Food and Agriculture
Organization of the
United Nations

AFRICA SUSTAINABLE LIVESTOCK 2050

Livestock sector development in Asia and sub-Saharan Africa

A framework for comparative analysis

USAID
FROM THE AMERICAN PEOPLE

Financial support provided by the United States
Agency for International Development (USAID)

ASL 2050

AFRICA
SUSTAINABLE
LIVESTOCK
2050

Livestock sector development in Asia and sub-Saharan Africa

A framework for comparative analysis

Food and Agriculture Organization of the United Nations
Rome, 2019

Required citation:
FAO. 2019. *Africa Sustainable Livestock 2050 – Livestock sector development in Asia and sub-Saharan Africa – A framework for comparative analysis.* Rome. 22 pp. Licence: CC BY-NC-SA 3.0 IGO.

Contents

Summary

Africa Sustainable Livestock 2050 (ASL2050) aims to understand how Africa's changing livestock sector will affect public health, environment and livelihoods. ASL2050 has produced six papers comparing livestock sector development in Asia and Sub-Saharan Africa:

1. Framework for comparative analysis
2. Comparative analysis of the drivers of livestock sector development
3. Comparison of sector growth and transformation
4. Comparative analysis of public health impacts
5. Comparison of livelihoods impacts
6. Comparison of environmental impacts

This paper presents a framework for a comparative overview of livestock sector development in the different world regions. Comparative analysis sharpens our capacity to understand issues by highlighting contrasts and similarities, thereby contributing to formulate and test hypotheses, develop theories and inform the decision-making process. The framework has been used by the ASL2050 Programme to compare trends in livestock development between Asia and Sub-Saharan Africa, with the objective to generate evidence for decision-making. It recommends investigating the drivers of livestock sector growth and transformation; the structural elements of livestock sector growth and transformation; and the impact of livestock sector growth and transformation on three societal dimensions, comprising livelihoods, public health and the environment. The framework is comprehensive as it is by looking at livestock from multiple perspectives that decision-makers can anticipate its possible growth and transformation trajectories and take action now to ensure its sustainable development.

Key words: livestock development, comparative analysis, framework

Authors: Joachim Otte and Ugo Pica-Ciamarra

Date of Publication: January 2018

1. Introduction

In the past two decades, and especially since the turn of the millennium, the African continent has been one of the fastest-growing regions of the world. Annual GDP growth rate for the entire continent has been over 4 percent on average, though with ups and downs and differences between countries (WB, 2017). Prospects for the future are good, both for the medium and long-term, because of exponential population growth dominated by youth; gains in per capita income and the rise of a middle class; rapid urbanization; technology adoption; political vision and commitment (AfDB, 2017; AUC, 2015; MGI, 2013).

The anticipated development of the African continent will go hand in hand with transformative changes in its agriculture. The agricultural sector will transform not only to meet a spectacular increase in the demand for food, but also to satisfy the changing food preferences of an increasingly affluent and urbanized population. The sheer numbers are impressive: Africa's population is expected to reach 2.5 billion by 2050 versus 1.2 billion today, with per capita consumption of food, as measured in kilocalories, more than doubling (FAO, 2017).

Within agriculture, the livestock sector is predicted to change dramatically. As GDP and consumer purchasing power grow, so will the demand for high-value products, including animal source foods such as meat and milk. This phenomenon has been dubbed the 'Livestock Revolution' (Delgado *et al.,* 1999). In response, producers will invest in and expand livestock production and respective value chains to satisfy consumer demand. The livestock sector, which currently accounts for about 1/3 of the value added of agriculture, is expected to become the largest contributor to agriculture, as in industrialized economies.

The anticipated expansion of livestock production and associated value chains, if uncontrolled, may not only satisfy consumers' demand but could also have negative effects on public health, the environment and livelihoods, as experience elsewhere, for instance in Asia, has shown. In the last 30 years, meat consumption in South Asia, Southeast Asia and East Asia combined increased from about 36 to over 125 million tonnes; and milk consumption from 60 to almost 220 million tonnes, that is by over 250 percent for both commodities. Parallel increases have occurred on the production side, due to increases in animal population. For example, between 1985 and 2013 the poultry population passed from 3.5 to 12.4 billion and the off-take rate from 141 to 207 percent (FAOSTAT, 2017). This spectacular change in the livestock sector has had some negative effects on society. Examples include small farmers being squeezed out from the poultry and pig businesses (Paopongsakorn, 2012); human health being affected by outbreaks of zoonotic diseases, such as avian influenzas and animal food borne-diseases (Coker *et al.*, 2013; WHO, 2015); and by livestock-associated pollution of soil and water (Bouwman *et al.* 2013; Strokal *et al.,* 2016).

As world regions are growing at different speed and follow different development patterns, comparative analyses of livestock sector trends and trajectories can sharpen our capacity to understand issues and inform the decision-making process by highlighting contrasts and similarities. This paper provides a framework for a comparative analysis of livestock development trajectories in Asia and sub-Saharan Africa, or any other region for that matter. The framework recommends first investigating the drivers of livestock sector growth and transformation, which underpin the velocity and extent of any change in the livestock sector. It then suggests to explore the structural elements of livestock sector growth and transformation, which relate to changes in livestock production systems. Finally, it proposes to assess the impact of livestock sector growth and transformation on three societal dimensions, namely livelihoods, public health and the environment. The Africa Sustainable Livestock 2050 (ASL2050) Programme has relied on this framework to produce a series of reports comparing livestock development trajectories in Asia and sub-Saharan Africa over the past decades.

2. Drivers of Livestock Sector Growth and Transformation

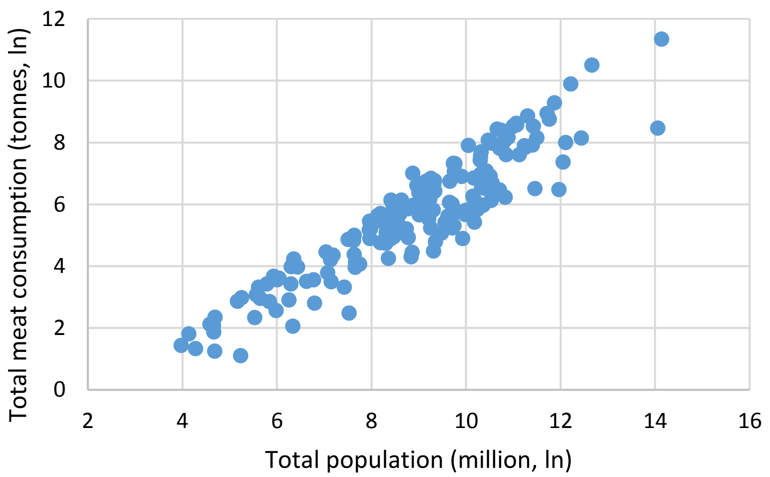
Over the past couple of decades, global agriculture has shifted its main focus from the supply of cereals as staples to providing an increasingly protein-rich diet based on livestock and fisheries products. Globally, milk, beef and pork feature among the top five agricultural commodities by value of output (the other two being rice and wheat) with growth rates of animal source food (ASF) production that are in general substantially higher than those for most plant-based products. The strong growth of the livestock sector over the past quarter of a century has been driven by three major intertwined factors:

(i) Population growth;
(ii) Income growth;
(iii) Urbanization.

2.1 Population growth

Since 1990, global population has grown from 5.9 billion to 7.4 billion in 2016. According to UN projections, world population is expected to reach 8.5 billion by 2030 and 9.7 billion by 2050, with most of the growth occurring in sub-Saharan Africa and Asia (UN-DESA, 2015). Urban populations are growing faster and generally have higher disposable incomes than rural populations, leading to a concentration of demand for ASF in urban areas and away from traditional rural production areas. The larger the population, the higher the consumption of food, including livestock products. Fig. 1 presents a scatter plot of the world's countries, ordered by population size, and their total amount of meat consumption.

Fig 1. Countries by size of population and total meat consumption (2013)

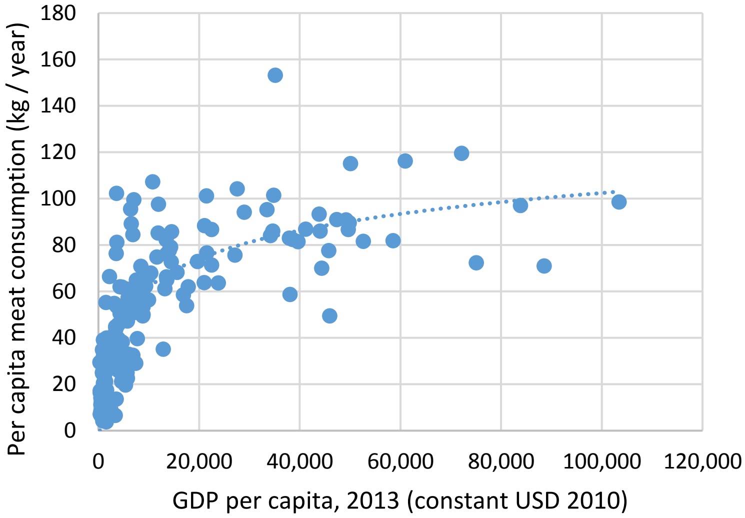


Source: FAOSTAT (2018)

2.2 Income growth

Population growth will be coupled with increasing disposable incomes, which translates into substantial growth in demand for higher-value food items, such as ASF and fruits and vegetables. Between 2000 and 2010, *per capita* consumption of cereals in developing countries stagnated, while for meat, milk and eggs it grew by 25, 47, and 24 percent, respectively. Demand growth for ASF is projected to continue well into the future and will outpace population growth in all developing regions (FAO, 2012). Fig. 2 presents a scatter plot of countries ordered by GDP per capita, a proxy of disposable income, and per capita consumption of meat of all types. It shows that people with higher level of per capita income consume more livestock products. Engel's law predicts, however, that at some point the increase in demand for food diminishes relative to the increase in income as there's an upper bound to what human beings can physically consume.

Fig. 2. Countries by GDP per capita and per-capita meat consumption (2013)

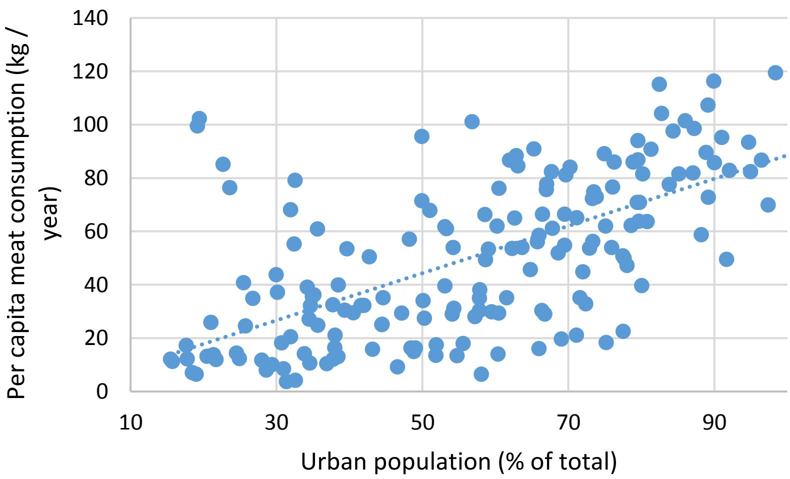


Source: FAOSTAT (2018)

2.3 Urbanization

Urbanization has two major effects on the food basket. First, urban dwellers allocate a larger share of their food budget to purchase "luxury" food items, such as vegetables and ASF, than rural dwellers. This behaviour is partly explained by the availability of infrastructure, such as cold chains (electric power), which allows trading perishable products, including milk and meat (Satterthwaite *et al.*, 2010; WHO, 2003). Second, cities offer greater opportunities to find employment outside the home than rural areas, which raises income but also the opportunity cost of spending time shopping and preparing food. Thus, an increasing number of urban households are willing to pay for prepared foods and packaging (e.g. Veeck and Veeck, 2000). Fig. 3 presents a scatter plot of countries by level of urbanization, as measured by the proportion of people living in cities, and per-capita meat consumption.

Fig 3. Countries by urbanization rate and per capita meat consumption (2013)



Source: FAOSTAT (2018)

3. Structural elements in livestock sector growth transformation

As response to the growing demand for animal source foods, livestock farmers and other actors along the value chain invest resources to expand production and improve productivity. The livestock sector thus transforms, both from a technological and organizational perspective. This process, often referred to as 'structural change', encompasses the following main elements:

(i) 'scaling up';
(ii) intensification;
(iii) specialization and stratification;
(iv) spatial concentration;
(v) 'corporatization' and vertical coordination / integration;
(vi) consolidation and concentration of market shares;
(vii) 'internationalization'; and
(viii) transition from 'informal' to 'formal' of market arrangements.

3.1 Scaling-up

Scaling-up refers to the growth in average holding / herd sizes, which is generally accompanied by a decrease in the total number of producers. The largest holdings also tend to get larger and larger. Eventually most animals are kept in a relatively small share of all livestock holdings. For example in India, whose livestock sector is still in a transformative process, there are about 76 million dairy farms, keeping an average of about 2 cows (Hemme et al. 2015). Conversely, in Australia there are about 7 000 dairy farms, keeping an average of about 230 cows (Douphrate et al., 2013).

3.2 Intensification

Livestock intensification means increased number of animals raised per unit of land or area, and it is associated with growing use of inputs. Intensive food animal production is based on the use of livestock breeds selected for high production potential (at the expense of adaptive traits) and, in the case of chicken and increasingly also pigs, exploitation of hybrid vigour (Box 1). Animals rely on an optimized production environment, which comprises balanced high density feed rations, high quality housing and enhanced health care.

Industrial livestock production, occurring mainly in poultry and pig systems, represents the extreme end of intensification, whereby large numbers of highly productive animals are kept at high densities, production inputs are derived from other farms, and the production process is mechanized and automated with limited labour employed. For example, the European Union 'Broiler Directive' reads that 'Member States shall ensure that the maximum stocking density in a holding house or a house of a holding does not at any time exceed 33 kg/m^2' (EU, 2007), which, with an average slaughter weight of 2.2 kg equates to about 15 birds per square meter.

3.3 Specialization and stratification

Livestock sector intensification is often accompanied by specialization and stratification of production. Specialization occurs when farms move from keeping different species of livestock (traditionally kept to make use of diverse farm resources and ensure a steady flow of products partly intended for own consumption) to keeping only one species and within species moving from dual or multi-purpose to single purpose breeds, e.g. layer or broiler chicken, dairy or beef cattle, wool or meat sheep. For example, Angus is a popular breed of beef cattle in Northern and Southern America as well as in Oceania, regions with comparative advantages in beef production.

Stratification occurs when, within a particular ASF commodity, farms specialize on a specific production step, giving rise to 'breeders', 'multipliers' and 'finishers', which are industries on their own. The Irish Agriculture and Food Development Authority, for example, undertakes statistical surveys specifically targeting so-called "cattle finishing enterprises". Animal breeding in particular has become a highly specialized segment of animal production, with very few companies dominating world markets (Box 1).

Box 1 Hybrid livestock and the breeding industry

Hybrid chicken were first developed in the 1940s by Henry Wallace, who applied breeding methods that he had used to develop Pioneer Hi-bred corn to poultry. When two different lines are crossbred, productivity of the offspring can increase due to hybrid vigour. However, this effect gets lost in the next generation, so that farmers using these breeds have to buy new breeding stock every time.

The multipliers receive hybrid parent animals from the breeding companies, but only male animals of the male line and female animals of the female line, to exclude the possibility of breeding by the multipliers – the biological lock.

There are only four globally operating poultry genetics companies worldwide, with just two of them, Erich Wesjohann (EW) Group and Hendrix Genetics controlling the global layer hen breeding sector, covering half of the world's egg production. In 2005 and 2006, consolidation between poultry, pig, cattle and aquaculture genetic businesses intensified substantially. The world's largest pig breeding company PIC, the largest cattle breeding company ABS (USA), and the world's largest shrimps breeder (Sygen) together formed one company, Genus plc (UK).

In 2007, the world's second largest poultry breeder Hendrix Genetics, bought the second largest pig breeding company Hypor. And most recently, the world's largest poultry breeder, EW Group, acquired the majority shares of world market leader in salmon and trout breeding, the Norway-based Aqua Gen AS. Exclusive access to gene and information technologies is fostering further concentration.

The achievable rates of return have attracted Monsanto, known for its GMO plant breeding monopolies, to invest in livestock and Monsanto now also engages in pig and cattle genetics.

Source: Gura, 2007; Gura, 2008.

3.4 Spatial concentration

Given feed, the main input to intensive animal production, is purchased, the cost of transporting feed to the production site and the cost of transporting animals to consumption centres are important determinants of the competitiveness of an enterprise. Consequently, as soon as urbanization and economic growth translate rising incomes into 'bulk' demand for animal food products, large-scale operators establish 'finishing' units in the proximity of feed mills, processing plants, and / or markets. This leads to production clusters with high numbers of production units, which in turn each harbour large numbers of animals. For example, in the United States, Iowa is the leading state in swine production because of large supplies of corn and soybeans, primary elements in swine feed (IPPA, 2017). Although a high degree of spatial concentration has its advantage in the marketing and sourcing of inputs, it presents significant challenges to on-farm disease control and waste management (Costales *et al.,* 2006).

3.5 'Corporatization', contract farming and vertical integration

Scaling-up and specialization are often accompanied by an increase in company-owned / corporate farms vis-à-vis independent / 'family' farms. Companies successively expand the scope of their operations to eventually integrate all elements of the value chain from feed production to final retail of food products. At its most extreme, integrated production involves a single firm owning and operating every aspect of production from importing parent stock to marketing packaged meats in company owned outlets. This allows the firm to achieve economies of scale, decrease transactions costs, as well as the ability to closely monitor product quality at every stage of production by controlling all inputs and processes at every level.

Within the 'integrated' approach to ASF supply, a company may contract farmers to raise the animals; provide the farmer with specific types of feed, medicine, and other inputs; require certain production methods; pick up the animals and transport them to a processing facility; and process and distribute the meat, i.e. coordinate production of a larger number of 'independent' farmers under contracts to ensure timely supply of animals satisfying the company's specifications. The growth of the Brazil's poultry industry, for instance, has been shaped by effective relationships between the major processing companies – two companies, JBS and BRF, account for almost 50 percent of the poultry slaughtered in the country – and about 180 000 poultry farmers, with the former providing the latter with birds, feed and medicine in advance (Reporter Brasil, 2016).

3.6 Concentration of market share / power

Over time, vertical integration and mergers and acquisitions can lead to concentration of market power in a handful of agribusinesses. It is generally believed that when an industry's CR4 (the market share of the top 4) exceeds 40 percent, market competitiveness begins to decline, leading to higher spreads between what consumers pay and what producers receive for their produce (Murphy, 2006). This is the case for Malaysia, for instance, where a 2008 report by the Malaysian Company Commission on the broiler industry estimated that 67 percent of the parent stock in the country were supplied by 5 integrators and that the four largest firms in the poultry processing industry controlled over 85 percent of the market (Umar Muazu *et al.*, 2016).

3.7 Internationalization

With the objective of securing input supplies, expanding output markets and increasing flexibility to react to supply / demand volatility, larger companies extend their business activities across national borders. For example, the International Farm Comparison Network (IFCN) list of Top 20 milk processor's by milk intake shows that they process more than 25 percent of the world's milk production. Dairy Farmers of America tops the ranking, processing 3.6 percent of the global milk production (Cornall, 2016).

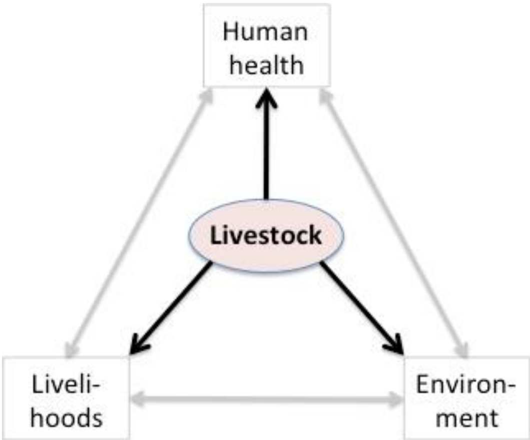
3.8 Transition of retail markets

With growth of population and per-capita income, hypermarkets and other 'convenience' outlets increase in popularity, particularly in urban areas. Such outlets require suppliers that are able to provide steady and timely flows of standardized, high quality products. This emergent demand leads to market segmentation between producers who can meet these demands and those who cannot, i.e. between the 'formal' and the 'informal' supply chains, and between the 'wet' markets for fresh and warm meat and the supermarket outlets of processed, frozen, packaged and branded meat (Costales *et al.,* 2006). For instance Shoprite, a South African food retailer, has expanded from eight stores worth 1.2 USD million in 1979, to become Africa's largest retail chain with annual turnover of over USD 10 billion in 2016 (www.shortiteholdings.co.za). However, despite the expansion of supermarkets, informal markets persist in most countries, due mainly to preference for traditional products (Reardon *et al.,* 2003).

4. Effects of Livestock Sector Growth and Transformation

Livestock sector growth and transformation affect three major domains at micro, meso and macro level: (ii) livelihoods (ii) human health, (iii) the environment.

Fig 4. Linkages between livestock, human health, livelihoods and the enivronment



As depicted in Fig 4, these links can be direct (black arrows) and indirect (grey arrows). For instance, zoonotic diseases can directly impact human health, which may in turn negatively affect the livelihoods dimension through medical expenses incurred by the household. Alternatively, livestock may provide the income needed to access better health care and thereby indirectly improve human health. As there are a multitude of ways through which livestock sector growth and transformation can affect livelihoods, public health and the environment, the following will be limited to describing the direct linkages.

5. Livestock's contribution to livelihoods and food security

The trajectory of livestock sector growth and transformation changes the role livestock play in supporting livelihoods and contributing to food security (and improving nutrition), particularly in low-income countries by:

(i) Generating income for livestock keepers through the provision of goods and services and generating additional livelihoods opportunities through the creation of jobs along the value chain;

(ii) Supporting availability and access to food at household and community level, both directly and indirectly;

(iii) Reducing household and community vulnerability to climatic and market shocks, thereby supporting stability in food access.

5.1 Cash, non-cash income and value addition

Livestock-derived income can stem from the sale of live animals, animal products, and processing of animal products. According to Davis *et al.* (2007), two out of three households in developing countries earn income from livestock. Notably, livestock's share of income is highest in the poorest income quintile, which shows that they are particularly important to the poor. In addition to income, livestock also provide a number of non-tradable or marginally tradable benefits, such as draft power and hauling services, insurance and savings, energy through the use of dung. Available evidence suggests that these benefits account for a non-marginal, if not the largest share of livestock's contribution to the livelihoods of poor households (Zane *et al*., 2016).

Beyond livestock farmers, a number of people are employed in livestock product value chains, with the total world's population depending on livestock estimated at 1.3 billion people (Herrero *et al*., 2009). Trading and processing jobs in the livestock sector are especially high in the informal sectors of countries in Asia and Africa. For example, it is estimated that in the Kenya dairy sector for every on-farm job, another 1.25 jobs are generated in processing and services (USAID, 2014).

People employed in the livestock value chain, from raising animals to retail, generate value for society. The livestock sector as a whole contributes between one third to over sixty percent of agricultural value added on average in developing and industrialised countries respectively. National accounts, however, do not estimate the value of non-tradable livestock products, such as draft power and insurance. For instance, a review of the Ethiopia national accounts concluded that the agricultural value addition calculation underestimated the contribution of livestock, and suggested to adjust the figure upwards by 47 percent (ICPALD, 2013).

5.2 Availability and access to food

Food security encompasses four major dimensions, including food availability, food access, stability and utilization. While at country and regional level a variety of elements, such as infrastructural investments and trade policies, affect food security, at community and household level ownership of livestock is an important determinant of food security. Animals, and in particular milk animals and poultry, provide a regular source of nutritious food to household and community members, i.e. they ensure that food is both available and accessible.

Livestock also contribute indirectly to food availability by increasing crop output through providing manure, which is a valuable source of organic plant nutrients and reduces the need for chemical fertilizers. The economic value of manure is well recognized by farmers. In high-potential areas of Kenya, for example, the market value of manure has been found to be about five times the value of the equivalent nutrients in fertilizer (Lekasi *et al.,* 1998).

Finally, livestock increase food availability by transforming the biomass available in grasslands, which are unsuitable for crop production, into meat, milk and other edible products. They also convert large amounts of plant materials associated with the production and processing of food crops that are not edible by humans (e.g. straws, stovers, oilseed cakes, brewers grains) into valuable food. Fadel (1999) has estimated that every 100 kg of crop-derived food yields 37 kg of animal feed by-product. For example in India, dairy cattle and buffalo, which are almost exclusively fed on crop residues and by-products, produce enough milk to cover the caloric needs of around 115 million people and the protein requirements of about 230 million people.

5.3 Stability in availability and access to food

Livestock support stability in availability and access to food, first of all because there is less seasonality in livestock than in crop production. In addition, ownership of livestock makes communities and households more resilient to climatic and market shocks by smoothing out seasonal variations in food availability. Livestock are a regular source of food and generally more adaptable to environmental shocks than crops are, and are able to digest a wide variety of feedstuffs, thereby having the capacity to survive dramatic reductions in specific feed resources. Furthermore, they are mobile, which increases their survivability, and offers households the possibility of keeping them in case of displacement.

6. Livestock's impact on public health

Livestock sector growth and transformation can affect human health through the following main pathways:

(i) Provision of ASFs, which, if consumed in adequate amounts, provide essential nutrients required for healthy growth and development; excessive consumption of ASF can also harm human health;

(ii) Exposure to infectious disease causing agents transmissible from livestock to humans (zoonotic pathogens);

(iii) Promotion of antimicrobial resistance in microorganisms carried by food animals and subsequent spread of genetic elements that confer resistance to a wide range of microorganisms not limited to livestock.

(iv) Promotion of pollution-related diseases through the leakage of pollutants from livestock production, such as nitrate (NO_3) and ammonia (NH_3), into the environment.

6.1 Nutrition

ASFs are dense and palatable sources of energy and high-quality protein and also provide a variety of essential micronutrients, some of which, such as vitamin A, vitamin B12, riboflavin, calcium, iron, zinc, and various essential fatty acids, are difficult to obtain in adequate amounts from plant-based foods alone (Murphy and Allen, 2003). ASFs provide multiple micronutrients simultaneously, which can be important in diets that are lacking in more than one nutrient. These characteristics make ASFs important for population groups with limited food intake capacity relative to their needs, such as young children, and pregnant and lactating women. For example, the distribution of livestock assets to households both in Nepal and Rwanda has resulted in improved child anthropometric measures also due to increased consumption of ASFs (IFPRI, 2017).

Malnutrition, besides having direct negative impacts on human health, is also predisposing factor for infectious diseases greatly enhancing their debilitating impacts. Consumption of adequate amounts of micronutrients found in animal-source foods is associated with more competent immune systems and better immune responses (Keusch and Farthing, 1986). Conversely, for instance, zinc and vitamin A deficiency are important risk factors for DALYs due to diarrhoea among children younger than 5 years (GBD DDC, 2017). At the same time, overconsumption of livestock products, and particularly read meat, has been found to increase the risk of cardiovascular disease and colon cancer (McAfee *et al.*, 2010).

6.2 Zoonotic diseases

Diseases, for which the causative agent is shared between humans and animals, are called zoonotic. For these, livestock can represent an important reservoir or act as spillover and amplifying host. In both cases, livestock itself may or may not develop clinical disease (Table 1).

Table 1. Zoonotic pathogens associated with livestock and the role of the main livestock species in their epidemiology

	Food animals important reservoir host	Food animals spill-over (and amplifying host)
Zoonotic pathogens of food animal and human health impor-tance#	• Influenza A viruses (pigs and poultry) • RVF virus (LRs, SRs) • Wesselsbron fever virus (SRs) • C. burnetti (Q-fever) (SRs/LRs) • Chlamydia abortus (LRs, SRs) • Brucella spp. (B. abortus, B. melitensis, B. suis) (LRs, SRs, pigs) • Leptospira spp. (selected serovars) (LRs, pigs) • M. bovis (LRs) • T. b. rhodesiense (LRs) • Fasciola spp. (F. hepatica, F. gigantica) (LRs) • Schistosoma spp. (e.g. S. japonicum, S. bovis, etc.) (LRs)	• Nipah virus (pigs) • Ebola virus (pigs) • JE virus (pigs) • Menangle virus (pigs) • Lyssa (rabies) virus (all) • B. anthracis (all)
Zoonotic pathogens mainly / only of human health impor-tance	• Hepatitis E virus (genotypes 3 and 4) (pigs) • MERS CoV (camels) • E. coli (selected serotypes, e.g. O157:H7; serogroups O26, O103, O104, etc.) (mainly LRs) • Campylobacter spp. (C. jejuni, C. coli) (all+) • Salmonella enterica (>2,500 serovars) (all+) • MRSA (pigs) • Streptococcus suis (pigs) • Listeria monocytogenes (all) • Cryptosporidium spp. (C. parvum) (mainly LRs and SRs) • Giardia intestinalis (all) • Teania spp. (Taeniasis / Cysticercosis) (pigs)	• SARS CoV (pigs) • Alkhurma virus (SRs) • CCHF virus (LRs and SRs(?)) • Toxoplasma gondii (all) • Trichinella spiralis (pigs)

Sources: Merck Veterinary Manual (http://www.merckvetmanual.com/public-health/zoonoses/zoonotic-diseases)

'Health importance' in livestock refers to likelihood of causing clinical disease and / or reducing production performance

LRs = cattle and buffalo; SRs = sheep and goats; all = all mammalian lstk; all+ = mammalian lstk and poultry.

Zoonotic diseases comprise diseases that are mainly (but not exclusively) transmitted through ASF (e.g. Campylobacter spp., Salmonella enterica), i.e. 'food-borne' zoonoses, 'classical' or 'established' zoonoses (e.g. brucellosis, leptospirosis, zoonotic tuberculosis), which may also be food-borne but are transmitted by direct or indirect animal contact and thus constitute an 'occupational' hazard, and the so-called 'emerging' infectious diseases (e.g. Nipah, HPAI). The latter arise as a consequence of changes in livestock – wildlife – human interactions, which alter established host-parasite equilibria. The cost of zoonotic diseases for society can be high. For example, outbreaks of emerging infectious diseases caused by animal pathogens often result in influenza pandemics, whose cost has been estimated to range from $374 billion (in 2014 US$) for a mild pandemic to $7.3 trillion for a severe one, with GDP losses estimated at 12.6%, without considering an estimated 142 million deaths (Pike *et al.*, 2014).

Livestock sector growth and transformation may also lead to environmental changes (e.g. deforestation), which enhance the risk of transmission of zoonotic pathogens directly from non-livestock species to humans. On the other hand, enhanced access to meat from food animals may reduce reliance on hunting and trapping, a practice, which increases the risk of pathogen transfer from wildlife to humans.

6.3 Antimicrobial resistance

As an alternative to investing in improved husbandry or in situations of poor animal health service provision, antimicrobials are often used for disease prevention and growth promotion (in addition to their therapeutic use). This practice promotes the evolution of antimicrobial resistance in zoonotic pathogens (Gilchrist *et al.,* 2007). Use for growth promotion involves extended exposure of microorganisms to sub-therapeutic doses, a practice that has been banned in the EU because it is particularly prone to drive the emergence of AMR.

Resistant bacteria can be transferred to humans through contact with livestock, through the food chain, and through wastewater from livestock operations. AMR burdens society through higher treatment costs due to use of more expensive compounds and longer hospitalization and through reduced productive life (increased case fatality rates). In Thailand, for example, in 2010 AMR has been estimated to have resulted in 3.24 million days of hospitalization and almost 40 000 deaths per year amounting to a total cost of 0.6 percent of GDP (Pumart *et al.*, 2012). In addition, resistance may also affect the treatment of individuals with non-resistant organisms as in areas with high rates of resistance physicians may change empiric therapy to more expensive drugs, increasing overall treatment costs. In some instances, these costs may exceed those attributable to treatment failure (Howard *et al.,* 2003).

6.4 Pollution-related diseases

Nitrate (NO_3) and ammonia (NH_3) are two pollutants associated with animal production. Infants below the age of six months can become seriously ill from intake of water with a concentration higher than 10 mg/L of nitrate causing the so-called 'blue-baby syndrome' (Zhou, 2015). Ammonia can react with a number of acidic compounds (such as nitric acid or sulfuric acid) to form very small secondary aerosol particles. This fine particulate matter has a diameter of <2.5 microns (referred to as PM 2.5) and can persist in the air for up to two weeks. PM 2.5 particles are a health concern for their impacts on respiratory function. Epidemiological studies of worker health have shown that swine, and to a lesser extent, poultry workers experience occupational respiratory disease in which chronic ammonia exposure may play a part. An epidemiological and exposure-response study on 2017 swine producers in the US found positive correlations between pulmonary functions over a work period and exposure to ammonia and other dusts (Donham *et al.*, 1995).

7. Livestock's effects on the environment

Livestock sector growth and transformation can have a major impact on the environment. Livestock rely on land and water for the provision of feed, thereby determining land use with environmental consequences and, while producing valuable food for human consumption, generate solid, liquid and gaseous 'by-products', which may have negative impacts on the environment. While livestock can have positive impact on the environment, for example cattle manure is a good fertilizer and improves soil structure, most of the impacts of livestock on the environment are negative. They comprise:

- (i) Grassland degradation through overgrazing and improper land conversion;
- (ii) Nutrient overloading of cropland and water sources resulting from manure and waste water mismanagement;

(iii) Water scarcity due to water withdrawals for the production of animal feed, cleaning and processing and drinking;

(iv) GHG emissions from enteric fermentation, manure management and energy-use;

(v) Biodiversity loss and reduced eco-system services due to land use change and all of the above.

7.1 Grassland degradation

A variety of factors, such as overgrazing, improper land conversion to cropland and adverse effects of drought exacerbated by climate change, are contributing to progressive degradation of grasslands across the globe. The major signs of grassland degradation are lower plant productivity (plant production has declined by 30-70 percent) and decreased biodiversity, increased frequency of rodent and grasshopper infestations, and accelerated soil erosion. Its environmental consequences are desert expansion, regional and continental dust storms, and, in extreme cases, environmentally induced human migration (Briske *et al.,* 2015).

Overgrazing, which occurs when pasture is unable to recover from animal grazing and trampling, is considered a major cause of grassland degradation. For example, Wang and Batkhishing (2014) find that soil organic matter is lower by 30 to 50 percent in overgrazed than in non-grazed areas of Mongolia, and Al-Rowaily *et al.* (2015) show that in grazing 'exlosures' in western Saudi Arabia the cover, density and variety of grasses, shrubs and trees is significantly higher in 'exclosed' areas than in grazing areas.

7.2 Nutrient overloading of cropland and water sources

Animal manure contains significant amounts of nitrogen (N) and phosphorous (P), both of which are important nutrients for plants and other organisms living in the soil and water. In traditional mixed crop-livestock farming systems, manure is a valuable resource for enhancement of soil fertility (and texture). However, the geographical concentration of large numbers of livestock in areas with little or no agricultural land can lead to high nutrient overloads. In China, for example, direct manure discharge accounts for over two-thirds of nutrients in the northern rivers and for 20 to 95 percent of nutrients in the central and southern rivers (Strokal *et al.,* 2016).

Excessive nutrients can have adverse effects on plant growth and increase the potential for environmental contamination due to leaching. In addition, high organic matter levels can cause poor drainage and water logging, which also impair plant / crop growth. The discharge of nitrogen, phosphorus, other nutrients and heavy metals in water streams, mainly associated with animal excreta and waste-water mismanagement contributes to water eutrophication, which results in oxygen depletion in water. This process can damage wetlands and fragile coastal ecosystems and fuels algal 'blooms'[1] that use up oxygen in the water, killing fish and other aquatic life.

7.3 Water stress

Livestock production draws on water resources as drinking water, water to produce feed and water for cleaning and processing. The amount of drinking water used varies from 20–50 litres per tropical livestock unit (TLU) per day and depends on the species, dry matter intake, composition of the feed, water content of the feed, live weight of the animal, level of milk and meat production, physiological status of the animal and the climate in which the livestock is managed. However, the water required to produce daily feed for livestock is about 100 times

[1] Phosphorus is often the limiting factor to the development of blue-green algae, which are able to utilize atmospheric N2.

the actual daily requirements for drinking water. Livestock typically require daily feed intake of dry matter amounting to about 3 percent of their weight and about 500 L of water are required to produce 1 kg dry matter (Peden *et al.,* 2002).

Globally, the water footprint (WF) of animal production has been estimated as one third of the water footprint of global agriculture and this fraction is likely to increase (Gerbens-Leenes *et al.,* 2013). The significance of a large WF for any product will depend to some extent on where the water use arises, and may have a greater impact in dry areas and seasons than in water rich areas and seasons. For estimating local environmental impacts of water use, the water footprint needs to be evaluated in the context of local water scarcity and waste assimilation capacity (Gerbens-Leenes *et al.,* 2013).

7.4 GHG emissions

Animal production is an important source of GHGs, considered the main cause of climate change. Methane (CH_4) is produced by ruminant livestock through enteric fermentation and as a product of manure management; nitrous oxide (N_2O), 200 times as powerful as CO_2, results from manure managed in pits or lagoons as well as from manure applied to soils and left on pasture; and carbon dioxide (CO_2) stems from on-farm energy use for livestock (e.g. cooling, ventilation and heating).

In addition to GHG emissions at production stage, livestock is responsible for up-stream GHG emissions resulting from land conversion, management of the residues of feed crops, production of fertilizer applied to feed crops, and energy used for the production and transport of inputs while downstream emissions originate from processing and distribution activities.

On a global scale, downstream emissions have been estimated to contribute less than three percent of total livestock sector related emissions while the upstream production of feed accounts for roughly 45 percent of the total (Gerber *et al*., 2013). Of the latter figure, however, approximately one third, i.e. 15 percent of total emissions, are attributed to applied and deposited manure.

7.5 Biodiversity loss

In order to cover the feed requirements of the livestock populations feed has to be produced. This can be done by planting feed crops, through switching current areas from food to feed crops and by expanding the feed or grassland areas through conversion of natural habitats. It can also be done by using food by-products as animal feed.

Land use change, particularly from primary vegetation to cropland or pasture as well as an increased intensity of land use leads to reduction in biodiversity as measured by species richness and total abundance (Newbold *et al.,* 2015; Souza *et al.,* 2015). Biodiversity loss reduces the efficiency by which ecological communities capture biologically essential resources, produce biomass, decompose and recycle biologically essential nutrients. Current global rates of extinction are about 1 000 times the estimated background rate of extinction (Pimm *et al*., 2014) and the number of species in decline is much higher in the tropics, even after accounting for the greater species diversity of the latter.

As conversion of natural habitats to expand the area to produce feed crops has been the main strategy pursued to satisfy livestock feed requirements, livestock production is possibly considered the single largest driver of habitat loss, increasing in tropical countries where the majority of biological diversity resides (Machovina *et al*., 2015).

8. Conclusion

This paper presented a framework for comparative overview of livestock sector development in the different world regions. Comparative analysis sharpens our capacity to understand issues by highlighting contrasts and similarities and thus contributes to formulate and test hypotheses, develop theories and inform the decision-making process. The framework recommends investigating the drivers of livestock sector growth and transformation; the structural elements of livestock sector growth and transformation; and the impact of livestock sector growth and transformation on three societal dimensions, comprising livelihoods, public health and the environment. The framework is comprehensive, as it is by looking at livestock from multiple perspectives that decision-makers can anticipate its possible growth and transformation trajectories and take action now to ensure its sustainable development. It is used by the ASL2050 Programme to compare livestock development trajectories between Asia and sub-Saharan Africa to generate evidence for informed decision-making.

References

AfDB. 2017. *African Economic Outlook. Entrepreneurship and Industrialisation*. African Development Bank, Abidjan. Ivory Coast.

Al-Rowaily, S.L., El-Banab, M.I., Al-Bakre, D.A., Assaeeda, A.M., Hegazyd, A.K. & Alia, M.B. 2015. Effects of open grazing and livestock exclusion on floristic composition and diversity in natural ecosystem of Western Saudi Arabia. *Saudi J. Biol. Sci*. 22 (4): 430–437.

AUC. 2015. *Agenda 2063. The Africa We Want*. African Union Commission, Addis Ababa, Ethiopia.

Bouwman, A.F., Beusen, A.H.W. & Billen, G. 2009. Human alteration of the global nitrogen and phosphorus soil balances for the period 1970-2050. *Global Biogeochem Cycles* 23: GB0A04 1–16.

Bradford, G.E. 1999. Contributions of animal agriculture to meeting global human food demand. *Livestock Production Science* 59: 95–112.

Briske, D.D. & *et al.* 2015. Strategies to alleviate poverty and grassland degradation in Inner Mongolia: Intensification vs production efficiency of livestock systems. *J Env Mgmt* 152: 177–182.

Cardinale, B.J., Duffy, J.E., Gonzalez, A., Hooper, D.U., Perrings, C. & *et al.* 2012. Biodiversity loss and its impact on humanity. *Nature* 486: 59–67.

Coker, R.J., Hunter, B.M., Rudge, J.W., Liverani, M. & Hanvoravongchai, P. 2013. Emerging infectious diseases in southeast Asia: regional challenges to control. *The Lancet* 9765: 599 – 609.

Cornall, J. 2016. Who are the world's top 20 milk processors. *The Dairy Reporter*, 8 June 2016.

Costales, A., Gerber, P., Steinfeld, H. 2006. Underneath the Livestock Revolution. In: *Livestock Report 2006*, FAO, Rome, 15–28.

Davis, B., Winters, P., Carletto, G., Covarrubias, K., Quinones, E. & *et al*. 2007. Rural income-generating activities: a cross-country comparison. ESA Working Paper 07-16. FAO, Rome.

Delgado, C., Rosegrant, M., Steinfeld, H., Ehui, S., Courbois, C. 1999. *Livestock to 2020: the next food revolution*. IFPRI Food, Agriculture, and the Environment Discussion Paper 28. IFPRI, Washington D.C.

Douphrate, D.I., Hageevort, G.R., Nonnenmann, M.W., Klostrup, C.L., Reynolds, S.J., Jakob, M. & Kinsel, M. 2013. The Dairy Industry: A Brief Description of Production Practices, Trends and Farm Characteristics around the World. *Journal of Agromedicine* 18:187-197.

Donham, J.K., Reynolds, S.J., Whitten, P., Merchant, J.A., Burmeister, L. & Popendorf, W.J. 1995. Respiratory dysfunction in swine production facility workers: Dose-response relationships of environmental exposures and pulmonary function. *American J. of Ind. Med.* 27(3): 405-418.

EU. 2007. Council Directive 2007/43/EC of 28 June 2007 laying down minimum rules for the protection of chickens kept for meat production. *Official Journal of the European Union* L 182:19-28.

Fadel, J.G. 1999. Quantitative analysis of selected by-product feedstuffs: A global perspective. *Anim Feed Sci Technol* 79: 255–268.

FAO. 2012. *World Agriculture towards 2030/2050 – The 2012 Revision*. ESA Working Paper 23-03. FAO, Rome.

FAO. 2017. *The future of food and agriculture: Scenarios for alternative development pathways to 2050*. FAO, Rome.

GBD (Diarrhoeal Diseases Collaborators). 2017. Estimates of global, regional, and national morbidity, mortality, and aetiologies of diarrhoeal diseases: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet Infectious Diseases,* Published Online June 1, 2017 http://dx.doi.org/10.1016/ S1473-3099(17)30276-1

Gerbens-Leenes, P.W., Mekonnen, M.M., Hoekstra, A.Y. 2013. The water footprint of poultry, pork and beef: A comparative study in different countries and production systems. *Water Resources and Industry* 1-2: 25–36.

Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C. & et al*.* 2013. *Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities*. FAO, Rome.

Gilchrist, M.J., Greko, C. & Wallinga, D.B. 2007. The Potential Role of Concentrated Animal Feeding Operations in Infectious Disease Epidemics and Antibiotic Resistance. *Environmental Health Perspectives* 115(2): 313-316. DOI: 10.1289/ehp.8837.

Gura, S. 2007. Livestock Genetics Companies - Concentration and proprietary strategies of an emerging power in the global food economy. League for Pastoral Peoples and Endogenous Livestock Development (www.pastoralpeoples.org), Germany.

Gura, S. 2008. *Industrial livestock production and its impact on smallholders in developing countries*. Consultancy report to the League for Pastoral Peoples and Endogenous Livestock Development (www.pastoralpeoples.org), Germany.

Hemme, T., Saha, A. & Tripathi, P. 2015. *Dairy Farming in India. A Global Comparison*. YesBank, Gurgaon, India, and International Farm Comparison Network, Kiel.

Herrero, M., Thornton, P.K., Gerber, P. & Reid, R.S. 2009. Livestock, livelihoods and the environment: understanding the trade-offs. *Current Opinion in Environmental Sustainability* 1: 111–120.

Howard, D.H. & *et al.* 2003. The Global Impact of Drug Resistance. *Clinical Infectious Diseases* 36 (Suppl 1): S4–10.

ICPALD. 2013. *The Contribution of Livestock to the Ethiopian Economy*. Policy Brief ICPALD/CLE/8/2013. IGAD Center for Pastoral Areas & Livestock Development, Nairobi.

IFPRI. 2017. Nutrition-Sensitive Agriculture. What Have We Learned and Where Do We Go from Here? IFPRI Discussion Paper 01681. IFPRI: Washington D.C.

IPPA. 2017. *Iowa Pork Facts.* Iowa Pork Producer Association, Clive, Iowa.

Johnson, P.T.J. & *et al.* 2010. Linking environmental nutrient enrichment and disease emergence in humans and wildlife. *Ecol. Appl.* 20(1): 16–29.

Keusch, G.T. & Farthing, M.I. 1986. Nutrition and infection. *Ann Rev Nutr* 6: 131–154.

Lekasi, J.K., Tanner, J.C., Kimani, S.K. & Harris, P.J. 1998. *Manure management in the Kenya highlands: Practices and potential*. Nairobi, KARI, ILRI, and Coventry, Li WJ, Ali SH, Zhang Q (2007) Property rights and grassland degradation: A study of the Xilingol Pasture, Inner Mongolia, China. *Journal of Environmental Management* 85: 461–470

Machovina, B., Feeley, K.J. & Ripple, W.J. 2015. Biodiversity conservation: The key is reducing meat consumption. *Sci of the Total Environ* 536: 419–431.

McAfee, A.J., McSorely, E.M., Cuskelly, G.J., Moss, B.W., Wallace, J.M.W., Bonham, M.P. & Fearon, A.M. 2010. Red meat consumption: An overview of the risks and benefits. *Meat Science* 84(1):1-13.

MGI. 2013. *Lions go digital: The Internet's transformative potential in Africa.* McKinsey Global Institute, Johannesburg, South Africa.

Murphy, S. 2006. Concentrated Market Power and Agricultural Trade. Washington, DC: Heinrich Böll Foundation Discussion Paper Series 1. 41pp.

Murphy, S.P. & Allen, L.H. 2003. Nutritional importance of animal source foods. *Journal of Nutrition* 133: 3932S–3935S.

Newbold, T., Hudson, L.N., Hill, S.L.L., Contu, S., Lysenko, I. & *et al*. 2015. Global effects of land use on local terrestrial biodiversity. *Nature* 520: 45–50.

Paopongsakorn, N. 2012. *Livestock Industrialization in Asia: Growth, Scaling-up, Competitiveness and Outlook for Smallholders*. Keynote speech delivered at the FAO, APHCA and ILRI Regional Policy Forum on Asian Livestock Challenges, Bangkok.

Peden, D, Tadesse, G. & Mammo, M. 2002. Improving the water productivity of livestock: An opportunity for poverty reduction. Available at http://www.ilri.org/publications/cdrom/integratedwater/iwmi/Documents/Papers/Don.htm

Perry, B. & Grace, D. 2009. The impacts of livestock diseases and their control on growth and development processes that are pro-poor. *Philosophical Transactions of the Royal Society B: Biological Sciences* 364: 2643–2655.

Pike, J., Bogich, T., Elwood, S., Finoff, D.C. & Daszak P. 2014. Economic optimization of a global strategy to address the pandemic threat. *PNAS*, 111(52): 18519-18523.

Pimm, S.L., Jenkins, C.N., Abell, R., Brooks, T.M., Gittleman, J.L. & *et al*. 2014. The biodiversity of species and their rates of extinction, distribution and protection. *Science* 344(6187): 1246752.

Postel, S. 2000. Entering an era of water scarcity: the challenges ahead. *Ecological Applications* **10**: 941**–**948.

Pumart, P., Phodha, T., Thamlikitkul, V., Riewpaiboon, A., Prakongsai, P. & Limwattananon, S. 2012. Health and economic impacts of antimicrobial resistant infections in Thailand: a preliminary study. *J Health Syst Res*. 6: 352-360.

Quartz Africa. 2016 The grocery chain that became Africa's biggest retailer by betting on its middle class. Quartz Africa, Johannesburg, Dec. 1, 2016.

Reardon, T., Timmer, C.P., Barret, C.B. & Berdegue, J. 2003. The Rise of Supermarkets in Africa, Asia and Latin America. *Amer. Journal of Agricultural Economics* 85 (5): 1140**–**1146.

Reporter Brasil. 2016. *Brasil's poultry industry. Monitor #2.* Reporter Brasil, Sao Paulo.

Rijsberman, F.R. 2006. Water scarcity: Fact or fiction? *Agricultural Water Management* 80: 5–22.

Rockström, J. & Barron, J. 2007. Water productivity in rainfed systems: Overview of challenges and analysis of opportunities in water scarcity prone savannahs. *Irrigation Science* 25: 299**–**311.

Rosegrant, M., Ximing, C., Cline, S. & Nakagawa, N. 2002. The role of rainfed agriculture in the future of global food production. EPTD Discussion Paper No. 90. Washington DC: International Food Policy Research Institute, Environment and Production Technology Division.

Satterthwaite, D., McGranahan, G. & Tacoli, C. 2010 Urbanization and its implications for food and farming. *Philosophical Transactions of the Royal Society B* 365: 2809-2820.

Souza, D.M., Teixera, R.F.M., Ostermann, O.P. 2015. Assessing biodiversity loss due to land use with Life Cycle Assessment: are we there yet? Global Change Biology 21: 32–47, doi: 10.1111/gcb.12709.

Strokal, M., Ma, L., Bai, Z., Luan, S., Kroeze, C. & *et al*. 2016. Alarming nutrient pollution of Chinese rivers as a result of agricultural Transitions. *Environ Res Lett* 11: 024014 Doi:10.1088**/**1748-9326**/**11**/**2**/**024014.

Umar Muazu, A., Abidin, M.Z., Shamsuddin, N. & Abdulatif, I. 2016. Measuring Market Power in the Integrated Malaysian Poultry Industry: New Empirical Industrial Organization Approach. *Journal of Food Products Marketing* (22) 4: 455-470.

United Nations, Department of Economic and Social Affairs, Population Division. 2015. World Population Prospects: The 2015 Revision, Data Booklet. ST/ESA/SER.A/377, UN, New York.

United Nations, Commission on Sustainable Development. 1997. *Comprehensive assessment of the freshwater resources of the world. Report of the Secretary General.*

Commission on Sustainable Development. Economic and Social Council. United Nations: New York. E/CN.17/1997/9 (4 February).

USAID, 2014. *Workforce Connections - Kenya Youth Assessment*. Available at https://www.usaid.gov/sites/default/files/documents/1865/Kenya_Youth_Assessment_Final_Report.pdf

Veeck, A. & Veeck, G. 2000. Consumer segmentation and changing food purchasing patterns in Nanjing, PRC. *World Development* 28 (3): 457–471.

Wang, Q. & Batkhishig, O. 2014. Impact of Overgrazing on Semiarid Ecosystem Soil Properties: A Case Study of the Eastern Hovsgol Lake Area, Mongolia. *J. Ecosys Ecogrph* 4(1): 1000140.

WHO. 2015. *WHO Estimates of the global burden of foodborne diseases.* World Health Organization, Geneva.

WB. 2017. World Bank World Development Indicators. Available at https://data.worldbank.org/data-catalog/world-development-indicators

WHO. 2002. Protein and amino acid requirements in human nutrition: report of a joint FAO/WHO/UNU expert consultation. WHO technical report series; no. 935.

WHO. 2003. *Diet, Nutrition and the Prevention of Chronic Diseases.* WHO Technical Report Series No 916. WHO, Geneva.

Zane, G., Nsiima, L., Pica-Ciamarra, U. & Sserugga, J. 2016. (Mis)measuring the contribution of livestock to household livelihoods: evidence and lessons from LSMS surveys in Tanzania and Uganda. Proceedings, Seventh International Conference on Agricultural Statistics, Rome, October.

Zhou, Z. 2015. *A global assessment of nitrate contamination in groundwater*. Internship report to the International Groundwater Resources Assessment Centre and Wageningen University. 27pp.

CA3590EN/1/03.19