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Review on Current Treand and Future Impacts of Livestock Production

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Livestock is one of agricultural sector that play a great role in socio-economic of human being. However, the livestock sector globally is highly dynamic where the livestock productivity is being stagnated, while a rapidly increasing demand for livestock products in developing countries. The main reason that driven this historical changes in the demand for livestock products have been largely related to human population growth, income growth, and urbanization and the production response in different livestock systems has been associated with science and technology as well as increases in animal numbers. In the future, production will be increasingly affected by competition for natural resources, particularly land and water, competition between food and feed and by the need to operate in a carbon-constrained economy. Developments in breeding, nutrition, and animal health will continue to contribute to increasing potential production and further efficiency and genetic gains. The purpose of this paper is to review the present-day state and trend of livestock production via briefly assessing whether these trends are likely to continue into the future.

Keywords: Demand, Supply, Sustainability

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INTRODUCTION

Livestock is a global agricultural resource of significant benefits to society in the form of food, income, nutrients, employment, insurance, traction, clothing, and others. The 30 per cent ice-free terrestrial surface area of planet is occupied by Livestock (Steinfeld *et al.* 2006) and is a significant global asset with a value of at least $1.4 trillion. In developing world, the livestock sector is increasingly organized in long market chains that employ at least 1.3 billion people globally and directly support the livelihoods of 600 million poor smallholder farmers (Thornton *et al.* 2006). Keeping livestock is suggested as one of important risk reduction strategy for vulnerable communities, and livestock are important providers of nutrients and traction for growing crops in smallholder systems. Livestock products contribute 17 per cent to kilocalorie consumption and 33 per cent to protein consumption globally, but there are large differences between rich and poor countries (Rosegrant *et al.,* 2009).

Livestock systems have often been the subject of substantial public debate, because in the process of providing societal benefits, some systems use large quantities of natural resources and emit significant amounts of greenhouse gases. Therefore, the systems have both positive and negative effects on the natural resource base, public health, social equity, and economic growth (World Bank 2009). Currently, livestock is one of the fastest growing agricultural subsectors in developing countries. Its share of agricultural GDP is already 33 per cent and is quickly increasing. This growth is driven by the rapidly increasing demand for livestock products, this demand being driven by population growth, urbanization, and increasing incomes in developing countries (Delgado 2005).

The global livestock sector is characterized by a dichotomy between developing and developed countries. Total meat production in the developing world tripled between 1980 and 2002, from 45 to 134 million tons (World Bank 2009). Much of this growth was concentrated in countries that experienced rapid economic growth, particularly in East Asia, and revolved around poultry and pigs.

On the other hand, in developed countries the production and consumption of livestock products are now growing only slowly or stagnating, although at high levels. Even so, livestock production and merchandizing in industrialized countries account for 53 % of agricultural GDP (World Bank 2009). This combination of growing demand in the developing world and stagnant demand in industrialized countries represents a major opportunity for livestock keepers in developing countries, where most demand is met by local production, and this is likely to continue well into the near future.

TRENDS IN LIVESTOCK PRODUCTION AND LIVESTOCK SYSTEMS EVOLUTION

The increasing demand for livestock products

Human population

The increment of human population in 2050 is estimated to be 9.15 billion, with a range of 7.96–10.46 billion (UNPD, 2008). Most of the increase is projected to take place in developing countries. East Asia will have shifted to negative population growth by the late 2040s (FAO, 2010). In contrast, population in sub-Saharan Africa (SSA) will still be growing at 1.2 per cent per year. Rapid population growth could continue to be an important impediment to achieving improvements in food security in some countries, even when world population as a whole ceases growing sometime during the present century. In Ethiopia, we find that the overall share of urban population increased from 3.7 percent in 1984 to 14.2 percent in 2007 (Emily & Mekamu, 2009).

Urbanization

Urbanization is another important factor determining demand for food. As of the end of 2008, more people now live in urban settings than in rural areas (UNFPA 2008), with urbanization rates varying from less than 30 per cent in South Asia to near 80 per cent in developed countries and Latin America. The next few decades will see unprecedented urban growth, particularly in Africa and Asia. Urbanization has considerable impact on patterns of food consumption in general and on demand for livestock products in particular: urbanization often stimulates improvements in infrastructure, including cold chains, and this allows perishable goods to be traded more widely (Delgado, 2005). In comparison to other African countries, Ethiopia has a low urbanization rate. According to the World Bank World Development Report (WDR) 2009, Sub-Sahara Africa is 30% urbanized; whereas Ethiopia is only 14.2, percent rate urbanized (Emily and Mekamu, 2009).

Income growth

A third driver leading to increased demand for livestock products is income growth. Between 1950 and 2000, there was an annual global per capita income growth rate of 2.1 per cent (Maddison, 2003). As income grows, so does expenditure on livestock products (Steinfeld et al. 2006). Economic growth is expected to continue into the future, typically at rates ranging from between 1.0 and 3.1 per cent (Van Vuuren *et al.*, 2009). Growth in industrialized countries is projected to be slower than that in developing economies (Rosegrant et al., 2009).

The resultant trends in meat and milk consumption figures in developing and developed countries are shown in together with estimates for 2015–2050 (FAO, 2006; Steinfeld et al., 2006). Differences in the consumption of animal products are much greater than in total food availability, particularly between regions. On the other hand, in most Organization For Economic Cooperation and Development (OECD) countries that already have high calorie intakes of animal products (1000 kcal per person per day or more), consumption levels will barely change, while levels in South America and countries of the Former Soviet Union will increase to OECD levels (Van Vuuren et al., 2009). (see Table 1)

The production response

Global livestock production has increased substantially since the 1960s. Beef production has more than doubled, while over the same time chicken meat production has increased by a factor of nearly 10, made up of increases in both number of animals and productivity. Carcass weights increased by about 30 per cent for both chicken and beef cattle from the early 1960s to the mid-2000s, and by about 20 per cent for pigs (FAO, 2010). Carcass weight increases per head for camels and sheep are much less, about 5 per cent only over this time. Increases in milk production per animal have amounted to about 30 per cent for cows' milk although about the same as for increases in egg production per chicken over the same time of period (FAO, 2010).

Table 1: The past and projected trends in consumption of meat and milk

Countries		Annual per capita consumption		Total consumption	
		Meat (kg)	Milk (kg)	Meat (Mt)	Milk (Mt)
Developing	1980	14	34	47	114
	1990	18	38	73	154
	2002	28	44	137	222
	2015	32	55	184	323
	2030	38	67	252	452
	2050	44	78	326	585
Developed	1980	73	195	86	222
	1990	80	200	100	251
	2002	78	202	102	265
	2015	83	203	112	273
	2030	89	209	121	284
	2050	94	216	126	295

Source: Rosegrant *et al.* (2009)

These changes have been accompanied with substantial shifts in the area of arable land, pastures, and forest. Arable and pasturelands have expanded considerably since the early 1960s, although the rates of change have started to slow over the last 20 years, large forest conversions have occurred in the Amazon Basin, Southeast Asia and Central and West Africa. While forest area has increased owing to agricultural land abandonment in the Eurasian boreal forest and parts of Asia, North America, and Latin America and the Caribbean (LAC) (GEO4, 2007).

Considerable expansion of cropland planted to soybean (as a protein source in animal feed) has occurred in Latin America over the last 30 years. Developing countries' share of global use of cereals for animal feed nearly doubled (to 36%) from the early 1908s to the late 1990s (Delgado 2005). Some cropland has been converted to other uses, including urban development around many major cities.

Land-use intensity has increased in some places: cereal yields have trebled in East Asia over this time, while yields have increased not at all in sub-Saharan Africa, for example. Land-use change is complex and driven by a range of drivers that are regionally specific, although it is possible to see some strong historical associations between land abundance, application of science and technology and land-use change in some regions (Rosegrant *et al.,* 2009). In Latin America, for instance, land abundance has slowed the introduction of new technologies that can raise productivity.

Historically, production response has been characterized by systems' as well as regional differences. Confined livestock production systems in industrialized countries are the source of much of the world's poultry and pig meat production, and such systems are being established in developing countries, particularly in Asia, to meet increasing demand. Bruinsma (2003) estimates that at least 75 per cent of total production growth to 2030 will be in confined systems, but there will be much less growth of these systems in Africa.

While crop production growth will come mostly from yield increases rather than from area expansion, the increases in livestock production will come about more as a result of expansion in livestock numbers in developing countries, particularly ruminants. In the intensive mixed systems, food-feed crops are vital ruminant livestock feed resources. The prices of food-feed crops are likely to increase at faster rates than the prices of livestock products (Rosegrant et al., 2009). Changes in Stover production will vary widely from region to region out to 2030 (Herrero et al., 2009). Large increases may occur in Africa mostly as a result of productivity increases in maize, sorghum, and millet. Yet Stover production may stagnate in areas such as the ruminant-dense mixed systems of South Asia, and Stover will need to be replaced by other feeds in the diet to avoid significant feed deficits.

Meeting the substantial increases in demand for food will have profound implications for livestock production systems over the coming decades. In developed countries, carcass weight growth will contribute an increasing share of livestock production growth as expansion of numbers is expected to slow; numbers may contract in some regions. Globally, however, between 2000 and 2050, the global cattle population may increase from 1.5 billion to 2.6 billion, and the global goat and sheep population from 1.7 billion to 2.7 billion (Rosegrant et al. 2009). Ruminant grazing intensity in the rangelands is projected to increase, resulting in considerable intensification of livestock production in the humid and sub humid grazing systems of the world, particularly in LAC.

The prices of meats, milk, and cereals are likely to increase in the coming decades, dramatically reversing past trends. Rapid growth in meat and milk demand may increase prices for maize and other coarse grains and meals. Bioenergy demand is projected to compete with land and water resources, and this will exacerbate competition for land from increasing demands for feed resources. Growing scarcities of water and land will require substantially increased resource use efficiencies in livestock production to avoid adverse impacts on food security and human wellbeing goals. Higher prices can benefit surplus agricultural producers, but can reduce access to food by a larger number of poor consumers, including farmers who do not produce a net surplus for the market. As a result, progress in reducing malnutrition is projected to be slow (Rosegrant et al., 2009). Livestock system evolution in the coming decades is inevitably going to involve trade-offs between food security, poverty, equity, environmental sustainability and economic development.

LIVESTOCK SCIENCE AND TECHNOLOGY AS A DRIVER OF CHANGE

Breeding and genetics

Conventional livestock breeding techniques

The uses of conventional livestock breeding techniques have been largely responsible for the increases in yield of livestock products that have been observed over recent decades (Leakey *et al.,* 2009). At the same time, considerable changes in the composition of livestock products have occurred. If past changes in demand for livestock products have been met by a combination of conventional techniques, such as breed substitution, crossbreeding and within-breed selection, future changes are likely to be met increasingly from new techniques (Philip K., 2010).

Of the conventional techniques, selection among breeds or crosses is a one-off process, in which the most appropriate breed or breed cross can be chosen, but further improvement can be made only by selection within the population (Simm *et al.,* 2004). Selection within breeds of farm livestock produces genetic changes typically in the range 1–3% per year, in relation to the mean of the single or multiple traits that are of interest (Smith, 1984). Such rates of change have been achieved in practice over the last few decades in poultry and pig breeding schemes in several countries and in dairy cattle breeding programmes in countries such as the USA, Canada and New Zealand (Simm ,1998), mostly because of the activities of breeding companies. Rates of genetic change achieved in national beef cattle and sheep populations are often substantially lower than what is theoretically possible. Ruminant breeding in most countries is often highly dispersed, and sector-wide improvement is challenging.

Rates of genetic change have increased in recent decades in most species in developed countries for several reasons, including more efficient statistical methods for estimating the genetic merit of animals, the wider use of technologies such as artificial insemination and more focused selection on objective traits such as milk yield (Simm *et al.,* 2004). The greatest gains have been made in poultry and pigs, with smaller gains in dairy cattle, particularly in developed countries and in the more industrialized production systems of some developing countries. Some of this has been achieved through the widespread use of breed substitution, which tends to lead to the predominance of a few highly specialized breeds, within which the genetic selection goals may be narrowly focused. While most of the gains have occurred in developed countries, there are considerable opportunities to increase productivity in developing countries. Within-breed selection has not been practiced very widely, in part because of the lack of the appropriate infrastructure needed (such as performance recording and genetic evaluation schemes).

Crossbreeding, widespread in commercial production, exploits the complementarities of different breeds or strains and makes use of heterosis or hybrid vigour (Simm, 1998). Breed substitution or crossing can result in rapid improvements in productivity, but new breeds and crosses need to be appropriate for the environment and to fit within production systems that may be characterized by limited resources and other constraints. High-performing temperate breeds of dairy cow may not be appropriate for some developing-country situations: for example, heat stress and energy deficits make the use of Friesians in smallholdings on the Kenyan coast unsustainable, partly because of low cow replacement rates (King *et al.,* 2006a). There is much more potential in the use of crosses of European breeds with local Zebus that are well-adapted to local conditions.

In the future, many developed countries will see a continuing trend in which livestock breeding focuses on other attributes in addition to production and productivity, such as product quality, increasing animal welfare, disease resistance and reducing environmental impact. The tools of molecular genetics are likely to have considerable impact in the future. For example, DNA-based tests for genes or markers affecting traits that are difficult to measure currently, such as meat quality and disease resistance, will be particularly useful (Leakey *et al.,* 2009).

Transgenic livestock production

This is another technique of livestock production for food production; these are technically feasible, although the technologies associated with livestock are at an earlier stage of development than the equivalent technologies in plants. In combination with new dissemination methods such as cloning, such techniques could dramatically change livestock production. Complete genome maps for poultry and cattle now exist, and these open up the way to possible advances in evolutionary biology, animal breeding and animal models for human diseases (Lewin 2009). Genomic selection should be able to at least double the rate of genetic gain in the dairy industry (Hayes et al. 2009), as it enables selection decisions to be based on genomic breeding values, which can ultimately be calculated from genetic marker information alone, rather than from pedigree and phenotypic information. Genomic selection is not without its challenges, but it is likely to revolutionize animal breeding.

As the tools and techniques of breeding are changing, so are the objectives of many breeding programmes. Although there is little evidence of direct genetic limits to selection for yield, if selection is too narrowly focused there may be undesirable associated (Simm et al. 2004) for example, in dairy cattle, where along with genetic gain in some production traits, there is now considerable evidence of undesirable genetic changes in fertility, disease incidence and overall stress sensitivity, despite improved nutrition and general management (Hare et al., 2006).

New tools of molecular genetics may have far-reaching impacts on livestock and livestock production in the coming decades. Ultimately, whether the tools used are novel or traditional, all depend on preserving access to animal genetic resources. In developing countries, if livestock are to continue to contribute to improving livelihoods and meeting market demands, the preservation of farm animal genetic resources will be critical in helping livestock adapt to climate change and the changes that may occur in these systems, such as shifts in disease prevalence and severity (FAO 2007).

Nutrition

Farm animals need the nutrition with respect to energy, protein, minerals, and vitamins have long been known, and these have been refined in recent decades. In different countries for ruminants and non-ruminants various requirement determination systems exist, which were originally designed to assess the nutritional and productive consequences of different feeds for the animal once intake was known. However, a considerable body of work exists associated with the dynamics of digestion, and feed intake and animal performance can now be predicted in many livestock species with high accuracy.

A large agenda of work still remains concerning the robust prediction of animal growth, body composition, feed requirements, and the outputs of waste products from the animal and production costs. Such work could go a long way to help improve the efficiency of livestock production and meeting the expectations of consumers and the demands of regulatory authorities. Better understanding of the processes involved in animal nutrition could also contribute to improved management of some of the trade-offs that operate at high levels of animal performance, such as those associated with lower reproductive performance (Butler, 2000).

While understanding of the science of animal nutrition continues to expand and develop, most of the world's livestock, particularly ruminants in pastoral and extensive mixed systems in many developing countries, suffer from permanent or seasonal nutritional stress (Bruinsma, 2003). Poor nutrition is one of the major production constraints in smallholder systems, particularly in Africa. Much research has been carried out to improve the quality and availability of feed resources, including work on sown forages, forage conservation, the use of multi-purpose trees, fibrous crop residues, and strategic supplementation. There are also prospects for using novel feeds from various sources to provide alternative sources of protein and energy, such as plantation crops and various industrial (including ethanol) by-products. Given the prevalence of mixed crop–livestock systems in many parts of the world, closer integration of crops and livestock in such systems can give rise to increased productivity and increased soil fertility (McIntire *et al.,* 1992).

In such systems, smallholders use crops for multiple purposes (food and feed, for example), and crop breeding programmes are now well established that are targeting stover quality as well as grain yield in crops such as maize, sorghum, millet and groundnut. Considerable work is under way to address some of the issues associated with various antinutritional factors. These include methods to reduce the tannin content of tree and shrub material, the addition of essential oils that may be beneficial in ruminant nutrition and the use of other additives such as enzymes that can lead to beneficial effects on livestock performance. Enzymes are widely added to feeds for pigs and poultry, and these have contributed (with breeding) to the substantial gains in feed conversion efficiency that have been achieved (McIntire et al., 1992).

For the mixed crop–livestock smallholder systems in developing countries, there may be places where these will intensify using the inputs and tools of high-input systems in the developed world. In the places where intensification of this nature will not be possible, there are many ways in which nutritional constraints could be addressed, based on what is locally acceptable and available. Addressing the nutritional constraints faced by pastoralists in extensive rangeland systems in the developing world is extremely difficult. While there is potential to improve livestock productivity in semi-arid and arid areas, probably the most feasible solutions require integrated application of what is already known, rather than new technology. This could involve dissemination of information from early warning systems and drought prediction, for example, so that herders can better manage the complex interactions between herd size, feed availability and rainfall (NRC, 2009).

For the developed world, various drivers will shape the future of livestock nutrition. First, there is the continuing search for increased efficiency in livestock production. Margins for livestock farmers are likely to remain volatile and may be affected heavily by changes in energy prices, and increased feed conversion efficiency is one way to try to keep livestock production profitable. Public health issues will become increasingly important, such as concerns associated with the use of antibiotics in animal production, including microbiological hazards and residues in food (Vallat *et al.,* 2005).

The World Health Organization recommended that all subtherapeutic medical antibiotic use be stopped in livestock production in 1997, and proposed strict regulation and the phasing-out of other subtherapeutic treatments such as growth promotants; but appropriate surveillance and control programmes do not exist in many countries. All antibiotics as growth promoters were banned in the European Union (EU) in 2006, but not all countries have made the same choice as the EU. Similarly, certain hormones can increase feed conversion efficiencies, particularly in cattle and pigs, and these are used in many parts of the world. The EU has also banned the use of hormones in livestock production. The globalization of the food supply chain will continue to raise consumer concerns for food safety and quality (Philip K., 2010).

Disease

Animal diseases generate a wide range of biophysical and socio-economic impacts that may be both direct and indirect, and may vary from localized to global (Perry & Sones 2009). The last few decades have seen a general reduction in the burden of livestock diseases, as a result of more effective drugs and vaccines and improvements in diagnostic technologies and services (Perry & Sones, 2009). At the same time, new diseases have emerged, such as avian influenza H5N1, which have caused considerable global concern about the potential for a change in host species from poultry to man and an emerging global pandemic of human influenza.

In the developing world, there have been relatively few changes in the distribution, prevalence and impact of many epidemic and endemic diseases of livestock over the last two decades, particularly in Africa (Perry & Sones, 2009) with a few exceptions such as the global eradication of rinderpest. A difficulty in assessing the changing disease status in much of the developing world is the lack of data, a critical area where progress needs to be made if disease diagnostics, monitoring and impact assessment are to be made effective and sustainable. Globally, the direct impacts of livestock diseases are decreasing, but the total impacts may actually be increasing, because in a globalized and highly interconnected world, the effects of disease extend far beyond animal sickness and mortality (Perry & Sones, 2009).

For the future, the infectious disease threat will remain diverse and dynamic, and combating the emergence of completely unexpected diseases will require detection systems that are flexible and adaptable in the face of change (King *et al.,* 2006b).Travel, migration and trade will all continue to promote the spread of infections into new populations. Trade in exotic species and in bush meat are likely to be increasing causes of concern, along with large-scale industrial production systems, in which conditions may be highly suitable for enabling disease transmission between animals and over large distances (Otte *et al.,* 2007).

Over the long term, future disease trends could be heavily modified by climate change. For some vector-borne diseases such as malaria, trypanosomiasis and bluetongue, climate change may shift the geographical areas where the climate is suitable for the vector, but these shifts are not generally anticipated to be major over the next 20 years: other factors may have much more impact on shifting vector distributions in the short term (Woolhouse 2006). This has obvious implications for policy-makers and the sheep and cattle industries, and raises the need for improved diagnosis and early detection of livestock parasitic disease, along with greatly increased awareness and preparedness to deal with disease patterns that are manifestly changing.

Future disease trends are likely to be heavily modified by disease surveillance and control technologies. Potentially effective control measures already exist for many infectious diseases, and whether these are implemented appropriately could have considerable impacts on future disease trends. (Perry & Sones, 2009). There are also options associated with the manipulation of animal genetic resources, such as cross-breeding to introduce genes into breeds that are otherwise well-adapted to the required purposes, and the selection via molecular genetic markers of individuals with high levels of disease resistance or tolerance

POSSIBLE MODIFIERS OF FUTURE LIVESTOCK PRODUCTION AND CONSUMPTION TRENDS

Competition for resources

Land

Recent assessments expect little increase in pastureland (Bruinsma 2003; MA 2005). Some intensification in production is likely to occur in the humid–subhumid zones on the most suitable land, where this is feasible, through the use of improved pastures and effective management. In the more arid–semiarid areas, livestock are a key mechanism for managing risk, but population increases are fragmenting rangelands in many places, making it increasingly difficult for pastoralists to gain access to the feed and water resources that they have traditionally been able to access.

In the future, grazing systems will increasingly provide ecosystem goods and services that are traded. The mixed crop–livestock systems will continue to be critical to future food security, as two-thirds of the global population live in these systems. Some of the higher potential mixed systems in Africa and Asia are already facing resource pressures, but there are various responses possible, including efficiency gains and intensification options.

Increasing competition for land in the future will also come from biofuels, driven by continued concerns about climate change, energy security, and alternative income sources for agricultural households. Future scenarios of bioenergy use vary widely (Herrero et al., 2010) and there are large evidence gaps concerning the likely trade-offs between food, feed and fuel in production systems in both developed and developing countries, particularly related to second-generation bioenergy technology.

Water

Globally, freshwater resources are relatively scarce, amounting to only 2.5 per cent of all water resources (MA, 2005). Groundwater also plays an important role in water supply: between 1.5 and 3 billion people depend on groundwater for drinking, and in some regions, water tables are declining unremittingly (Rodell et al. 2009). By 2025, 64 per cent of the world's population will live in water-stressed basins, compared with 38 per cent today (Rosegrant et al., 2002).

Increasing livestock numbers in the future will clearly add to the demand for water, particularly in the production of livestock feed: one cubic metre of water can produce anything from about 0.5 kg of dry animal feed in North American grasslands to about 5 kg of feed in some tropical systems (Peden et al., 2007). Several entry points for improving global livestock water productivity exist, such as increased use of crop residues and by-products, managing the spatial and temporal distribution of feed resources to better match availability with demand and managing systems so as to conserve water resources (Peden et al., 2007).

Climate change

Climate change may have substantial effects on the global livestock sector. Livestock production systems will be affected in various ways (Thornton et al., 2009) and changes in productivity are inevitable. Increasing climate variability will undoubtedly increase livestock production risks as well as reduce the ability of farmers to manage these risks. At the same time, livestock food chains are major contributors to greenhouse gas emissions, accounting for perhaps 18 per cent of total anthropogenic emissions (Steinfeld et al., 2006).

Impact of climate change on animal health

The effects of climate change on the health of farm animals have not been studied in depth. However, it can be assumed that as in the case of humans, climate change, in particular global warming, is likely to greatly affect the health of farm animals, both directly and indirectly(Philip K., 2010). Direct effects include temperature-related illness and death, and the morbidity of animals during extreme weather events. Indirect impacts follow pathways that are more intricate and include those deriving from the attempt of animals to adapt to thermal environment or from the influence of climate on microbial populations, distribution of vector-borne diseases, host resistance to infectious agents, feed and water shortages, or food-borne diseases.

Climate change will have severely deleterious impacts in many parts of the tropics and subtropics, even for small increases in the average temperature. This is in contrast to many parts of the temperate zone; at mid- to high latitudes, agricultural productivity is likely to increase slightly for local mean temperature increases of 1–3°C (IPCC, 2007). There is a burgeoning literature on adaptation options, including new ways of using weather information to assist rural communities in managing the risks associated with rainfall variability and the design and piloting of livestock insurance schemes that are weather-indexed (Mude, 2009).

There are several options related to livestock, including grazing management and manure management. Global agriculture could offset 5–14% (with a potential maximum of 20%) of total annual CO_2 emissions for prices ranging from $20 to 100 per t CO_2 eq (Smith et al. 2008). Of this total, the mitigation potential of various strategies for the land-based livestock systems in the tropics amounts to about 4 per cent of the global agricultural mitigation potential to 2030 which could still be worth of the order of $1.3 billion per year at a price of $20 per t CO_2 eq.

Impact of climate change on reproduction

High environment temperatures may compromise reproductive efficiency of farm animals in both sexes and hence negatively affect milk, meat and egg production and the results of animal selection. Wolfenson et al. (2000) reported that over 50% of the bovine population is located in the tropics and it has been estimated that heat stress may cause economic losses in about 60% of the dairy farms around the world. Heat stress compromises oocyte growth in cows by altering progesterone, the secretion of luteinizing hormone and follicle-stimulating hormone and dynamics during the oestrus cycle (Ronchi et al., 2001).

Heat stress has also been associated with impairment of embryo development and increased embryo mortality in cattle (Bényei et al., 2001; Hansen, 2007; Wolfenson et al., 2000). Moreover, heat stress may reduce the fertility of dairy cows in summer by poor expression of oestrus due to a reduced estradiol secretion from the dominant follicle developed in a low luteinizing hormone environment (De Rensis and Scaramuzzi, 2003). A drop can occur in summer of about a 20–27% in conception rates (Chebel et al., 2004; Lucy, 2002) or a decrease in 90-day non-return rate to the first service in lactating dairy cows (Al-Katanani et al., 1999).

Heat stress during pregnancy slows down growth of the foetus and can increase foetal loss, although active mechanisms attenuate changes in foetal body temperature when mothers are thermally stressed. In addition, beef cows are negatively affected by heat stress. In a ten-year study of calving records, Amundson et al. (2006) examined the effects of environmental conditions during breeding season on pregnancy rate and reported a reduction in pregnancy rate when the average daily minimum temperature and average daily THI were equal to or exceeded 16.7 °C and 72.9, respectively.

Roy and Prakash (2007) reported a lower plasma progesterone and higher prolactin concentration during oestrus cycle in Murrah buffalo heifers. These authors concluded that prolactin and progesterone profiles during the summer and winter months are directly correlated with the reproductive performance of buffaloes, and that hyperprolactinaemia may cause acyclicity/infertility in buffaloes during the summer months due to severe heat stress.

Socio-cultural modifiers

Livestock have multiple roles in human society. They contribute substantially and directly to food security and to human health. For poor and under-nourished people, particularly children, the addition of modest amounts of livestock products to their diets can have substantial benefits for physical and mental health (Neumann *et al.*, 2003).

Livestock's contribution to livelihoods, particularly those of the poor in developing countries, is also well recognized. Livestock generate income by providing both food and non-food products that the household can sell in formal or informal markets. Non-food products such as wool, hides and skins are important sources of income in some regions: wool production in the high-altitude tropical regions of Bolivia, Peru or Nepal, for example. Hides and skins from home-slaughtered animals are rarely processed, as the returns may not justify the costs involved (Otte and Upton 2005).

Kristjanson et al. (2004), in western Kenya, have documented livestock acquisition as a pathway out of poverty. They provide nutrients in the form of manure, a key resource particularly for the mixed systems of sub-Saharan Africa. Livestock also serve as financial instruments, by providing households with an alternative for storing savings or accumulated capital, and they can be sold and transformed into cash as needed and so also provide an instrument of liquidity, consumption smoothing and insurance. For some poorer households, livestock can provide a means of income diversification to help deal with times of stress.

In addition to their food security, human health, economic and environmental roles, livestock have important social and cultural roles. In many parts of Africa, social relationships are partly defined in relation to livestock, and the size of a household's livestock holding may confer considerable social importance on it. The sharing of livestock with others is often a means to create or strengthen social relationships, through their use as dowry or bride price, as allocations to other family members and as loans (Kitalyi et al. 2005). Social status in livestock-based communities is often associated with leadership and access to (and authority over) natural, physical and financial resources.

Compared with the biophysical environment, the social and cultural contexts of livestock and livestock production are probably not that well understood, but these contexts are changing markedly in some places. External pressures are being brought to bear on traditional open-access grazing lands in southern Kenya, for example, such as increasing population density and increasing livestock–wildlife competition for scarce resources.

Wildcard drivers of change

There is considerable uncertainty related to technological development and to social and cultural change. This section briefly outlines an arbitrary selection of wildcards, developments that could have enormous implications for the livestock sector globally, either negatively/ highly disruptive /or positively /highly beneficial/ (Philip K., 2010).

Artificial meat

From a technological point of view, this may not be a wildcard at all, as its development is generally held to be perfectly feasible (Cuhls 2008), and indeed research projects on it have been running for a decade already. There are likely to be some issues associated with social acceptability, although presumably meat ‘grown in vats’ could be made healthier by changing its composition and made much more hygienic than traditional meat, as it would be cultured in sterile conditions. In vitro meat could potentially bypass many of the public health issues that are currently associated with livestock-based meat. The development and uptake of in vitro meat on a large scale would unquestionably be hugely disruptive to the traditional livestock sector.

Nanotechnology

Nanotechnology is a highly diverse field, and includes extensions of conventional device physics, completely new approaches based upon molecular self-assembly, and the development of new materials with nanoscale dimensions. Some food and nutrition products containing nanoscale additives are already commercially available, and nanotechnology is in widespread use in advanced agrichemicals and agrichemical application systems (Brunori et al., 2008).

The next few decades may well see nanotechnology applied to various areas in animal management. Nanosized, multipurpose sensors are already being developed that can report on the physiological status of animals, and advances can be expected in drug delivery methods using nanotubes and other nanoparticles that can be precisely targeted. Nanoparticles may be able to affect nutrient uptake and induce more efficient utilization of nutrients for milk production, for example. One possible approach to animal waste management involves adding nanoparticles to manure to enhance biogas production from anaerobic digesters or to reduce odours (Scott, 2006).

However, considerable uncertainties concerning the possible human health and environmental impacts of nanoparticles, and these risks will have to be addressed by regulation and legislation: at present (Speiser, 2008). nanotechnology could redefine the entire notion of agriculture and many other human activities.

Deepening social concerns about specific technology

Much evidence points to a serious disconnect between science and public perceptions. Marked distrust of science is a recurring theme in polls of public perceptions of nuclear energy, genetic modification and, spectacularly, anthropogenic global warming. One of several key reasons for this distrust is a lack of credible, transparent and well-communicated risk analyses associated with many of the highly technological issues of the day (Speiser, 2008). Technology is necessary for the radical redirection of global food systems that many believe is inevitable, but technology alone is not sufficient: the context has to be provided whereby technology can build knowledge, networks and capacity (Kiers et al., 2008).

One area where there are numerous potential applications to agriculture is the use of transgenic methodology to develop new or altered strains of livestock. These applications include ‘improved milk production and composition, increased growth rate, improved feed usage, improved carcass composition, increased disease resistance, enhanced reproductive performance, and increased prolificacy’ (Wheeler, 2007).

CONCLUSION

Increases in the demand for livestock products, driven largely by human population growth, income growth, and urbanization, will continue for the next three decades at least. Globally, increases in livestock productivity in the recent pasts have been driven mostly by animal science and technology, and scientific and technological developments in breeding, nutrition, and animal health will continue to contribute to increasing potential production and further efficiency and genetic gains. Demand for livestock products in the future, particularly in developed countries, could be heavily moderated by socio-economic factors such as human health concerns and changing socio-cultural values.

REFERENCES

Al-Katanani, Y.M., Webb, D.W., Hansen, P.J. (1999). Factors affecting seasonal variation in 90-day nonreturn rate to first service in lactating Holstein cows in a hot climate. J. Dairy Sci. 82, 2611–2616.

Amundson, J.L., Mader, T.L., Rasby, R.J., Hu, Q.S. (2006). Environmental effects on pregnancy rate in beef cattle. J. Anim. Sci. 84, 3415–3420.

Bényei, B., Gaspard, A., Barros, C.W.C. (2001). Changes in embryo production results and ovarian recrudescence during the acclimation to the semiarid tropics of embryo donor Holstein–Frisian cows raised in a temperate climate. Anim. Rep. Sci. 68, 57–68.

Bruinsma, J. (2003). World agriculture: towards 2015/2030, an FAO perspective. Rome, Italy: Earthscan, FAO.

Brunori, G., Jiggins, J., Gallardo, R. & Schmidt, O. (2008). The Second SCAR Foresight Exercise, Synthesis Report, ‘New challenges for agricultural research: climate change, food security, rural development, agricultural knowledge systems’, p. 105. EU Commission Standing Committee on Agricultural Research (SCAR).

Butler, W. R. (2000). Nutritional interactions with reproductive performance in dairy cattle. Anim. Reprod. Sci. 60–61, 449–457.

Chebel, R.C., Santos, J.E.P., Reynolds, J.P., Cerri, R.L.A., Juchem, S.O., Overton, M. (2004). Factor affecting conception rate after artifi cial insemination and pregnancy loss in lactating dairy cows. Anim. Rep.

Sci. 84, 239–255.
Cuhls, K. (2008). Science, technology and innovation drivers: short report to the SCAR Expert Working Group. See http:// ec.europa.eu/research/agriculture/scar/index_en.cfm?p = 3_foresight.
De Rensis, F., Scaramuzzi, R.J. (2003). Heat stress and seasonal effects on reproduction in the dairy cow—a review. Theriogenology 60, 1139–1151.
Delgado, C. (2005). Rising demand for meat and milk in developing countries: implications for grasslands-based livestock production. In Grassland: a global resource (ed. D. A. McGilloway), pp. 29–39. The Netherlands: Wageningen Academic Publishers.
Emily Schmidt and Mekamu Kedir (2009). Urbanization and Spatial Connectivity in Ethiopia: Urban Growth Analysis Using GIS. Ethiopia Strategy Support Program (ESSP2) Discussion Paper No 003 **ESSP2**
FAO. (2006). World agriculture: towards 2030/2050. Interim report, Global Perspective Studies Unit. Rome, Italy:Food and Agriculture Organization of the United Nations.
FAO. (2007). Global plan of action for animal genetic resources and the Interlaken Declaration. Int. technical conf. on animal genetic resources for food and agriculture, Interlaken, Switzerland, 3–7 September 2007, Rome, Italy: FAO.
FAO. (2010). Food and agriculture organization of the United Nations statistical databases. See http://faostat.fao.org/.
GEO4. (2007). Global Environment Outlook 4, Environment for Development. United Nations Environment Programme. See http://www.unep.org/GEO/geo4.
Hansen, P.J. (2007). Exploitation of genetic and physiological determinants of embryonic resistance to elevated temperature to improve embryonic survival in dairy cattle during heat stress. Theriogenology 68S, S242–S249.
Hare, E., Norman, H. D. and Wright, J. R. (2006). Trends in calving ages and calving intervals for dairy cattle breeds in the United States. J. Dairy Sci. 89, 365–370.
Hayes, B. J., Bowman, P. J., Chamberlain, A. J. and Goddard, M. E. (2009). Genomic selection in dairy cattle: progress and challenges. J. Dairy Sci. 92, 433–443.
Herrero, M., Thornton, P. K., Notenbaert, A. M. O., Msangi, S., Wood, S., Kruska, R. L., .and Li, X. (2009). Drivers of change in crop-livestock systems and their potential impacts on agro-ecosystems services and human well-being to 2030. Study commissioned by the CGIAR Systemwide Livestock Programme (SLP). Nairobi, Kenya: ILRI
Herrero, M., Thornton, P. K., Notenbaert, A. M., Wood, S., Msangi, S., Freeman, H. A., and Lynam, J. (2010). Smart investments in sustainable food production: revisiting mixed crop-livestock systems. *Science*, *327*(5967), 822-825.
IPCC (Intergovernmental Panel on Climate Change) (2007). Climate Change 2007: impacts, adaptation and vulnerability. Summary for policy makers. See ch/publications_and_data/ar4/wg2/en/spm.html
Kiers, E. T., Leakey, R. R. B., Izac, A.-M., Heinemann, J. A., Rosenthal, E., Nathan, D. & Jiggins, J. (2008). Agriculture at a crossroads. Science 320, 320–321.
King, D. A., Peckham, C., Waage, J. K., Brownlie, J. &Woolhouse, M. E. J. (2006b). Infectious diseases: preparing for the future. Science 313, 1392–1393. (doi:10.1126/ science.1129134)
King, J. M., Parsons, D. J., Turnpenny, J. R., Nyangaga, J., Bakara, P. & Wathes, C. M. (2006a). Modelling energy metabolism of Friesians in Kenya smallholdings shows how heat stress and energy deficit constrain milk yield and cow replacement rate. Anim. Sci. 82, 705–716.
Kitalyi, A., Mtenga, L., Morton, J. U., McLeod, A., Thornton, P., Dorward, A. & Saadullah, M. (2005). Why keep livestock if you are poor? In Livestock and wealth creation: improving the husbandry of animals kept by resource-poor people in developing countries (eds E. Owen, A. Kitalyi, N. Jayasuriay & T. Smith), pp. 13–27.
Kristjanson, P., Krishna, A., Radeny, M. & Nindo, W. (2004). Pathways out of poverty in western Kenya and the role of livestock. PPLPI Working Paper No. 14. Rome, Italy: FAO.
Leakey, R. et al. (2009). Impacts of AKST (Agricultural Knowledge Science and Technology) on development and sustainability goals. In Agriculture at a crossroads (eds B. D. McIntyre, H. R. Herren, J. Wakhungu & R. T. Watson), pp. 145–253. Washington, DC: Island Press.
Lewin, H. A. (2009). It's a bull's market. Science 323, 478–479. MA 2005 The millennium ecosystem assessment, ecosystems and human well-being: scenarios, vol. 2. Washington, DC: Island Press.
Lucy, M.C. (2002). Reproductive loss in farm animals during heat stress. Proceedings 15th Conference on Biometeorology and Aerobiology, pp. 50–53.
MA (2005). The millennium ecosystem assessment, ecosystems and human well-being: scenarios, vol. 2. Washington, DC: Island Press.
Maddison, A. (2003). The world economy: historical statistics. Paris, France: OECD. McIntire, J., Bourzat, D. & Pingali, P. 1992 Crop-livestock interactions in sub-Saharan Africa. Washington, DC: World Bank.
McIntire, J., Bourzat, D. & Pingali, P. (1992). Crop-livestock interactions in sub-Saharan Africa. Washington, DC: World Bank.
Mude, A. (2009). Index-based livestock insurance for northern Kenya's arid and semi-arid lands: the Marsabit pilot, p. 14. Nairobi, Kenya: Project document, ILRI.
Neumann, C. G. et al. (2003). Animal source foods improve dietary quality, micronutrient status, growth and cognitive function in Kenyan school children: background, study design and baseline findings. J.

Nutr. 133, 3941S–3949S.
NRC (National Research Council) (2009). Emerging technologies to benefit farmers in sub-Saharan Africa and South Asia. Washington, DC: National Academies Press.
Otte, J. & Upton, M. (2005). Poverty and livestock agriculture. WAAP Book of the Year 2005, 281–296. The Netherlands: Wageningen Academic Publishers.
Otte, J., Roland-Holst, D., Pfeiffer, D., Soares-Magalhaes, R., Rushton, J., Graham, J. and Silbergeld, E. (2007). Industrial livestock production and global health risks. Pro-Poor Livestock Policy Initiative Research Report. Rome, Italy: FAO.
Peden, D., Tadesse, G. & Misra, A. K. (2007). Water and livestock for human development. In Water for food, water for life: a comprehensive assessment of water management in agriculture, ch. 13 (ed. D. Molden), London, UK: Earthscan; Colombo: IWMI.
Perry, B. & Sones, K. (2009). Global livestock disease dynamics over the last quarter century: drivers, impacts and implications. Rome, Italy: FAO. (Background paper for the SOFA 2009).
Philip K. Thornton (2010). Review Livestock production: recent trends, future prospects. R. Soc. B (2010) 365, 2853–2867. Available on: http://rstb.royalsocietypublishing.org/
Rodell, M., Velicogna, I. & Famiglietti, J. S. (2009). Satellitebased estimates of groundwater depletion in India. Nature 460, 999–1002. (doi:10.1038/nature08238)
Ronchi, B., Stradaioli, G., Verini Supplizi, A., Bernabucci, U., Lacetera, N., Accorsi, P.A., Nardone, A., Seren, E. (2001). Infl uence of heat stress and feed restriction on plasma progesterone, estradiol-17β LH, FSH, prolactin and cortisol in Holstein heifers. Liv. Prod. Sci. 68, 231–241.
Rosegrant, M. W. et al. (2009). Looking into the future for agriculture and AKST (Agricultural Knowledge Science and Technology). In Agriculture at a crossroads (eds B. D. McIntyre, H. R. Herren, J. Wakhungu & R. T. Watson), pp. 307–376. Washington, DC: Island Press.
Rosegrant, M. W., Cai, X. & Cline, S. A. (2002). Global water outlook to 2025, averting an impending crisis. A 2020 vision for food, agriculture, and the environment initiative. Washington, DC: IFPRI and IWMI.
Roy, K.S., Prakash, B.S. (2007). Seasonal variation and circadian rhythmicity of the prolactin profile during the summer months in repeat-breeding Murrah buffalo heifers. Reprod. Fertil. Develop. 19, 569–575.
Scott, N. R. (2006). Impact of nanoscale technologies in animal management. The Netherlands: Wageningen Academic Publishers. (WAAP Book of the Year 2006, 283–291).
Simm, G. (1998). Genetic improvement of cattle and sheep. Wallingford, UK: CABI Publishing.
Simm, G., Bunger, L., Villanueva, B. & Hill, W. G. (2004). Limits to yield of farm species: genetic improvement of livestock. In Yields of farmed species: constraints and opportunities in the 21st century (eds R. Sylvester-Bradley & J. Wiseman), pp. 123–141. Nottingham, UK: Nottingham University Press.
Smith, P. et al. (2008). Greenhouse gas mitigation in agriculture. Phil. Trans. R. Soc. B 363, 789–813. (doi:10.1098/ rstb.2007.2184)
Speiser, B. (2008). Nano-particles in organic production? Issues and opinions. Paper presented at 16th IFOAM Organic World Congress, Modena, Italy, 18–20 June 2008.
Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M. & de Haan, C. (2006). Livestock's long shadow: environmental issues and options. Rome, Italy: FAO.
Thornton, P. K. & Gerber, P. (2010). Climate change and the growth of the livestock sector in developing countries. Mitigation Adapt. Strateg. Glob. Change 15, 169–184.
Thornton, P. K. et al. (2006). Mapping climate vulnerability and poverty in Africa. Nairobi, Kenya: ILRI. See http://www. dfid.gov.uk/research/mapping-climate.pdf.
Thornton, P. K., van de Steeg, J., Notenbaert, A. & Herrero, M. (2009). The impacts of climate change on livestock and livestock systems in developing countries: a review of what we know and what we need to know. Agric. Syst. 101, 113–127.
UNFPA (United Nations Population Fund). (2008). The State of World Population 2007: unleashing the potential of urban growth. United Nations Population Fund.
UNPD (United Nations Population Division). (2008). The 2006 revision and world urbanization prospects: the 2005 Revision. Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects. See http://esa. un.org/unpp.
Vallat, B., Acar, J. F. & Schudel, A. (2005). Antibiotic use in animal production and consequences on food safety. The Netherlands: Wageningen Academic Publishers. (WAAP Book of the Year 2005, 311–317).
Van Vuuren, D. P. et al. (2009). Outlook on agricultural change and its drivers. In Agriculture at a crossroads (eds B. D. McIntyre, H. R. Herren, J. Wakhungu & R. T. Watson), pp. 255–305. Washington, DC: Island Press.
Wheeler, M. B. (2007). Agricultural applications for transgenic livestock. Trends Biotechnol. 25, 204–210.
Wolfenson, D., Roth, Z., Meidan, R. (2000). Impaired reproduction in heatstressed cattle: basic and applied aspects. Anim. Rep. Sci. 60–61, 535–547.
Woolhouse, M. (2006). Mathematical modelling of future infectious diseases risks: an overview. Foresight, infectious diseases: preparing for the future, office of science and innovation. See http://www.foresight.gov.uk/ Infectious%20Diseases/t8_1.pdf.

World Bank (2009). Minding the stock: bringing public policy to bear on livestock sector development. Report no. 44010-GLB.Washington, DC.