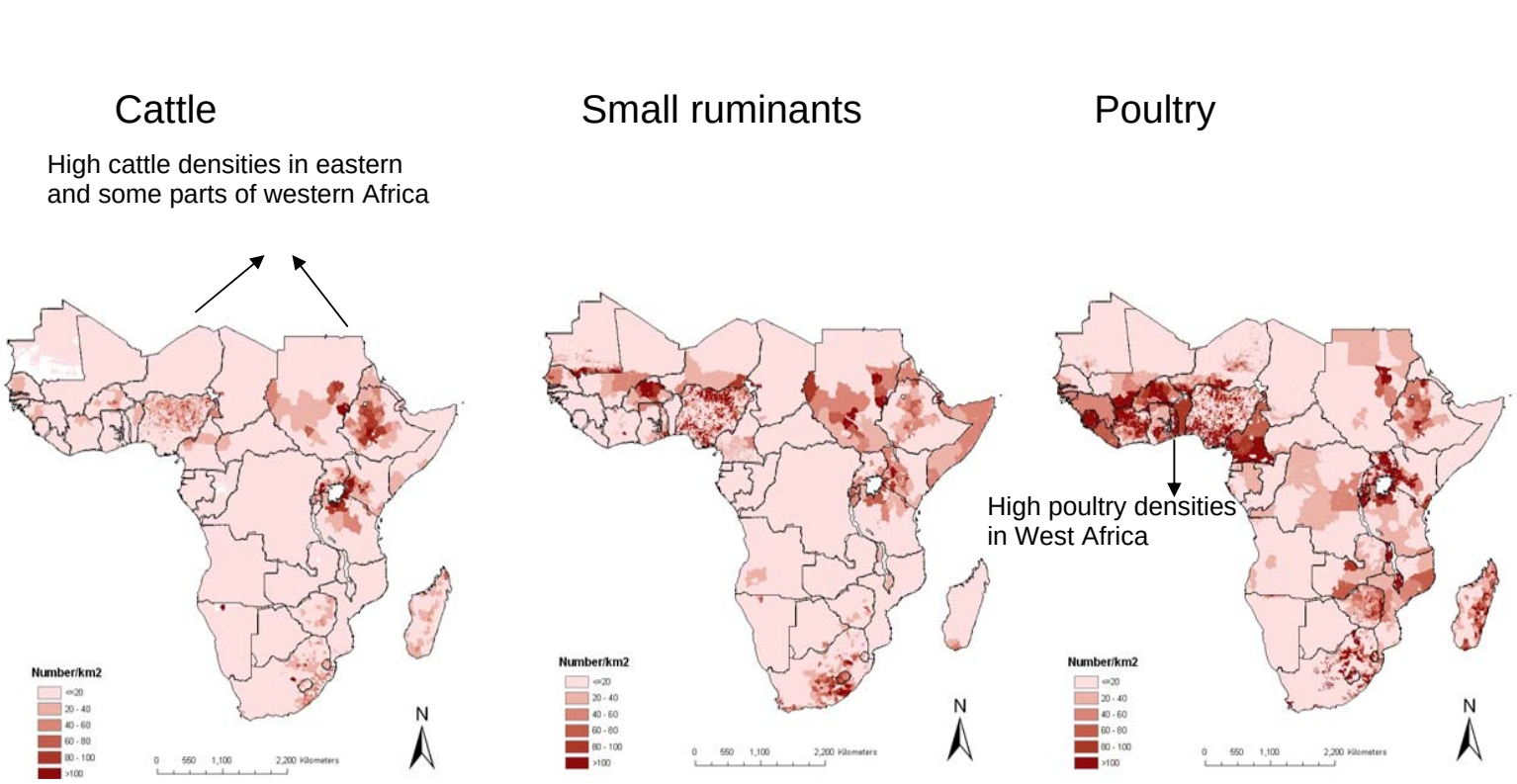


Figure 10: Livestock densities in sub-Saharan Africa.

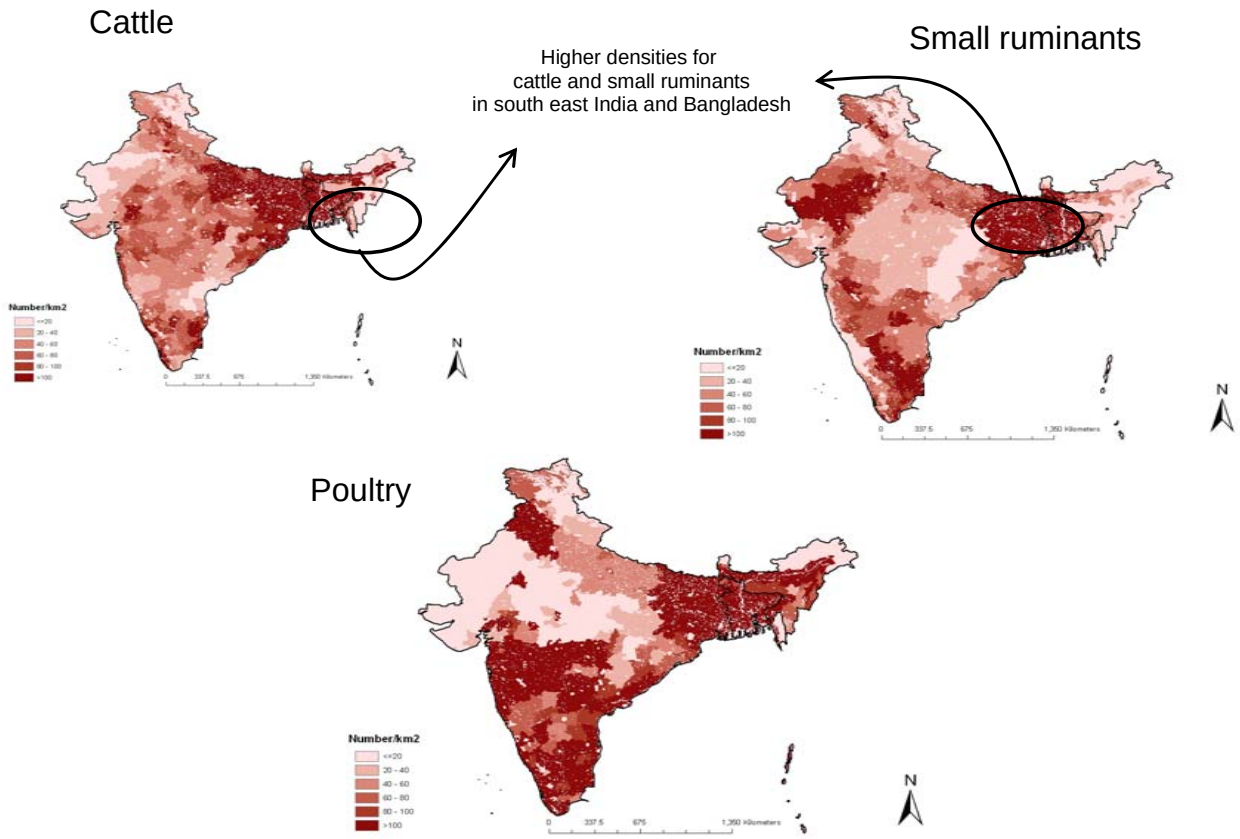


Figure 11: Livestock densities in South Asia.

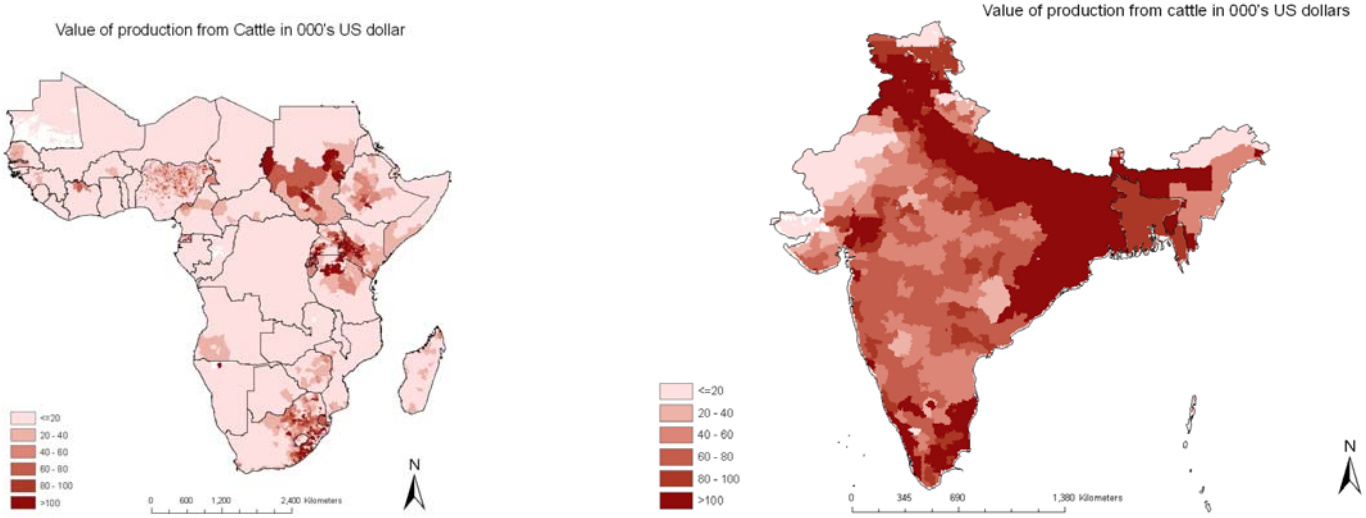


Figure 12: Value of production: Cattle, sub-Saharan Africa and South Asia.

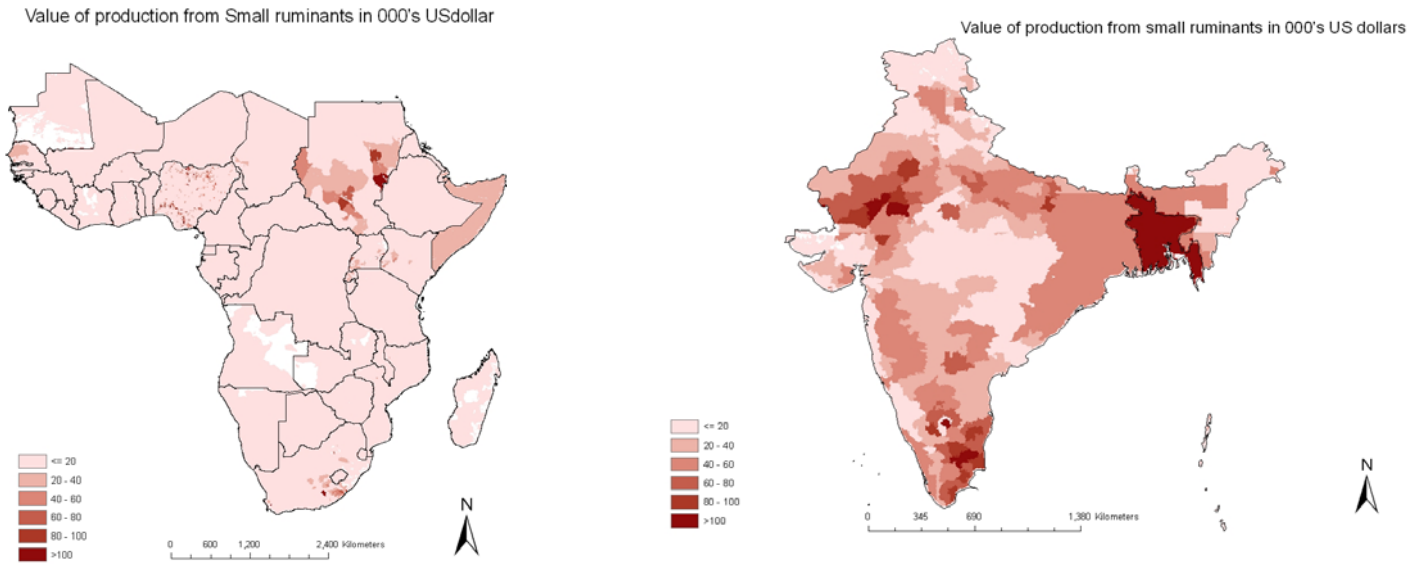


Figure 13: Value of production: Small ruminants, sub-Saharan Africa and South Asia.

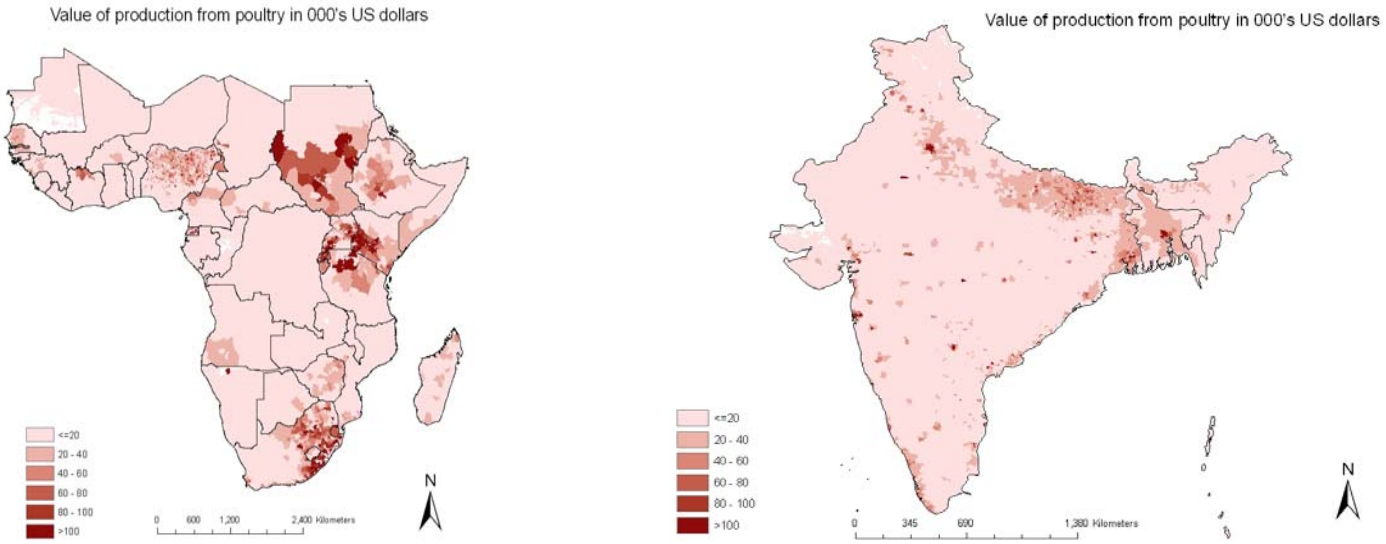


Figure 14: Value of production: Poultry, sub-Saharan Africa and South Asia.

Table 7: Value of production for species and production system by region (million US$)

Region/species	Mixed humid/ subhumid	%	Mixed temperate/ tropical highland	%	Arid/ semi-arid	%	Other	%	Total	%
Sub-Saharan Africa										
Cattle	721	36	1447	65	7487	58	724	42	10,380	55
Small ruminants	199	10	200	9	2988	23	202	12	3589	19
Poultry	1066	54	565	26	2400	19	785	46	4816	26
All species	1986	11	2213	12	12,874	69	1711	9	18,784	100
South Asia										
Cattle	1018	54	122	61	5510	61	1291	68	7941	61
Small ruminants	443	24	60	30	1579	18	283	15	2364	18
Poultry	421	22	18	9	1910	21	327	17	2676	21
All species	1882	15	199	2	8999	69	1901	15	12,981	100

Although broad-brush, the results of the study enable comparison of the economic importance of species and production systems in sub-Saharan Africa and South Asia. Most of the value of production in sub-Saharan Africa was derived from cattle (55%), followed by poultry (25%) and small ruminants (20%). In South Asia these proportions were 61%, 21% and 18%, respectively, giving a similar pattern. In both regions the arid/semi-arid zone contributed most to value of production (57% in sub-Saharan Africa, 69% in South Asia), though the mixed temperate/tropical highland system was of much greater relative importance in sub-Saharan Africa.

Turning to subregional consideration of species, some interesting features emerge. In sub-Saharan Africa discrepancies between poultry density and value reflect variations in productivity and price. In West Africa, for example, poultry density is high (Figure 10) but value of production is comparatively low (Figure 14) due to lower productivity and prices in that region. Sudan displays an opposite pattern with low densities yet high value of production. Throughout South Asia, the generally low value of production of poultry is striking (Figure 14).

For cattle, there is broad convergence in sub-Saharan Africa between cattle density and value of production (Figure 10 and Figure 12). A similar pattern is found in South Asia (Figure 11 and Figure 12). Small ruminants in West Africa display a pattern similar to poultry, with high density but relatively lower value of production. In South Asia there is a high density of small ruminants in eastern India and Bangladesh (as for cattle). Throughout South Asia value of production for small ruminants generally coincides with the pattern of density. In the next section, an analysis of productivity gaps is undertaken to identify areas where investment could close gaps between current and potential production.

Productivity gaps in livestock production

Within sub-Saharan Africa and South Asia, livestock support the livelihoods of vast numbers of small-scale producers who face formidable challenges in improving the scale and efficiency of production and the quality of their products. The study (Mwacharo et al.) was undertaken to identify differences in productivity for key livestock species – dairy and beef cattle, poultry and small ruminants – in the primary livestock production systems in sub-Saharan Africa (West, East and Southern) and South Asia, in order to help identify investment priorities.

Three types or breeds of livestock were studied: indigenous genotypes; exotic genotypes, often introduced to improve productivity; and crossbreeds of various types. Information gathered from a literature review was used to derive the productivity gap for key livestock species and genotypes – i.e. the difference between the mean highest and lowest observed levels of production (e.g. of milk) in a specific production system (e.g. arid/semi-arid, humid/subhumid).

From analysis of the data three main factors were identified that might account for the productivity gaps, namely differences in animal husbandry practices, genotype and production system. Looking first at dairy cattle, some examples will be given to illustrate a wide-ranging study. Figure 15 shows lowest and highest (light and dark shading) milk yields for crossbred cattle for three regions of sub-Saharan Africa. The highest potential to increase milk production was observed in East Africa (over 300%). This productivity gap can be attributed to different animal husbandry practices, given the similarity in genotype and production system.

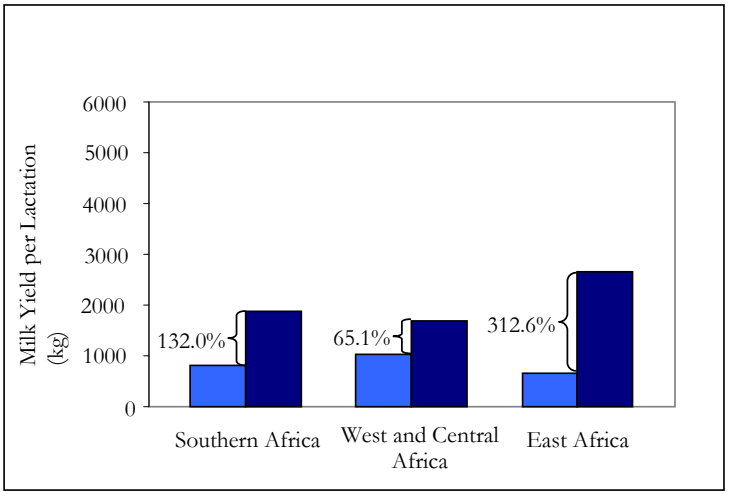


Figure 15: Maximum and minimum levels of milk production for crossbred cattle in sub-Saharan Africa.

Figure 16 compares milk yields for the three genotypes across production systems in Southern Africa (light and dark shading indicate minimum and maximum for each category). Type *x* gaps are due to differences in animal husbandry practices (see Figure 15); type *y* gaps, across different breeds in the same production system, can be attributed to differences in genotype; and type *z* gaps are due to differences in production system (for the same genotype). Figure 17 presents data for South Asia (synthetics = hybrids).

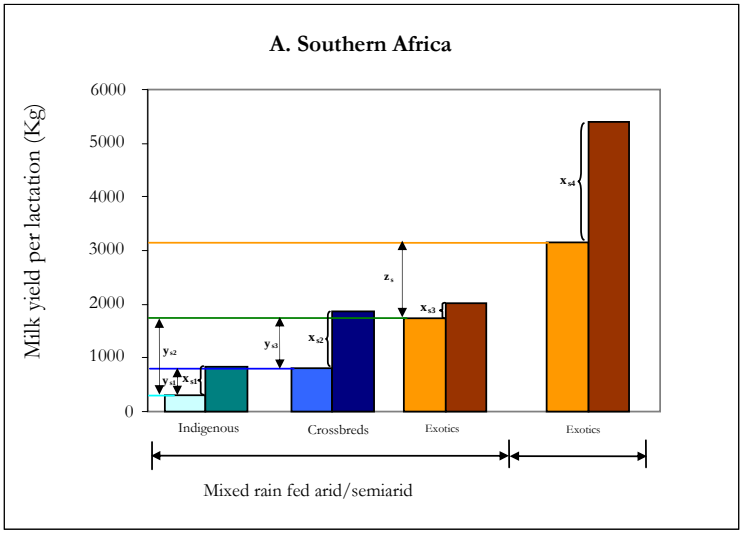


Figure 16: Differences in milk yields by genotype and production system in Southern Africa.

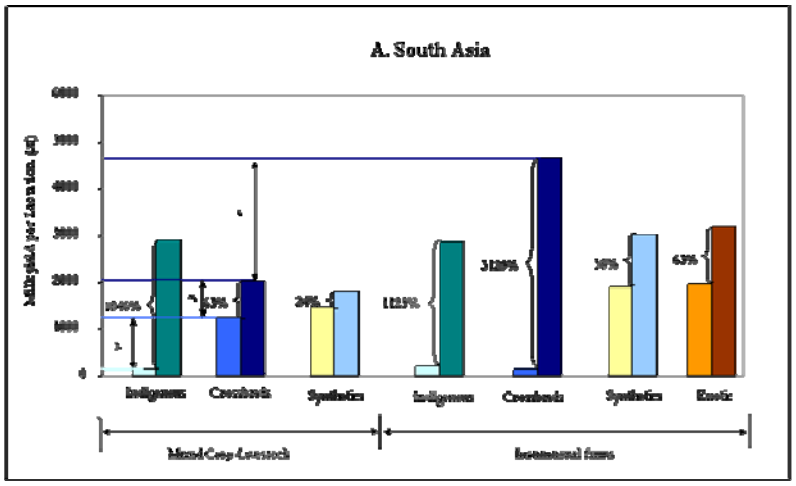


Figure 17: Differences in milk yields by genotype and production system in South Asia.

The difference between the observed minimum and maximum levels of milk production for each genotype in different regions, and the production levels achieved in commercial ranches, indicate that the genetic potential of most genotypes is not being realized in smallholder settings, and there is considerable potential in all regions to increase yields with adoption of improved genotypes and better animal husbandry practices. The highest potential to increase milk production was observed in East Africa in crossbred animals (Figure 15). In West/Central Africa the potential was greatest for purebred indigenous cattle, and in Southern Africa for exotic cattle. In South Asia, results indicate that it is possible to more than double milk production from indigenous and crossbred animals with targeted intervention, with due attention given to nutrition and animal health care.

Similar exercises were performed for poultry, small ruminants and beef cattle, and examples will be given for each.

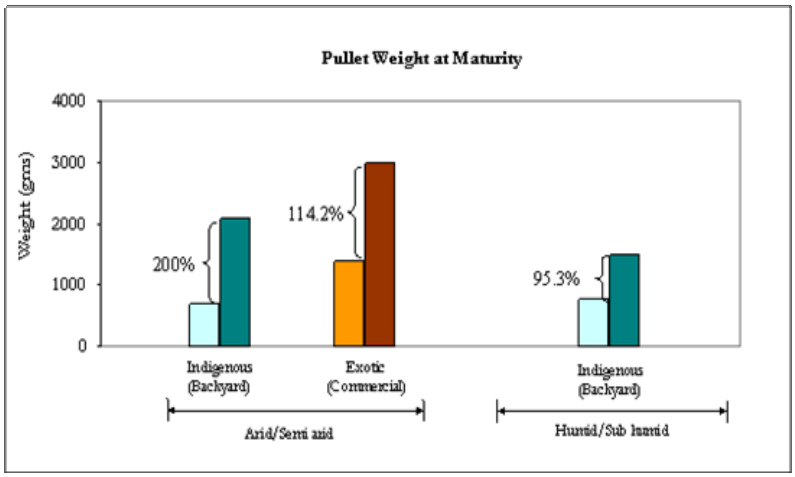


Figure 18: Yield gaps for pullets of different genotypes of chicken in Southern Africa.

For poultry, data on egg production and pullet weight at maturity were collated. In both sub-Saharan Africa and South Asia, low input-output backyard scavenging systems predominate, and are a critical household source of income and high-quality proteins (Spadbrow 1997; Gueye 1998). Figure 18 gives the example of pullet weight under difference systems and for different genotypes in Southern Africa. Broadly similar patterns were identified in all regions, with productivity gaps of varying sizes indicating potential for improved meat and egg production in both commercial and backyard systems.

Poultry is a promising sector for nutrition and poverty alleviation, as modest initial capital investment can act as the first step on the ladder of capital accumulation (Todd 1999). For indigenous genotypes, selective breeding, improved management, supplementary feed and disease control can significantly improve both meat and egg productivity. The commercial sector, with its wealth of human, technical and financial resources, could be a catalyst

in promoting backyard poultry production as a practical and viable option for poverty alleviation.

For small ruminants, production and reproduction data were collated from studies in West, East and Southern Africa. Small ruminants are highly suited to low-income households in marginal environments, given their low feed and capital requirements, their ability to utilize a wide range of feed resources and their adaptation to prevailing conditions (Devendra 2002; Holst 1999). With the reduction in average landholding sizes due to increased human population and increased competition for animal feed resources, small ruminants are expected to play a bigger role in sustaining livelihoods in the future.

The potential to increase small ruminant meat and milk productivity was found to be high in sub-Saharan Africa. This was clearly demonstrated by data from the East African region. Where environmental conditions and management standards are conducive, exotic and crossbred genotypes could more than triple milk and meat productivity, as demonstrated in FARM-Africa's Dairy Goat Development Project in Eastern Kenya (Peakock 2008) and in cases in Tanzania (Mtenga and Kifaro 1993). The climatic conditions in West Africa on the other hand are not conducive to optimal performance by exotics and crossbreeds, favouring only the best-adapted indigenous breeds, which offer a high potential for meat productivity.

For beef cattle, production and reproduction data were again assembled for sub-Saharan Africa, where both production and consumption have increased significantly over the last decade (Tambi and Maina 2005), though growth in beef production per animal has lagged. Most production takes place in arid/semi-arid environments where crop production is risky due to unfavourable climatic conditions.

Productivity gaps were most marked among indigenous breeds. Factors contributing to low production efficiency included prolonged calving intervals and low weaning weights among calves. Offtake rates (ratio of animals slaughtered to total herd) varied considerably, and there was significant potential for increased offtake in many areas, for example by vertical integration of pastoral and commercial production systems.

Simulating gains from alternative livestock technology and management interventions

The results above provide some evidence of which types of technology barriers constrain productivity of smallholder livestock producers, which may or may not translate into identification of the intervention which may best increase productivity. To further investigate this issue, some modeling was conducted to explicitly compare likely outcomes from alternative livestock interventions to improve productivity. Unlike crops, livestock not only produce products such as milk or egg, but also reproduce and grow in numbers and lead to herd growth, some of which can be sold. Measuring productivity in this larger context thus requires a multi-year approach due to long reproductive cycles in the case of cattle, and also requires a herd model. Further, a combined productivity

measure of different products (milk and cattle offtake for example) require a composite measure, the easiest of which to use is simply the monetary value.

As an example in a key value chain, a dynamic modelling approach was used to explore the effect of alternative productivity intervention strategies on the lifetime productivity of dairy cattle. We used RUMINANT, an individual-based, dynamic model in which performance depends on genetic potential of the breed and feeding (see Herrero et al 2002). We then used results of the individual simulations in the herd model of Lesnoff (2007) under different assumptions related to animal health and also reproductive management (calving interval). The model parameters and assumptions were based on data from smallholder dairy farms in the highlands of Central Kenya.

The herd model, run over a 20 year period with a starting herd of 100 animals, generates annual value in $ output. Two sets of values were generated: value of milk production only, and value of milk+value of herd growth/offtake. See table 2.1 below for details on the parameters and assumptions used to compare Poor and Good status of each type of intervention.

2.1 What underlies the estimations (simulation parameters):

Type of animal	Management standard	Production Performance	Nutrition	Animal health care	Reproductive performance
Improved dairy cow (crossbred)	Low/Poor	1000 kg	Grazing natural pastures only	- 20% infant mortality - 10% adult mortality	60% calving rates (out of 100 reproductive females 60 calve down)
	High/Good	3600 kg	- Grazing natural pastures - Supplemented with concentrates - Provided improved pastures/feeds - Supplemented with minerals & vitamins	- 10% calf mortality - 5% adult mortality	80% calving rates (Out of 100 reproductive females 80 calve down)

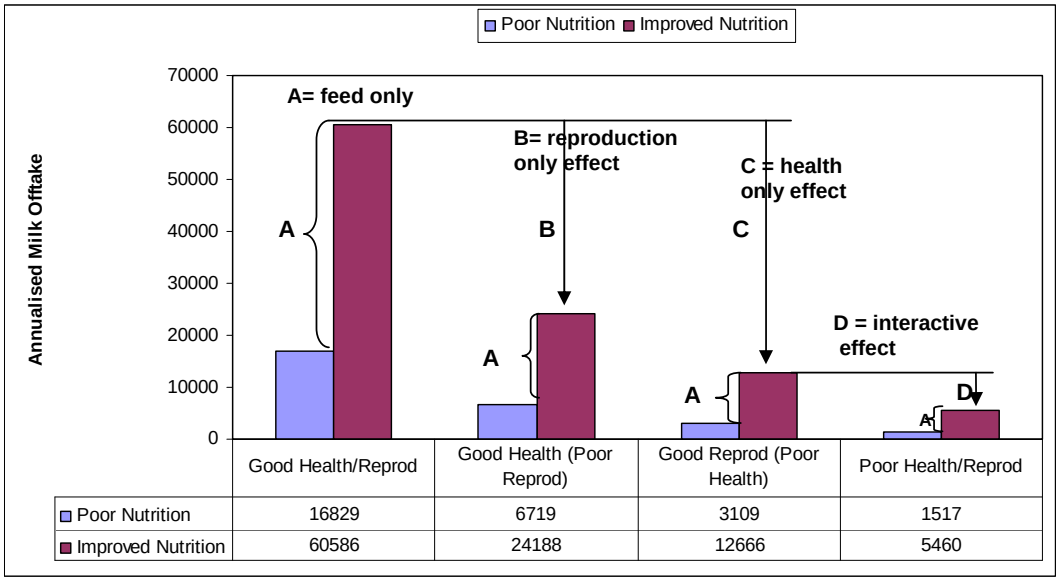
Additional simulation parameters

1. Initial Herd size = 100 animals (the final herd size depends on the simulated parameters such as mortalities)
2. Simulation period = 20 years to achieve steady state
3. Price of a litre of milk = US $ 0.3

4. Prices of cows = US $ 800
5. All results are based on annual out puts (milk and animals) per herd

Figure 2.2 shows results for annualized value of milk offtake only for comparative management scenarios. In each case, good nutrition and poor nutrition outcomes are compared to good or poor animal health and reproductive management. So for example, in the figure B represents the incremental drop in value of offtake due to poor reproductive management, campared to good reproductive management, under good and poor feeding scenarios. D represents an additional incremental effect due to interactions when both reproduction and animal health management are poor. Figure 2.3 describes the same analysis, but in this case combining value of offtake of milk plus herd growth.

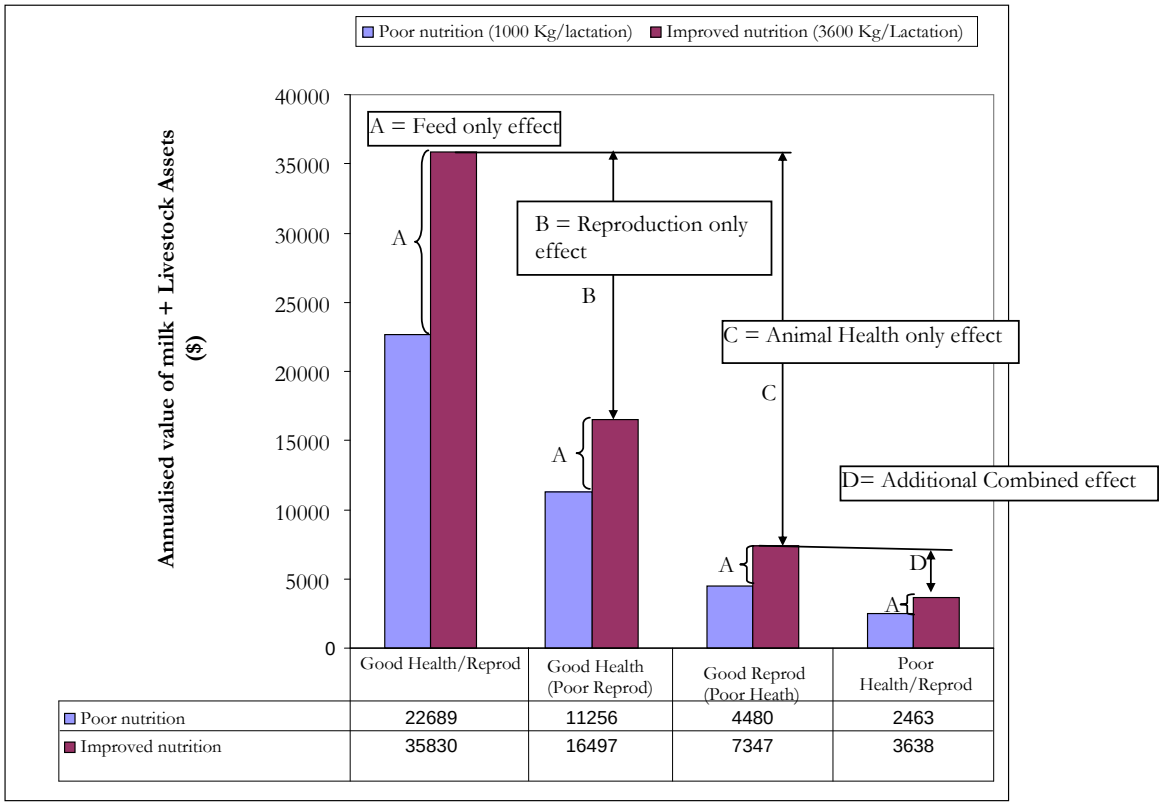
2.2 Effects of different management strategies on the increase in value of annualised milk off take



	Good Health/Reprod	Good Health (Poor Reprod)	Good Reprod (Poor Health)	Poor Health/Reprod
Poor Nutrition	16829	6719	3109	1517
Improved Nutrition	60586	24188	12666	5460

Note: A = Average feed effect only (272%); B = Reproduction effect only (150%);
C = Animal health effect only (91%); D = Additional combined effect (132%)

2.3 Effects of different management strategies on the increase in annualised value of milk and livestock assets (herd growth)



Note: A = Average feed effect only (54%); B = Reproduction effect only (117%);
C = Animal health effect only (125%); D = Additional combined effect (102%)

In order to achieve some overall perspective of the potential impacts of each type of technology intervention, given the complexity and interactions of the effects of those interventions, it was necessary to make pairwise comparisons of the change in value for each possible combination. For example, the effect of good feeding vs poor feeding can only be evaluated by comparing those feeding regimes under every other combination of poor vs good genetics, animal health and reproduction management. One thus can arrive at a range of outcomes, and a mean outcome in terms of value of offtake.

These values are illustrated in Figure 19 and Figure **20** below. In both cases, the highest gains are generally related to animal health interventions that reduce mortality in calves and adults. Due to survival of more females, and females entering into lactation over time, this translates into both higher herd milk yield and higher herd growth. The primary difference between the two figures is that improving feed has a higher impact when milk yield only is considered. This is as expected, given that improved feeding can stimulate rapid yield responses from some animals.

The two figures can be interpreted as short term and long term benefits from dairy technology interventions, and provide some guidance as to what the potential impacts may be from investment to reduce technical constraints to

dairy production. In terms of on-farm interventions, the analysis demonstrates that as generally recognized, short term gains can be achieved relatively simply and quickly through feed improvement, the outcome dependent somewhat of course on the other determinants. The analysis however also makes clear that over the long run, intervention in animal health will have greater cumulative benefits.

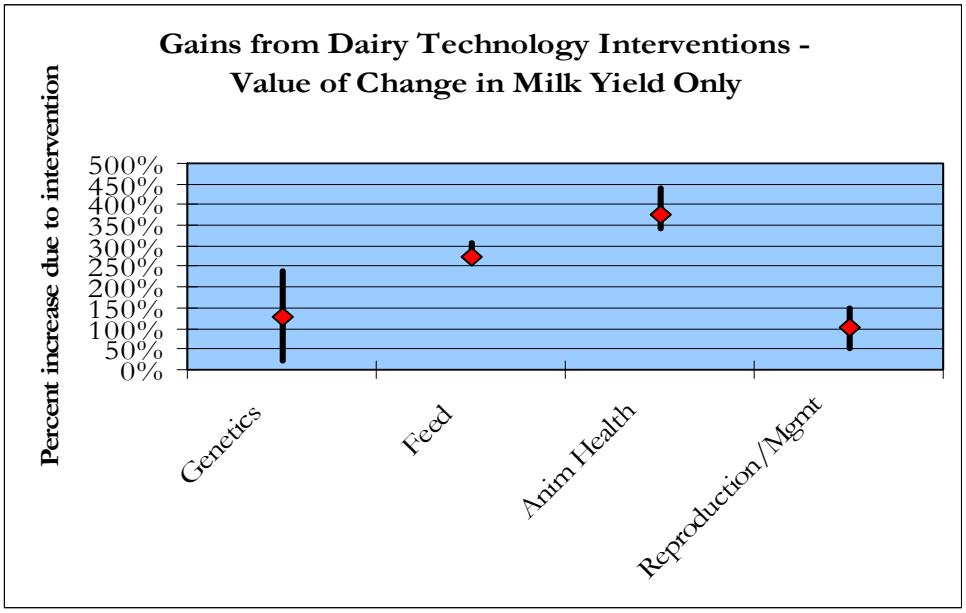


Figure 19. Gains from dairy technology interventions related to milk yield only – range and mean percentage gain

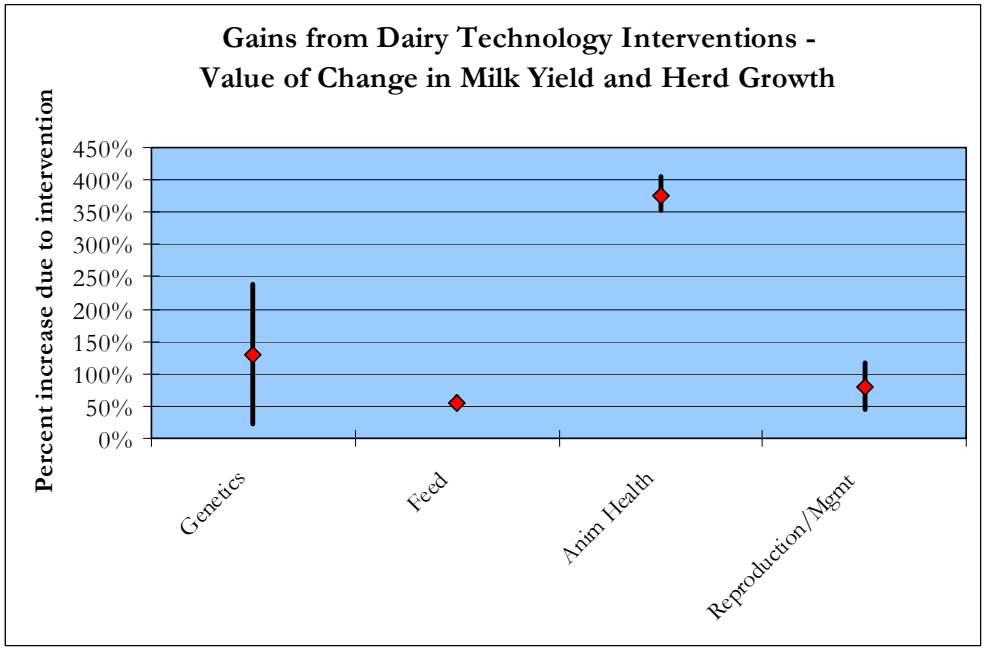


Figure 20. Gains from dairy technology interventions related to both milk yield and herd growth – range and mean percentage gain.

Livestock value chains and market opportunities

Investment in livestock may provide a pathway out of poverty for millions of people in developing countries. Targeting such investment requires a careful appraisal of current value chains and identification of those areas where investment might prove most beneficial. Central to returns on investment are the market opportunities driving demand for the resulting products.

The study (Njoroge et al.) therefore sought to answer the following questions:

- What are the dominant livestock value chains for smallholder farmers in different regions of sub-Saharan Africa and South Asia?
- For each region, in which countries is livestock value chain investment likely to have the highest impact on targeted communities?
- What are the potential interventions that should be appraised to assess their feasibility?

Production and consumption trends were derived for beef meat, chicken meat, fresh milk and small ruminant (sheep and goat) meat.[8] For each, the following main points were observed:

- For beef production, annual growth rate was highest in East Africa (5.8% during 2000–2003) though the growth in domestic consumption was slower (2.1%) (Figure 21). Beef consumption remains lowest in South Asia.
- Production and consumption of chicken meat showed positive growth in all regions, especially India, though actual consumption levels in South Asia remained lower than for West and Southern Africa, but comparable to East and Central Africa. In West Africa, faster growth in consumption has been satisfied in some countries by importation of chicken meat (Figure 22).
- Milk production increased in all regions apart from Central Africa; production growth considerably exceeded growth in milk consumption in East Africa (Figure 23). Current consumption levels vary considerably but are highest in East and Southern Africa and in India.
- For small ruminant meat, growths in production and consumption were most marked in East Africa and Bangladesh (Figure 24) in the earlier period 1990-1999, but flatter since, and consumption is generally low in all regions.

Trends in population increase, per capita income growth and urbanization were also analysed, as they are important drivers of changing demand for livestock products (Delgado et al. 1999). Growth rates of per capita income (over 5% per annum in all regions) were generally higher than population and urbanization growth rates, as well as being higher than growth rates for

[8] The main source of data and methodologies applied was the FAOSTAT database of the Food and Agriculture Organization of the United Nations (http://faostat.fao.org).

production and consumption of livestock products, indicating a possible “latent demand” for such products (Figure 21–Figure 24).

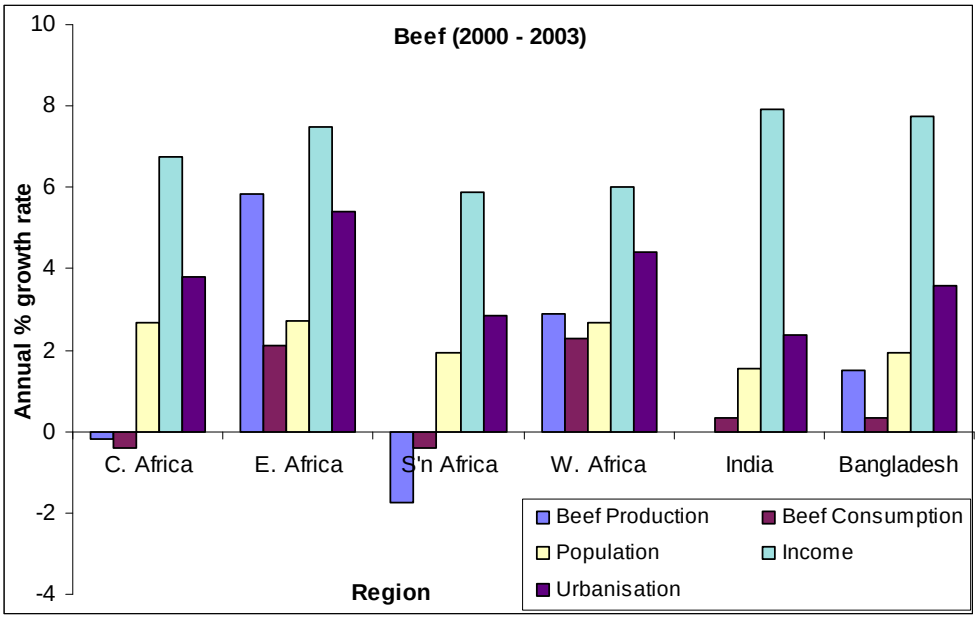


Figure 21: Trends in beef production and consumption, population, income and urbanization by region, 2000–2003.

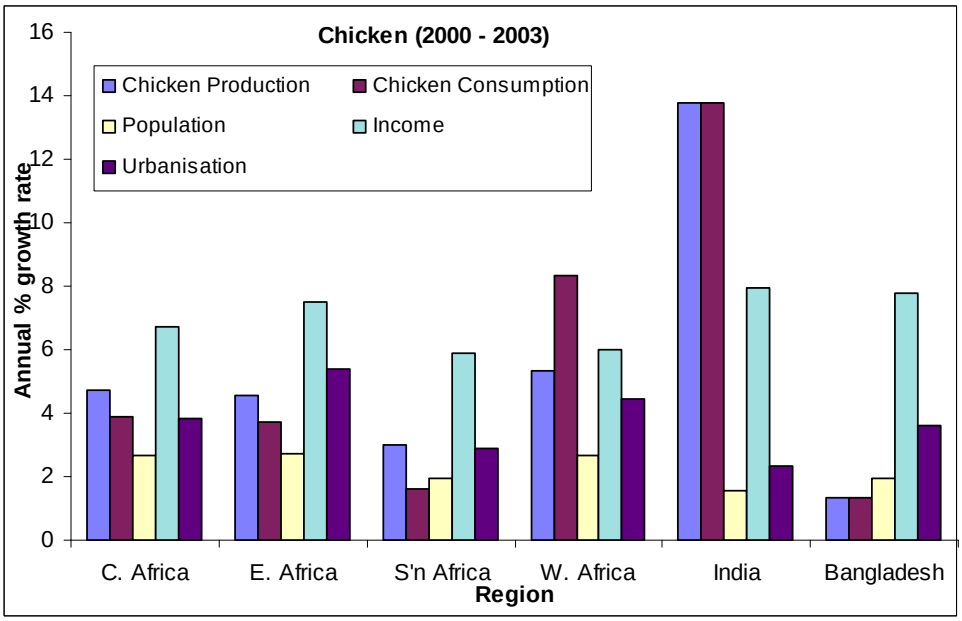


Figure 22: Trends in chicken meat production and consumption, population, income and urbanization by region, 2000–2003.

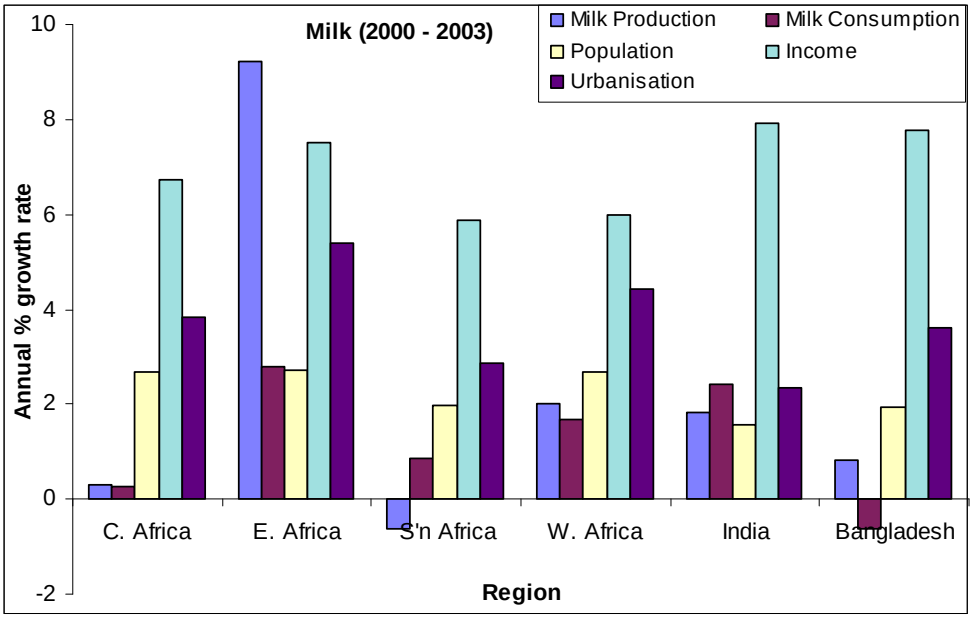


Figure 23: Trends in milk production and consumption, population, income and urbanization by region, 2000–2003.

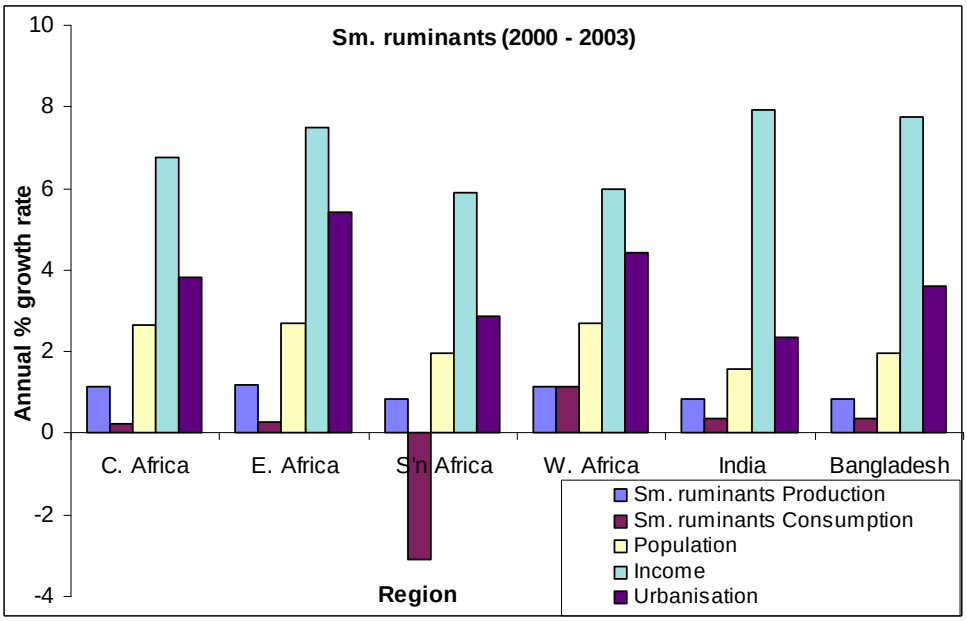


Figure 24: Trends in small ruminant production and consumption, population, income and urbanization by region, 2000–2003.

Turning next to consideration of opportunities for import substitution[9] (thereby saving foreign exchange and encouraging the domestic industry), certain regions show high levels of importation relative to domestic production, particularly for chicken meat and milk products (Table 8), though the potential for increased domestic production may be severely limited by technical and resource constraints, such as incidence of animal disease, lack of feed resources, limited tradition of livestock husbandry practices, poor veterinary services and deficient transport and market infrastructure.

Table 8: Importation of livestock commodities as percentage of domestic production, by region

Region	% Importation (relative to domestic total production)[a]				
(2003–2005 averages)	Beef	Chicken (meat)	Milk/dairy (cow)[b]	Small ruminants (meat)	Chicken (eggs)
Eastern Africa	0.2	6.5	1.7	0.2	0.6
Western Africa	7.7	26.8	**102.3**	2.1	1.3
Central Africa	4.7	**193.2**	**122.2**	1.2	21.9
Southern Africa	1.9	22.1	8.9	13.1	3.3
Bangladesh	0.0	1.6	40.3	0.0	0.0
India	0.0	0.0	0.1	0.0	0.0

[a] Includes live animal imports

[b] Converted to liquid milk equivalent

Regarding exports, the data indicate that levels of exportation relative to domestic production are low for all livestock products across all regions. Market orientation (both export and domestic) is generally low among smallholder farmers, who account for the majority of livestock production in sub-Saharan African and South Asia (McPeak and Barrett 2001). Reasons include unavailability of a reliable, profitable market and low levels of available surplus product (due to low production or high consumption levels within the family unit). Exceptions include milk marketing in Kenya and parts of India.

Based on consideration of the data gathered, and the factors outlined in this summary, opportunities can be identified for subregional interventions in particular value chains in sub-Saharan Africa and South Asia. These opportunities are summarized in Table 9.

[9] Import substitution: Reducing imports by satisfying demand through an increase in domestic production.

Table 9: Opportunities for targeting value chain interventions in sub-Saharan Africa and South Asia

Location	Intervention area	Opportunity	Comments
West Africa	Dairy	Import substitution	High import:domestic production ratio along coast. However, severe animal disease constraints may limit increase in production for foreseeable future.
West Africa	Beef	Domestic growth	Positive growth rate in production and consumption but per capita consumption still low; rising incomes, urbanization = latent demand.
West Africa	Small ruminants	Domestic growth	Positive growth rate in production and consumption but per capita consumption still low; rising incomes, urbanization = latent demand.
Central Africa	Poultry: chicken meat	Import substitution	High import:domestic production ratio, high consumption (Republic of Congo, Equatorial Guinea, Gabon). Difficult to overcome environmental, animal health and feed resource constraints.
East Africa	Dairy	Export potential	Positive production growth rates, already high consumption levels.
East Africa	Beef	Export potential	Production growth higher than consumption/population growth; also, income growth indicates domestic market potential.
East Africa	Small ruminants	Domestic growth	Growing per capita consumption and production; export potential also.
Southern Africa	Beef	Export potential	Consumption high; potential to reverse falling production trends and increase exports.
South Asia: India	Poultry: chicken meat	Domestic growth	High growth rate in production & consumption but per capita consumption still low; rising incomes, urbanization = latent demand.
South Asia: India	Dairy	Domestic growth	Very high production growth rate.

In conclusion, while the analysis here is preliminary only and gives little consideration to the many production constraints, it does enable some identification of the locations, products and market areas where value chain investment has the potential to contribute to the livelihoods of smallholders specifically and to economic, social and personal well-being more generally.

Summary of Part 1

This report has presented a synthesis of the deliverables prepared for the Bill and Melinda Gates Foundation on different aspects of livestock production, drawing on examples from sub-Saharan Africa and South Asia, to assist the Foundation in identifying livestock investment opportunities. The following broad conclusions can be drawn from the material presented:

1. Livestock production in smallholder systems exists throughout the developing world in a great variety of forms, varying considerably by livestock kept, production system and geographical setting.
2. Livestock contribute considerably to the livelihood strategies of the poor and can be an important source of income, though the extent of market participation varies considerably.
3. Livestock keeping can also make a vital contribution to household food security, with animal-source foods bestowing a range of nutritional benefits as part of a varied diet.
4. The value of production of different livestock species in different production systems again varies considerably according to a range of factors, though broad patterns emerge that can assist in identifying areas where investment may be advantageous.
5. Due to a range of constraints, most small-scale livestock keepers are operating at levels of productivity well below their potential. This applies for most key livestock species, including dairy and beef cattle, poultry and small ruminants. These productivity gaps are important evidence when considering where investment can be most beneficially targeted.
6. If livestock investment is to be successful it must consider the positioning of small-scale livestock producers within the whole value chain. Analysis of this dimension can give insight into which types of intervention – e.g. support for domestic growth, increased exportation or import substitution – may prove most cost-effective and beneficial in particular locations.

Part 2: Identifying key livestock value chains

Objectives and approach

In the previous sections, data and analysis were summarized that laid out a range of issues to be considered in a livestock development strategy that was aimed at positive outcomes in the poor. In this final section, we integrate some of those data results, and use a matrix of data to identify those Value Chains that offer the best opportunities to achieve pro-poor outcomes in rural communities through investment in livestock development in the short to medium term.

The approach uses a set of analytical filters that combine market potential, likelihood of impact at scale on the poor, and supply constraints. The data and information used is a combination of the quantitative data summarized in the preceding sections, and expert knowledge generated through several group and teleconference discussions of senior ILRI staff, including participants from South Asia, East, Southern and West Africa. The approach is illustrated in Figure 25.

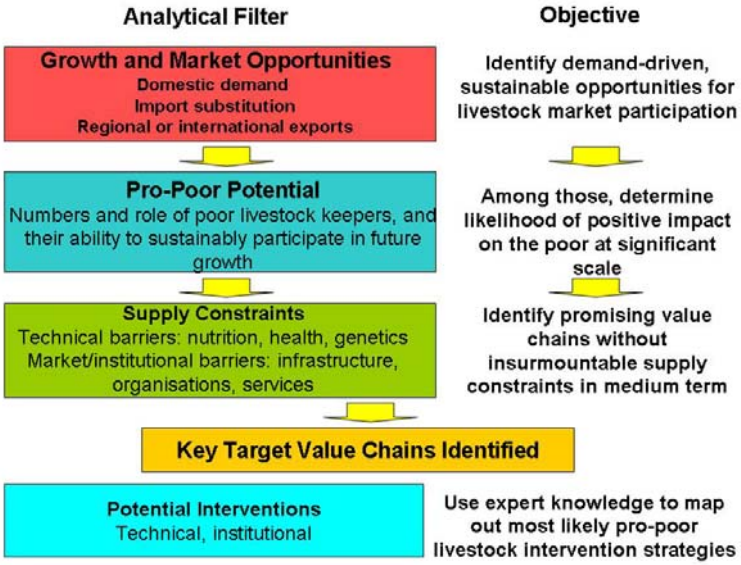


Figure 25: Illustration of analytical process for identifying key target value chains and strategies for interventions.

Analytical Filters

Growth and Market Opportunities

The aim of this filter is to differentiate value chains by their potential for demand-driven growth in the livestock species/commodity in question over the medium turn. We have used three distinct measures or indicators of potential:

Domestic demand: trends in national consumption of livestock products, driven in turn by real income growth, urbanisation and changes consumption habits. In most cases, this will be the largest source of demand.

Import substitution: market share of imported livestock products, which represent potential market for domestic products if they can be enabled to compete in price, quality, form.

Regional and international exports: potential, based on deficits elsewhere, to export livestock products. Regional markets may be more feasible due to lower standards and transactions costs. Although these opportunities often receive the highest policy priority, they generally offer limited opportunities given difficulty of compliance with quality and safety standards.

Pro-Poor Potential

There are two main elements of this analytical filter, which aims to assess which livestock value chains will have most direct impact on the poor, particularly rural poor livestock keepers (as opposed to poor consumers, or those involved indirectly in value chains).

Numbers of and role of rural poor: absolute number of rural poor who may be potential beneficiaries, and some understanding of proportion of them who are livestock keepers.

Ability of the poor to sustainably participate in future market growth: a somewhat subjective measure that is based primarily on likely structure of production in foreseeable future. Economies of scale, local factor values and resources, and species/breed mix will determine whether smallholder producers are likely to be able to compete, or whether the future lies mostly with industrial, large scale and capital-intensive producers.

The other determinant to participation is the nature of the supply chain: verticially integreated chains that have high standards of quality and safety will provide fewer opportunities for smallholders. Markets that are mostly local, informal, with few standards, will offer larger opportunities.

Supply Constraints

In many cases, particularly where large import shares are observed, there are strong technical reasons why increased domestic supply of particularly livestock

products is constrained, which sometimes manifest in high levels of risk that preclude sustained investment. In many cases, these may not be easily overcome by available development interventions or research approaches in the foreseeable future. This filter aims to differentiate those that face apparently insurmountable challenges from those for which options appear available. The constraints revolve around:

Disease challenge: zones where certain animal diseases constrain increased production, and for which few solution appear on the horizon.

Feed resources: zones where available local resources significantly constrain intensification or expansion.

Key Target Value Chains

By combining some measures to represent these analytical filters, some Key Target Value Chains can be identified that have the following characteristics

- Good market growth opportunities
- Some potential for poor people to participation in that growth
- Existing technical challenges can be addressed

What remains following that analysis, however, is to identify *what strategy* should guide development interventions in each value chain, and what relative emphasis should given to animal genetics, health and feeds, and what are the institutional, infrastructural and policies elements essential for success. Based on expert knowledge, these form the Potential Interventions for each value chain, which in turn could guide the direction of more in depth value chain assessment.

Selected target livestock value chains

The value chains as addressed in this section are defined as a combination of a) a region of SSA or South Asia, and b) a species/breed of livestock kept by the poor. The synthesis in Part 1 on Market opportunities, (see Table 9: Opportunities for targeting value chain interventions in sub-Saharan Africa and South AsiaTable 9, page 38) highlighted the opportunities across the range of regions and species that were addressed by the data.

Based on the data and expert knowledge, we have chosen **five value chains** to address in detail, applying the Analytical Filters above, and then highlighting most promising types of interventions. These are:

- South Asia dairy
- East Africa dairy
- West Africa small ruminant meat
- West Africa beef
- Southern Africa small ruminant meat

Livestock value chains with less promise

Before we describe the selected Value Chains of interest, it would be useful to briefly examine those that were not selected, and clarify the reasons for that.

West Africa dairy
West Africa is a huge importer of dairy products (imports are about equal to domestic production in volume – 99.9%), and would on the face of it present good opportunities for import substation. However, in the coastal areas where the milk deficit is highest, there are very strong technical and other factors that limit increases in production. Foremost are fierce animal disease challenges that constrain use of cross-bred or improved dairy cattle (trypanosomosis and dermatophilosis, etc), as well as high temperature low-altitude settings. Over the long term, research on disease control and genetics may overcome these barriers to some degree, but in the medium term the prospects are limited.

Central and Africa poultry
Again, this would seem to present a good opportunity for import substitution, with imports of chicken meat double the volume of regional production. However, in much of Central Africa grain production is limited and availability of low cost feed materials is very low. As a result, most economic poultry production is limited to scavenging backyard systems, which have little potential for intensification. In the medium term imports from grain-rich parts of the world will continue to out-compete local production. Where grain is available, larger scale commercial poultry enterprises are likely to out-compete smallholders.

South Asia poultry
While there are some excellent success stories in South Asia on smallholder intensive poultry, for example in Bangladesh, the expert consensus is that large scale industrial production is rapidly taking over the market, leaving little opportunities for smallholder producers. Due to the success of industrial poultry production, market-oriented backyard village poultry has virtually disappeared in many parts of the sub-continent. However, in marginal areas and the East rural poultry production is still widespread. There have been attempts at introduction of small-scale intensive production (200-500 birds) and although successful in some areas it has failed in others, mainly because of competition from the large-scale industrial sector. There will nevertheless be some opportunities locally for small scale commercial production, including cross-bred chickens in less developed regions.

East and Southern Africa beef
Smallholders participate to an important degree in these systems and markets, particularly where pastoral systems dominate. However, the largest opportunities, both locally and in export markets regionally and internationally, are seen to lie with ranchers and large scale producers who can meet the disease control and quality requirements, and the volume requirements imposed by the markets. Where smallholder producers can be empowered to take advantage of the formal market infrastructure, there will be opportunities in some areas.

Selected livestock value chains with pro-poor promise

South Asia dairy

The majority of farming households and a considerable proportion of landless households keep dairy animals, generally in small herds with 2-5 adult females. Both cattle and buffaloes are popular with the latter being more numerous in the North and the West of the sub-continent. Feeding is based mainly on crop residues from private farmland (fodder crops are limited in regional distribution and contribution) and common resource grazing. However, the availability of open-access land has declined considerably in many areas. Concentrates are fed by only a very few larger scale farmers. Milk is the main output and marketing, both through formal and informal channels is widespread. The family is the main source of labour with women often being responsible for managing the animals. The quality of available marketing options often determines production intensity with higher levels of production in areas with good market access. In India slaughter of cattle is banned in nearly all states but meat from buffaloes is marketed to some extent. Dung is used as a fertilizer or as fuel (and sometimes traded especially near urban centres). Draft power is still widely used in the less mechanized eastern regions while tractors have replaced bullocks in most other areas.

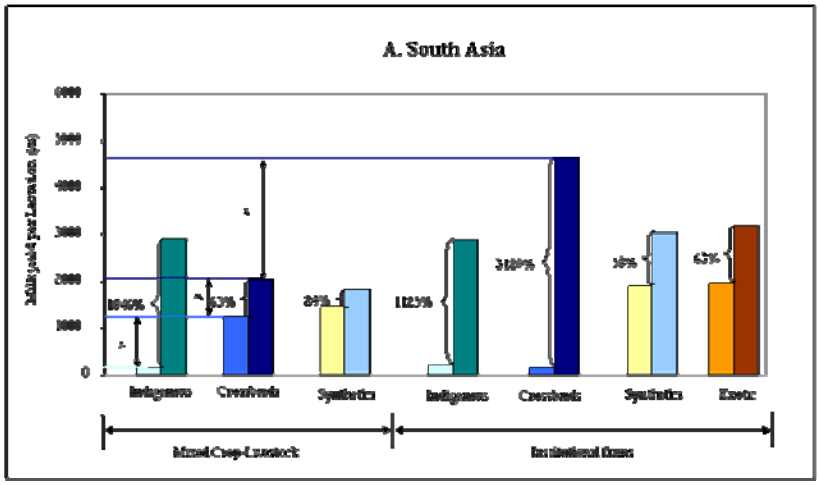


Figure 26: Differences in milk production by different genotypes in dairy cattle production systems in South Asia (from Figure 1.3.1, Deliverable 6 report).

Poor livestock keepers in SA living below $2 per day keeping dairy cattle

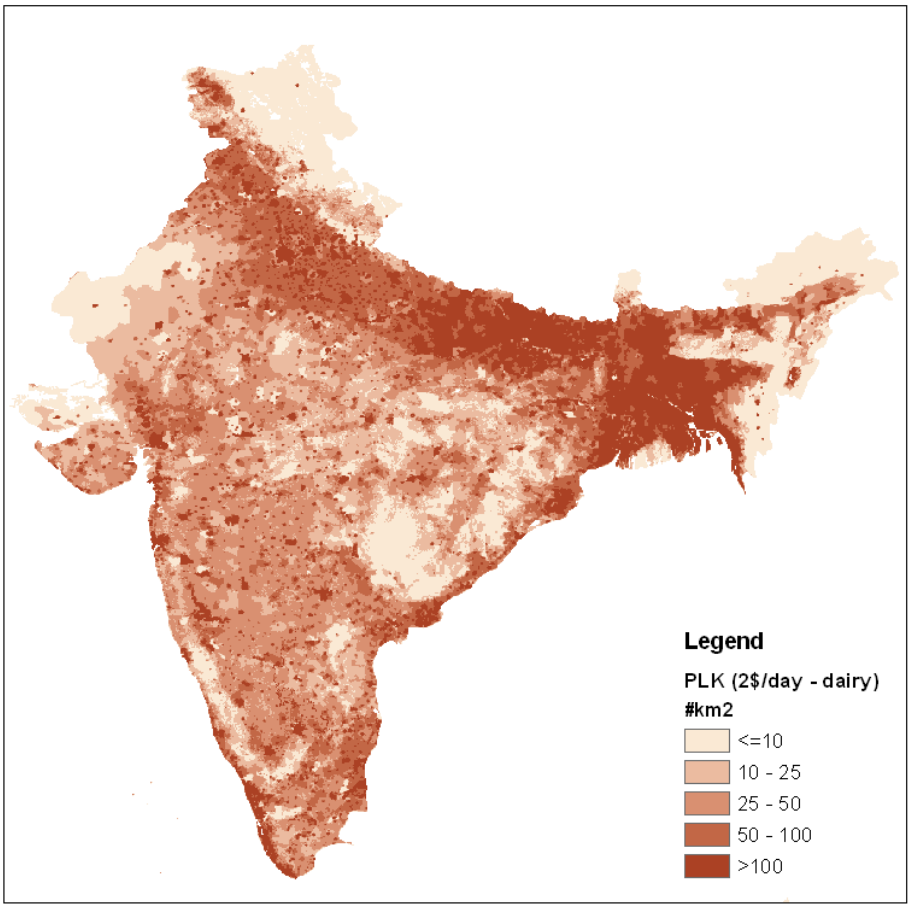


Figure 27: Livestock keepers in South Asia living under $2/day and keeping dairy cattle or buffalo.

South Asia dairy

Growth and Market Opportunities	
Domestic market: % annual consumption growth rate. Bangladesh: -0.6% India: 2.4% Import substitution: % imports of domestic prod. Bangladesh: 40.4% India: 0.1%	• Bangladesh and India both exhibit strong but different growth opportunities. • Bangladesh potential lies in import substitution • India growth potential lies in strong domestic demand and in future potential exports • Exports of buffalo meat, offtake from the dairy buffalo herd, to SE Asia are important and growing. • India is increasingly a milk exporter, and exhibits low costs of production.
Pro-Poor Potential	
Millions of poor keeping dairy cattle or buffalos: India: 124.3 million Bangladesh: 10.1 million Value of dairy production: Bangladesh: $US 200 million India: $7,088 million Millions of poor in the region under $1US per day: Bangladesh: 37 million India: 446 million	• Dairy production offers opportunities for many millions of poor in both India and Bangladesh • Because of low cost family labour and crop residues, smallholders will continue to dominate production for many years to come, but with increasing shift towards formal marketing • Evidence is very strong that smallholders have good ability to respond to market demand and intensify production if given adequate input services
Supply Constraints	
Genetics: Lack of improved indigenous sires; poor AI for upgrading Animal health: Not a major constraint relative to genetics and nutrition Nutrition: Poor quality basal diet and low level supplementation	• Reliable supply of improved animal genetics is a major barrier to increased production across S Asia. Very few systems exist for the supply of either improved indigenous cattle breeds, or for cross-bred AI. Use of AI in buffalo's is limited due to technical constraints. • Low quality crop residues provide the large bulk of feed resources, even in commercial systems, and concentrates are expensive and little used. • Relative to those constraints above, animal health is less of a barrier in most settings. Compared to SS Africa, S Asia has few lethal diseases affecting large ruminants.
Market/Institutional constraints : Poor access to formal output market and inadequate input services	• Dairy markets in India and Bangladesh are largely informal (estimated over 80% in India), and will likely remain so for decades. This limits the access of producers to formal markets, and while that continues, the high transactions costs in informal markets may pose barriers. Legal and social barriers to slaughter of cattle reduce value of production. • Inadequate inputs and services, including genetics, remain a significant barrier, and where it has proved successful, cooperative development has only partially met the challenge.
Potential Interventions	
Potential productivity gains (dairy cattle): For cross-bred cattle, 67% gain from low of 1200 kg to 2000kg are observed in mixed farms. However, some indigenous breeds can reach 3000kgs on farm. Higher yields are seen on institutional farms.	• Buffalo are likely to be the target dairy species, due to a) ability to utilize low quality roughage and b) no ban on slaughter raises the value of meat, including for buffalo meat exports (recently as high as $600M from India to SE Asia, etc) • Feed efficiency will be key issue, due to the aggregate constraint of feed resources in a largely Arid/Semi-arid subcontinent – so will need to reduce animal health interactions • Continued high food prices are likely to generate crop supply response, which will increase availability of crop residues • Despite the success of the cooperative Anand model in such areas, that has had limited penetration elsewhere. Alternative approaches need to be considered that a) are more closely aligned to the growing formal private sector, and b) build on the dominant traditional sector. • Public-private approaches to supply of genetics and veterinary services will be crucial.
Relative Potential Gains from Interventions	Existing technology: Improved genetics: 15%; health: 5%; nutrition: 40% Formal market access: 25% Good delivery of inputs: 30% New technology: Sexed embryos: 30%

East Africa dairy

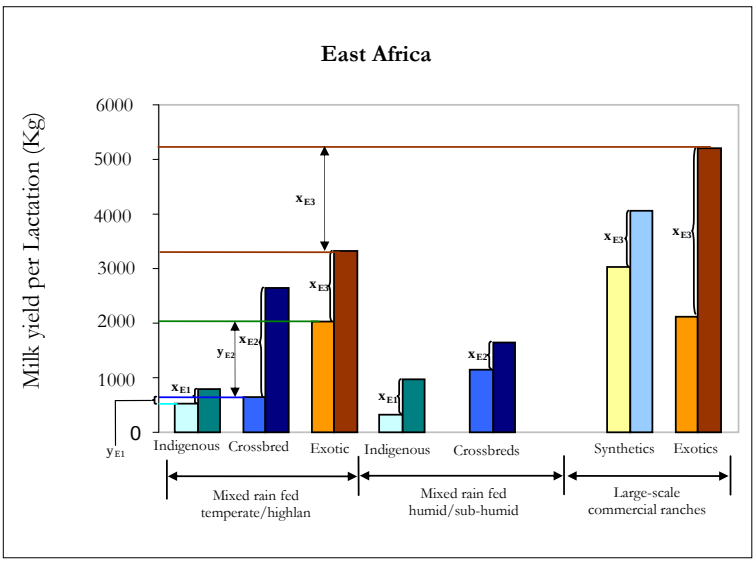


Figure 28: Differences in milk production by different genotypes in dairy cattle production systems in East Africa (from, Deliverable 6 report).

Dairy production systems in East Africa vary considerably, from extensive systems with indigenous cattle (limited external inputs where animals are mainly grazed either on own land but usually on communal land, with little feed supplementation) in the semi arid areas to more intensified systems in the Highlands where access to markets is also good. In these latter systems, crossbred or exotic cattle are stall-fed with feeds being brought to them, including fodder (grown on-farm or purchased) and supplements (for example purchased concentrates). In between these two extremes, farmers practice

semi-intensive systems where animals are grazed only part of the day and/or the year depending on feed availability. Average herd sizes vary from one to five cows in the most intensive systems, up to 10 in the extensive systems. Labour is mainly provided by family members, although intensive dairy is labour intensive and may require hiring external labourers, therefore creating employment opportunities. In extensive systems, milk is mainly consumed by the household, due to low production levels coupled with limited market opportunities. On the other hand, a high percentage of the milk production is sold in intensified systems, and manure is highly valued and used as fertilizer on crops.

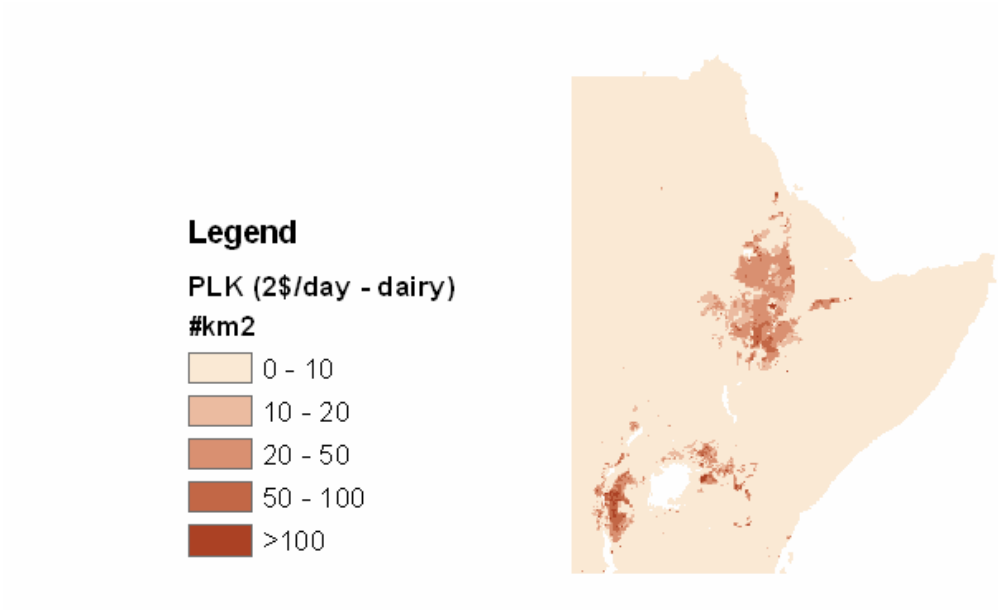


Figure 29: Poor livestock keepers in East Africa living under $2/day and keeping dairy.

East Africa Dairy

Growth and Market Opportunities	
Domestic market: % annual consumption growth rate. 2.8% Import substitution: % imports of domestic prod: 1.7%	• East Africa exhibits a strong growth opportunity, due to strong domestic demand for local products and in future potential exports. • Imports present little competition in a market that is mostly for fresh milk due to traditional tasks, with which they can only compete with difficulty. • Great regional differences in consumption levels (high of 100kg/capita milk consumption in Kenya, about 1/5 of that in Tanzania), suggests opportunities for regional trade
Pro-Poor Potential	
Millions of poor keeping dairy cattle: 1.1 million Value of dairy production: 4,290 million US$/year Millions of poor in the region under $1US per day: 68 million	• The figure of 1.1 M only includes farmers currently having dairy cattle. In the humid and temperate mixed systems of East Africa, there are about 24 M poor farmers keeping local or beef cattle, and in some area upgrading some of those herds to dairy would be profitable for some of them. • Because of low cost family labour and crop residues, smallholders will continue to dominate production for many years to come, but with some shift towards formal marketing • Evidence is very strong that smallholders have good ability to respond to market demand and intensify production if given adequate input services
Supply Constraints	
Genetics: Lack of cost-effective way of adopting crossbred cows Animal health: East Coast fever and FMD are major threats to improved dairy animals Nutrition: Poor quality basal diet and low level supplementation	• Reliable supply of appropriate animal genetics is a major barrier to increased production across East Africa. AI services are not available everywhere, and where available, they are expensive and have low conception rates. Partly as a consequence, they are little used by farmers even where available • Low quality crop residues and grazing provide the large bulk of feed resources, even in commercial systems, and concentrates are expensive and little used. Of great concern is the limited availability of feed during the dry season, resulting in large seasonal fluctuation in milk production. • Animal health is a major issue, unlike in South Asia, leading to mortalities in calves of 20%, and 10% or more annually among cows.
Market/Institutional constraints ; Limited access to formal output market and poor input services	• As in South Asia, dairy markets in East Africa are largely informal, and will likely remain so for decades. This limits the access of producers to formal markets, and while that continues, the high transactions costs in informal markets may pose barriers. • Inadequate inputs and services, including genetics and feed (quality), remain a significant barrier, and where it has proved successful, cooperative development has only partially met the challenge.
Potential Interventions	
Potential productivity gains (dairy cattle): For cross-bred cattle, milk production can be multiplied by 3, from low of 644 kg to 2657kg (mixed farms in temperate/highlands).	• Because much of the most favourable highland areas and already populated with dairy, additional production may come from dryer areas. • To do this sustainably, this will require cross-breeds being produced by farmers in more remote areas producing the calves, which are then sold to farmers in mixed systems. A market and services systems to support this would be required. • AI services, particularly the provision of cross-bred semen in appropriate zones, will need to be dramatically improved and sustained.

	• There may be some opportunities to produce a more appropriate crossbred cows for smallholders by using the Brazilian Gir (instead of European breeds), but this would need careful targeting. • In the most intensive areas, feeding relies on crop residues and planted forages, while in more extensive areas natural forages are utilized. Strategies for improving feeding will thus be location specific, but will require both improve quality/quantity of roughage and increased access to low-cost and high quality concentrate.
Relative Potential Gains from Interventions	Existing technology: Improved genetics: 20%; health: 25%; nutrition: 30% Formal market access: 30% Improved delivery of inputs: 40% New technology: Sexed embryos: 30%

West Africa beef

The region's agroecological zones ranging from the humid coastal zone to the dry Sahelian zone roughly define an increasing gradient of dependence on ruminant livestock for livelihoods. At the tip of this gradient, in the Sahel rangelands of Niger, Burkina Faso, Mali, Chad, Mauritania, Gambia and Senegal, keeping livestock in extensive pastoral systems (about 5 cattle/km^2) is the main land use form and main livelihood for millions of people who depend on them for meat, milk, transport, manure, as a store of wealth and source of societal prestige. For the latter reasons, households in the pastoral system use all available household labour to continue to build their herd sizes irrespective of the condition of the animals (50 cattle/hh of 6 is common). In climatically favourable years, pastoralists produce and market excess young bulls but during drought, poorly performing cattle of all sexes and ages are sold. However, some of these young bulls do not head directly to terminal markets and instead provide replacement stock for traction and fattening operations in the adjoining crop-livestock systems of the Savanna zones. In the latter, average households of 11 persons own 2-4 bulls and plant up to 5 ha of farmland to cereal and legumes using both household and hired labour. Availability of crop residues in this system enables farmers to maintain the bulls in very good to excellent body conditions through supplementary stall-feeding within homesteads. Though this practice is primarily aimed at keeping the bulls fit to provide traction, it ultimately not only yields heavier animals for the beef market (when the bulls are retired from traction) but also pools manure for return to farmlands at the beginning of each planting season. Commercial ranching with stall fed beef production is an emerging trend in the Northern Guinea Savanna (NGS) in Nigeria. Increased intensification of crop production will provide new fodder supply. Livestock marketing opportunities are enormous in response to the demand for meat in the urban areas primarily in coastal cities; and this occurs through well-developed although cost-constrained cross-border trade in live animals. Income from sale of livestock is controlled by the head of household. Men milk the animals while women market the milk and manage the income mainly to buy food for the household.

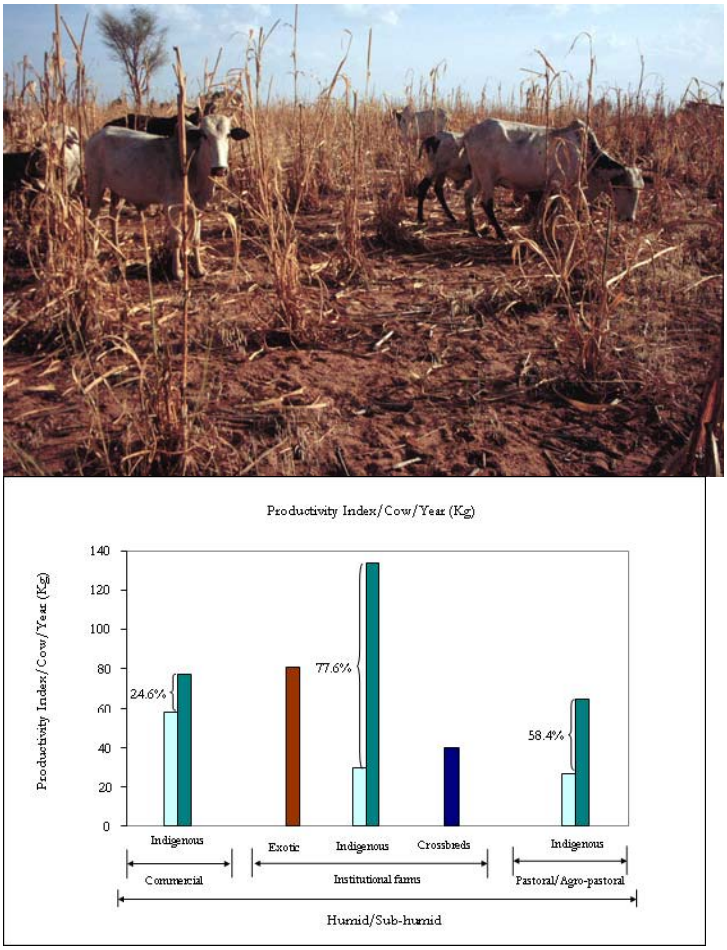


Figure 30: Percent magnitude of productivity gaps for different genotypes of beef cattle for productivity index/cow/year in West Africa (from Deliverable 6 report).

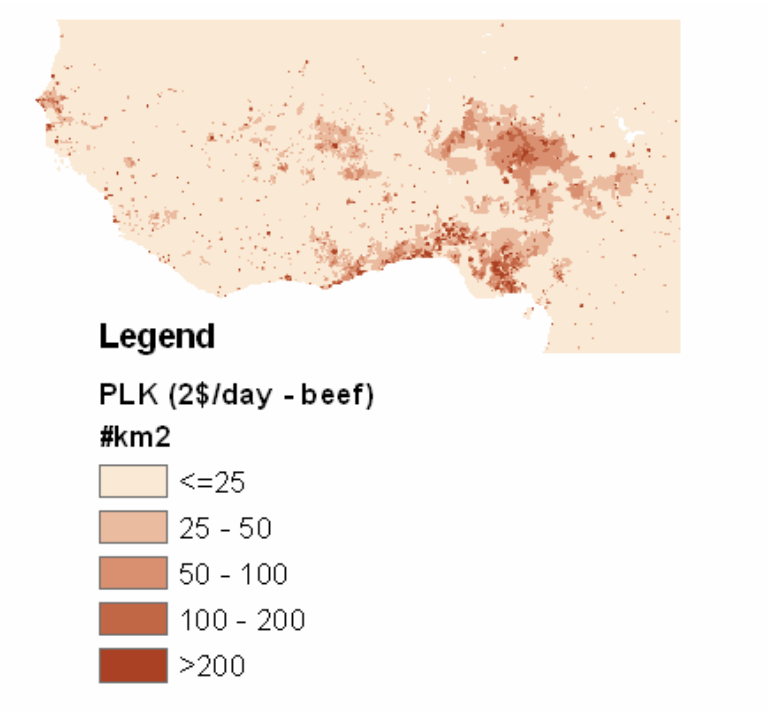


Figure 31: West Africa livestock producers keeping beef cattle, living under $2/day

West Africa beef

Growth and Market Opportunities	
Domestic market: % annual consumption growth rate. 2.3% Import substitution: % imports of domestic prod. 7.7%	• The strong regional consumption growth rate point to good opportunities for regional production. • Imports play some role, suggesting some opportunity for import substation in higher end markets if quality issues can be addressed.
Pro-Poor Potential	
Millions of poor keeping beef cattle: 70 million Value of beef production: 1,119 $US million Millions of poor in the region under $1US per day: 130 million	• Smallholders continue to dominate production of young feeder cattle aided by emerging stratification including feedlot enterprises • Feedlots exist in urban areas, mostly along the coastal region; their numbers are increasing due to improvement in infrastructure and market information, providing new markets for smallholders. • Traction is important for smallholder cattle keepers and off-take is targeted at males no longer needed for oxen. This forms another opportunity for benefits to smallholders. • This region is responsive to market demands and may provide returns on intensification if effective input services are available
Supply Constraints	
Genetics: Lack of improved indigenous sires (and proven cross-breeding systems for emerging stratified systems) Animal health: Nutrition x disease complexities and FMD are constraints. Nutrition: Under-nutrition of breeding females	• The ability to improve genetics in extensive systems, with reliance on natural breeding, will be very constrained in the absence of long-term investment in breeding infrastructure and institutions, and may be unlikely. • The interaction of nutrition and animal disease is a major cause of calf mortality and morbidity (low weight gain). • Lack of FMD vaccinations permits that disease to pose a large burden. • Under-nutrition of breeding females leads to high calf mortality and low weight gain among calves, and so lower value for feeder market.
Market/Institutional constraints : Very limited input services and inefficiencies in output marketing	• In these extensive systems, spread over large rural areas with poor infrastructure, access to services is minimal. • Output marketing relies on iterant traders and weekly markets, leading to high transactions costs.
Potential Interventions	
Potential productivity gains (beef cattle): For overall % gain and Kg, see Figure above; US$ 183 / animal. As observed on farms, gains of 50% or more are potentially achievable. Highest yields from indigenous cattle are seen on institutional farms (>130 kg).	• A range of complementary production system level activities would be required to provide productivity gains: o bulking, assembly, market information systems to overcome large TCs in extensive rural areas o animal health interventions to go along with CBPP, FMD vaccinations, etc o reducing calf mortality by addressing the nutrition/disease complex in females and calves simultaneously. It should be noted that under-feeding of females may be caused by under-lying economic restrictions and so resistant to change. o Timely intervention at critical points could be 2nd phase, will require controlling risk • Because surplus oxen are one important offtake,

	reducing reproductive wastage is a key aim • New feedlot schemes particularly in meat deficit coastal areas may be increasing possible, due to continueing improvements in infrastructure, information, and growing demand. These would need to be located in regions with low costs feed materials (e.g. crop by-products, cassava, sugar cane bagas, etc) • Economics of such interventions will depend on a) premium for the meat and b) cost ratio for meat/feed - this is working in Mali using a combination of local feed materials and some imports. • This would also generate demand for lean animals from rural areas where off-take / supply may be difficult
Relative Potential Gains from Interventions	Existing technology: Improved genetics: 20%; health: 15%; nutrition: 30%, Improved market access: 20% Good delivery of inputs: 15%

West Africa small ruminants

Small ruminants (sheep and goats) play an important role in household livelihoods in West Africa. Typically a household keeps up to 10 animals, with as few as 2-3 also being very common. In the southern (wetter humid and subhumid) parts of the region, West African Dwarf goats (and to a lesser extent sheep) are kept by many households mainly as an "insurance" or "emergency cash" resource; they are often owned and managed by women and there is very little husbandry – animals are left to scavenge, fed on household waste etc. In drier regions (semi-arid) small ruminants play a similar role in most cases, but there is an increasing market orientation, especially for sheep which in many parts are raised especially for Muslim festival times when their prices are at a premium. In some parts sheep are the purview of men only (e.g. northern Nigeria), whereas in other regions (e.g. Niger) women may purchase sheep to fatten specifically for *Tabaski* festival. Goats are frequently owned and managed by women and are an important "cash reserve" – sold to meet household emergencies. Small ruminants in this region are typically fed on crop residues – cereal stovers supplemented with legume (cowpea or groundnut) hay and various combination of bran generated by household processing of grain. As the systems intensify there is less opportunity for free grazing and small ruminants are increasingly confined within the home compound year-round. Most households collect manure and return it to crop fields at the start of the planting season. Small ruminants are not generally kept for milk. Most pastoral herds in the arid and Sahel region include small ruminants, sheep in particular which are managed along with large ruminants using mobility to meet feed needs.

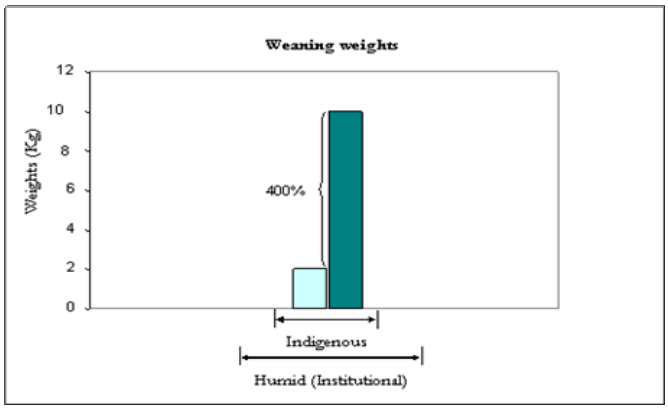


Figure 32: Percent magnitude of yield gap for weaning weights of different genotypes of indigenous goats in West Africa (from Deliverable 6 report)

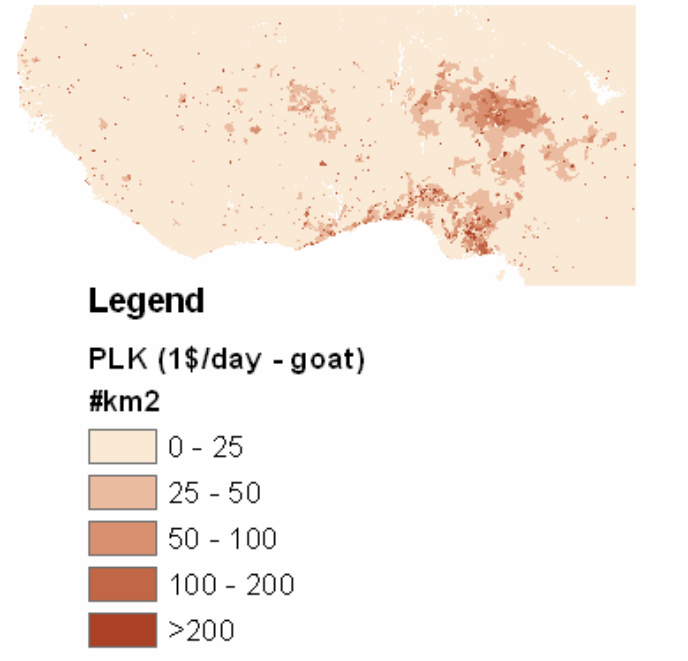


Figure 33: Poor livestock keepers in West Africa living under $1/day and keeping goats.

West Africa small ruminants

Growth and Market Opportunities	
Domestic market: % annual consumption growth rate. 1.1% Import substitution: % imports of domestic prod. 2.1%	• Steady growth in regional demand is likely to increase with income growth under future economic development.
Pro-Poor Potential	
Millions of poor keeping small ruminants: Local Goats: 81.6 million Dairy Goats: 108.6 thousand Sheep: 21.3 million Value of dairy production: Small ruminants (goat & sheep, meat & milk) 970 million Millions of poor in the region under $1US per day: 130 million	• Smallholders are dominating production with increasing stratification through close-to-market feedlots • Key opportunity for women – particularly in situations where men migrate for labour. Working models of this may be hard to find • Producers in this region are responsive to market demands but mostly manage low input systems which are less amenable to intensification • The potential may be mostly local market, so marketing issues may be easier. • However, growth may be mostly in urban areas.
Supply Constraints	
Genetics: Lack of improved indigenous sires Animal health: PPR a threat and high pre-weaning mortality Nutrition: Under-nutrition of breeding females.	• High pre-weaning mortality may be due to a combination of feed and disease constraints
Market/Institutional constraints ; Inefficient output marketing and absence of input services	•
Potential Interventions	
Potential productivity gains (beef cattle): For overall % gain and Kg, see Figures above; US$ 15 / animal. Highest yields from indigenous goats are seen on institutional farms in the semi-arid regions (>20 kg).	• Production interventions: o organize marketing to meet seasonal demand (control breeding to meet seasonal demand) o focus on prevention of PPR o strategic feeding o reduce mortality
Relative Potential Gains from Interventions	Existing technology: Improved genetics: 20%; health: 25%; nutrition: 30%, others ? Improved market access: 20% Good delivery of inputs: 15% Strategy: - improving market supply chains, coordination and market information - finishing/fattening may be targeted at peak periods, Eids etc, however, market premium is high and expected to continue - milk marketing / supply may provide small added value

Southern Africa small ruminants

Livestock is a key part of southern Africa's agricultural economy. Cattle, goats, sheep, pigs, and poultry are the predominant species. The livestock economy is characterized by two largely distinct production systems: large-scale commercial and semi-subsistence farming.

The large-scale commercial farming sector comprises large-scale farms under registered title. These are well developed in some parts of the region, particularly in Namibia, South Africa and Zimbabwe, to a lesser degree in Botswana and limited in Mozambique, Tanzania, Zambia and the rest of the southern Africa region. In contrast, most livestock production in the communal sector remains semi-subsistence. This sector is mainly characterized by extensive low-input production systems. Chronically poor nutrition and poor husbandry methods result in low reproduction rates, high mortality rates and low off-take. Cattle are valued as much for their outputs – draft power, transport, milk, manure, meat – as for their cash sale value. Goats and sheep are commonly maintained for food (meat and milk) and smaller cash needs – to be sold or slaughtered when school fees or medication need to be paid, or for household expenditures.

Goats, and to a lesser extent sheep, form the small ruminant herd. Unlike the cattle sector, small ruminants are produced almost entirely in the traditional sector with the exception of Namibia and South Africa where a few commercial flocks exist. Average flock sizes range from 5 -100. Goats are mostly reared on small farms in the drier parts of the country. Within these grazing areas, management is minimal and the natural resources are subject to continuous grazing resulting in a fragile natural resource base and increased degradation. Bush encroachment is widespread, reducing crop/livestock productivity and the carrying capacity of rangeland. Markets and processing for small stock are less developed than for cattle. Goats are mainly slaughtered or sold locally, contributing significantly to local food security either through meat provision or cash from sales. Use of fodder and other inputs is minimal.

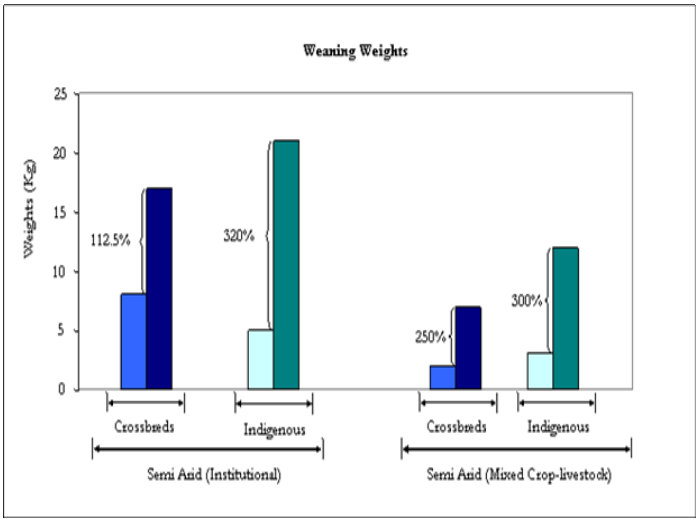


Figure 34: Percent magnitude of yield gaps for weaning weights for different genotypes of goats in Southern Africa (from Deliverable 6 report).

Southern Africa small ruminant meat (mutton)

Growth and Market Opportunities	
Domestic market: % annual consumption growth rate. The data available from FAO, etc, indicate negative per capita consumption of -3.1 %. Import substitution: % imports of domestic production: 16.1%	• Apparently declining per capita consumption rates may reflect economic turmoil in some countries in the region (Zimbabwe) as well as rising prices for small ruminants. • Imports remain a relatively large share of regional consumption, suggesting good opportunities for import substitution.
Pro-Poor Potential	
Millions of poor keeping small ruminants: estimates 21.2 million in the case of goats, and 7.1 million in case of sheep Value of small ruminant production: $ 132 million annually in case of goats, and $ 262 million annually in the case of sheep. Millions of poor in the region under $1US per day: Some 40 million people in the region live under $1 per day.	• There are tens of millions of very poor people in the region, a situation which has deteriorated in recent years due to political/economic turmoil in some countries. • Goats are particularly important for the poor, some 21 million of whom are estimated to keep them in the region. While sheep production overall is higher value, sheep are often kept by ranchers, rather than resource-poor farmers. • Smallholders dominate the production of goats, with in some cases increasing stratification, with smallholders producing young animals that are sold to close-to-market feedlots • Small ruminants are particularly important for women, who often own small stock rather than large ruminants. Small ruminant ownership allows the building of private assets that are inflation-proof, and grow only using locally available feed materials and family labour. Sale of small ruminants can finance children's school fees, emergency family health needs, or investment in small enterprises. • In Southern Africa, the significant number of male family members who migrate for wage labour opportunities increases the importance of goats as assets in the hands of women. • Smallholder goat production is very competitive compared to large-scale production, due to use of low cost local crop by-products and natural forage, and family labour, as well as public land.
Supply Constraints	
Genetics: Lack of improved indigenous sires, and systems to supply them. Animal health: PPR, and pre-weaning mortality Nutrition: Under-nutrition of breeding females	• In the case of small ruminants, control of breeding is sometimes problematic. Where that can be achieved, lack of improved indigenous stock is a constraint. The gap relates to both lack of systems to breed improved stock, but also systems to manage the maintenance and delivery of those genetics sustainably. • High pre-weaning mortality is a significant problem for herd growth and thus profitability, and PPR (peste de petit ruminant) is a threat. • Linked to that pre-weaning mortality is under-nutrition of breeding females. In general, inadequate feed for females and young animals is a key barrier, and may be responsible for the large observed productivity gap (see graph above). • Main constraints are thus linked to the interaction of poor feeding and heath.
Market/Institutional constraints: Inefficient output markets, and poor access to services.	• Small ruminant producers typically rely on itinerant traders or weekly markets to sell their stock, and may often have poor bargaining power, leading to low prices received. Formal animal health and other services are often minimal to non-existent.

Potential Interventions	
Potential productivity gains: Evidence from observed weaning weights in mixed systems suggests productivity gaps of 250 to 300%.	• Although weaning weights are only one indicator of productivity, the large observed gaps point to significant opportunities to increase productivity. • Gains will need to come primarily from improving combined feed and health management, to reduce mortalities of young animals, and to increase weight gain. • This will involve strategic feeding, combined with targeted animal health interventions. • Improved genetics may be difficult to provide given existing systems for improvement and delivery. • Organizing marketing through farmer-managed associations may help to overcome the transactions costs associated with spot markets. • Farmer organizations (clusters or hubs) may help to achieve that as well as provide a vehicle for health/feed improvements, although working models in the case of small ruminants are difficult to observe. • Explore new market opportunities for fibre (mohair and wool), linked to industries in South Africa. Market information systems will be key to that.
Relative Potential Gains from Interventions	Technology: Improved genetics: 30% (although longer term); health: 20%; nutrition: 25% Markets/institutions: Improved market access: 20% Good delivery of inputs: 15%

Conclusions

Supporting the market and institutional environment

Much of the strategies described above focus on the relative technical options for sustained productivity growth in market-oriented smallholder systems. Without these as a central and sustainable element, other development interventions are unlikely to have the desired impact. Some other considerations to the above strategies which should not be overlooked, and may in some parts be under emphasized however, have to do with wider institutional and value considerations. These should be addressed during more in-depth value chain analysis.

Value addition, and employment along the value chain: The level of value addition along value chains may differ greatly, and where important can in themselves form part of the rural employment strategy. For example in South Asia milk is traditionally processed in a labor-intensive manner into a wide variety of products by cottage processors, while in East Africa, most milk is consumed in liquid form, although still employing many as traders, vendors. Interventions that build on value addition potential are likely to generate employment beyond the farm.

Formal and traditional markets: A related issue is the dominance in the key value chains described above of local markets, where products reach end consumers in raw or traditionally processed form, with little or no implementation of cold chain or modern supply chain processes. These are also the markets that most poor producers and poor consumers depend on. Because these are likely to remain the dominants markets in SSA and S Asia for years to come, development strategies that work *with and through* these important markets are likely to be able to capture larger market share for foreseeable future. Market strategies focusing solely on formal, mostly urban, markets may be limited by demand for some time to come. Recognizing nevertheless that the trend is toward more formal markets, there are working models of interventions that enable traditional market players to improve product quality and standards to better compete and bridge the gap to formal markets, and possibly link to regional markets. Policies that regulate products and standards may have to be addressed simultaneously.

Collective action: Although in each of the value chain strategies above, some form of farmer organization is mentioned, when one examines the livestock development experience critically, the success of collective action has been mixed at best. A few well-known success stories (Operation Flood, etc) tend to overshadow the failures or limited successes that tend to be the pattern in most cases. At the same time, some form of institutional mechanisms that empower smallholder producers to increase their capacity for innovation, access to knowledge and services, and improve their market position, are essential. The message seems to be to continually re-examine existing models

and seek new models that are more closely tied to private sector, demand-driven incentives, and balance realistically farmer's own capacity with the need for professional business service providers, while always aiming at increased producer capacity in the long run.

Key value chains and their production strategies

The key value chains selected through the analysis are focused on ruminants, with emphasis on those systems where smallholders can compete and benefit. There are good reasons to consider poultry systems in some areas and cases. However, in the opinion of those involved in this analysis, including experts from SSA and South Asia, the prospects for smallholder poultry development are either a) strongly limited by economies of scale which set in once a shift from backyard to more commercial systems is taken, b) limited in income potential if maintained at the backyard level, and so not a meaningful vehicle for rural poverty reduction.

Among the strategies, small ruminants may present the strongest areas of opportunity for rural women, who typically are able to own and manage those species, and apparently capture much of the returns.

The production and development strategies described above are a combination of a) productivity enhancing interventions, and b) risk mitigating interventions. In the case of dairy, important productivity gains are available, which necessarily need to be complemented by risk mitigation components to sustain them. In the case of beef and small ruminants, risk and loss reduction is central to income generation outcomes, and to overall productivity in the long run.

Across all dairy systems: Genetic improvement may be a key intervention and opportunity in dairy systems, compared to other species. This is due to availability of systems for delivery of genetics, and also the manner of close farmer management of breeding. Opportunities exist from tailoring and implementing existing technologies and systems, or new ones from sexed semen, synthetic breeds. Sustainable supply of cross-breed genetics remains a major challenge across countries.

For both beef and small ruminant systems, a key area of intervention lies in the interaction of animal disease and nutrition, particularly among breeding females and young animals. This is key to both increasing herd growth through reduced mortality, but also to faster individual animal weight gain through stronger young stock – the two central elements of herd productivity.

Recognizing the increasing importance of larger, more specialized and commercial livestock production even in the poorest countries, the analysis identifies several opportunities for linking smallholders to those, both in the context of production of young stock for more specialized systems. These include production of cross-bred dairy heifers in marginal areas in East Africa, and supply of feeder calves across the livestock gradient in West Africa, for

feeding operations close to urban demand centres. Capturing these opportunities will require a shift from typical livestock development efforts that simply channel smallholders into the usual supply chain, and instead enable them to serve these specialized niches for which requirements may not be fully understood, or for which markets may not be developed.

References

Barrett B.C., Osterloh M.S., McPeak J.G., Mahmoud H., Luseno K.W., Little D.P. and Gebruf G. 2003. *Pastoralist livestock marketing behavior in northern Kenya and southern Ethiopia: An analysis of constraints limiting off-take rates*. International Livestock Research Institute (ILRI), Nairobi, and College of Natural Resources, Utah State University.

Deichmann U. 1996. *Africa population database*. Version 3. National Center for Geographic Information and Analysis (NCGIA), University of California, Santa Barbara; Consultative Group on International Agricultural Research (CGIAR); United Nations Environment Programme (UNEP)/Global Resource Information Database (GRID); and World Resources Institute (WRI) (http://www.grid2.cr.usgs.gov/globalpop/africa).

Delgado C., Rosegrant M., Steinfeld H., Ehui S. and Courbois C. 1999. *Livestock to 2020: The next food revolution.* Food, Agriculture and the Environment Discussion Paper 28. International Food Policy Research Institute (IFPRI), Food and Agriculture Organization of the United Nations (FAO) and International Livestock Research Institute (ILRI).

Delgado C., Rosegrant M. and Meijer S. 2001. *Livestock to 2020: The revolution continues*. Paper presented at the annual meeting of the International Agricultural Trade Research Consortium (IATRC), Auckland, New Zealand, 18–19 January 2001 (http://66.102.9.132/search?q=cache:ctDPGRc2BYwJ:ageconsearch.umn.edu/bitstream/14560/1/cp01de01.pdf+%22delgado+et+al+2000%22+%22the+revolution+continues%22&hl=en&ct=clnk&cd=1&gl=ke).

Devendra C. 2002. Potential productivity from small ruminants and contribution to improved livelihoods in developing countries. In: Batista A.M.V., Barbosa S.B.P., do Santos M.V.F. and Ferrira L.M.C. (eds), *Proceedings of the thirty-ninth reuniao anual, Sociedade Brasilia de Zootechnia, 29 July–l August 2002, Recife, Brazil*. Secretaria Executiva, Sociedade Brasileira de Zootecnia, Brasilia, Brazil. pp. 246–269.

FAO (Food and Agriculture Organization of the United Nations). 2006. *The state of food insecurity in the world, 2006*. FAO, Rome.

FAO (Food and Agriculture Organization of the United Nations). 2007. *Gridded livestock of the world 2007*. FAO, Rome (http://www.fao.org/docrep/010/a1259e/a1259e00.htm).

Gueye E.F. 1998. Village egg and fowl meat production in Africa. *World Poultry Science Journal* 54:73–86.

Herrero, M., Fawcett, R.H. and Jessop, N.S. 2002. Predicting intake and nutrient supply of tropical and temperate diets for ruminants using a simple dynamic model of digestion. Bioparametrics Monograph. Institute of Ecology and Resource Management, University of Edinburgh, 31 p.

Holst P.J. 1999. Recording and on-farm evaluations and monitoring: Breeding and selection. *Small Ruminant Research* 34:197–202.

Hyman G., Nelson A. and Lema G. 2000. *Latin America and Caribbean population database 2000*. United Nations Environment Programme (UNEP)/Global Resource Information Database (GRID), World Resources Institute (WRI) and Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia (HTTP://www.grid2.cr.usgs.gov/globalpop/lac/intro.html).

Kariuki P. and Notenbaert A. *Poor livestock keepers*. 2008. Deliverable 1, Bill and Melinda Gates Foundation (BMGF)/International Livestock Research Institute (ILRI) Project on Livestock Knowledge Generation. ILRI, Nairobi.

Kruska R., Reid R., Thornton P., Henninger N. and Kristjanson K. 2003. Mapping livestock-oriented agricultural production systems for the developing world. *Agricultural Systems* 77:39–63.

Lesnoff M, 2007. DynMod – A tool for demographic projections of ruminants under tropical conditions. User's Manual. International Livestock Research Institute, Nairobi, Kenya. 29 pages

Leroy J.L. and Frongillo E.A. 2007. Can interventions to promote animal production ameliorate undernutrition? *Journal of Nutrition* 137:2311–2316.

Leroy J.L., Nicholson C.F., Demment M.W., Schelling E., Randolph T.F., Pomeroy A.M. and Frongillo E.A. 2007. *Can livestock production ameliorate undernutrition?* Draft report. International Livestock Research Institute (ILRI), Nairobi.

McPeak J.G and Barrett C.B. 2001. Differential risk exposures and stochastic poverty traps among East African pastoralists. *American Journal of Agricultural Economics* 83(3):674–679.

Mtenga L.A. and Kifaro G.C. 1993. Dairy goat research and extension at Sokoine University of Agriculture (lowlands) and Mgeta (highlands) areas of Tanzania. In: Kategile J.A. and Mubi S. (eds), *Future of livestock industries in East and Southern Africa: Proceedings of the workshop held at Kadoma Ranch Hotel, Zimbabwe, 20–23 July 1992*. ILCA, Addis Ababa, Ethiopia. 227 pp.

Mwacharo J.M., Ojango J.M.K., Baltenweck I., Wright I., Staal S., Rege J.E.O. and Okeyo A.M. 2008. *Livestock productivity constraints and opportunities for investment in science and technology*. Deliverable 6, Bill and Melinda Gates Foundation (BMGF)/International Livestock Research Institute (ILRI) Project on Livestock Knowledge Generation. ILRI, Nairobi.

Njoroge L., Nzuma J., Poole J., Baltenweck I. and Staal S. 2008. *Livestock production and consumption trends*. Deliverable 2/4, Bill and Melinda Gates Foundation (BMGF)/International Livestock Research Institute (ILRI) Project on Livestock Knowledge Generation. ILRI, Nairobi.

Nzuma J. and Baltenweck I. 2008. *Contribution of livestock to household incomes*. Deliverable 5, Bill and Melinda Gates Foundation (BMGF)/International Livestock Research Institute (ILRI) Project on Livestock Knowledge Generation. ILRI, Nairobi.

Nzuma J. and Randolph T. 2008. *Role of livestock in human nutrition*. Deliverable 7, Bill and Melinda Gates Foundation (BMGF)/International Livestock Research Institute (ILRI) Project on Livestock Knowledge Generation. ILRI, Nairobi.

Omolo A. and Notenbaert A. 2008. *Value of production*. Deliverable 3, Bill and Melinda Gates Foundation (BMGF)/International Livestock Research Institute (ILRI) Project on Livestock Knowledge Generation. ILRI, Nairobi.

Otte M.J. and Chilonda P. 2002. *Cattle and small ruminant production systems in sub-Saharan Africa: A systematic review*. Livestock Information Sector Analysis & Policy Branch, Food and Agriculture Organization of the United Nations (FAO), Rome.

Peakock C. 2008. Dairy goat development in East Africa: A replicable model for smallholders? *Small Ruminant Research* 77:225–238.

Randolph T.F., Schelling E., Grace D., Nicholson C.F., Leroy J.L., Cole D.C., Demment M.W., Omore A., Zinsstag J. and Ruel M. 2007. Role of livestock in human nutrition and health for poverty reduction in developing countries. *Journal of Animal Science* 85:2788–2800.

Roland-Holst D., Epprecht M. and Otte J. 2007. *External shocks, producer risk, and adjustment in smallholder livestock production: The case of HPAI in Viet Nam*. A Living from Livestock Research Report. Pro-poor Livestock Policy Initiative, Agriculture Department, Animal Production and Health Division, Food and Agriculture Organization of the United Nations (FAO), Rome.

Rufino M.C, M. Herrero, M. T. Van Wijk, L. Hemerik, N. De Ridder and K. E. Giller. 2009. *Lifetime productivity of dairy cows in smallholder farming systems of the Central highlands of Kenya.* Animal (2009), & The Animal Consortium 2009, doi:10.1017/S1751731109004248

Seré C. and Steinfeld H. 1996. *World livestock production systems: Current status, issues and trends.* FAO Animal Production and Health Paper 127. Food and Agriculture Organization of the United Nations (FAO), Rome. 89 pp.

Spadbrow P.B. 1997. Policy framework for smallholder rural poultry development. In: Sonaiya E.B. (ed.), *Sustainable rural poultry production in Africa: Proceedings of an international workshop held at the International Livestock Research Institute, Addis Ababa, Ethiopia*. pp. 30–39.

Tambi E.N. and Maina O.W. 2005. Patterns of change in beef production and consumption in Africa. *Rev. Sci. Tech. Off. Epiz.* 22(3):965–976.

Todd H. 1999. Women climbing out of poverty through credit: Or what do cows have to do with it? In: Dolberg F. and Petersen P.H. (eds), *Women in agriculture and modern communication technology: Proceedings of a workshop, March 30–April 3, 1998, Tune Landboskole, Denmark* (www.husdyr.kvl.dk/htm/php/tune98/2-HelenTodd.htm; also published in Livestock Research for Rural Development http://www.cipav.org.co/lrrd/lrrd10/3/todd103.htm

Appendix

	SAsia Dairy	EAf Dairy	WAf Dairy	WAf Beef	WAf Mutt	SAf Beef	SAf Mutt	CAf Chmeat	CAf ChEggs	SAsia Chmeat	SAsia ChEggs
Demand/ Market Opportunity											
Domestic market: % consumption growth rate[a]	B: -0.6 I: 2.4*	2.8	1.7	2.3	1.1	-0.4	-3.1	3.9	??	B: 1.3 I: 13.8*	B; ? I: ?*
Import substitution: % imports of domestic prod.	0.1/40.4*	1.7	99.9	7.6	3.1	2.9	16.1	199.7	22.9	1.7/0.0*	0.0/0.0*
Pro-poor Potential											
Numbers of poor livestock keepers, million	270.3	16.1	4.8	84.8	84.9/30.8	32.9	28.9/14.4	0.081/18.42[c]	0.17[c]	0.94/279.8	0.098[c]
Value of production, US$ million	200/7088 (B/I)	1928	348	1038	383/313 (G/S)	1433	132/262	55	18	140/1504*	136/896[c]
Level of poverty, millions <US$1	37/446*	61	127	127	127	40	40	24	24	37/446*	37/446*

Comment [KE(1]: Goat/sheep

Comment [KE(2]: Broiler/local poultry