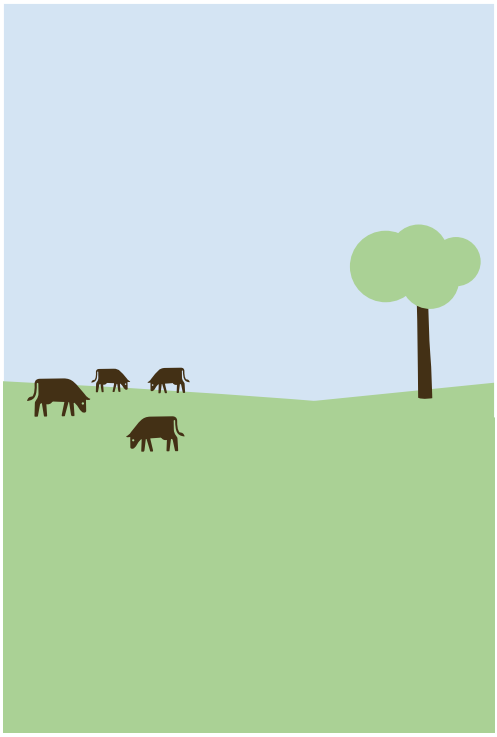
Sustainable global livestock development for food security and nutrition including roles for Sweden



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Sustainable global livestock development for food security and nutrition including roles for Sweden

Foreword

Almost 800 million people do not have enough food for the day and suffer from chronic undernourishment. There are 160 million children under the age of five who are affected by stunted growth. This is completely unacceptable in a world in which resources and opportunities have never been more abundant. Access to adequate and nutritious food is a human right. The increasing frequency of extreme weather events, natural disasters, political instability and civil war has hindered progress in guaranteeing food security. This was established by the Food and Agriculture Organisation of the United Nations (FAO), whose main task is to help reduce hunger and promote sustainable agriculture, forestry and fisheries. Forecasts predict that the global rise in population will mainly take place in low-income countries, i.e. countries where the most hungry people live. Africa is expected to account for more than half of this growth – from approximately 1.1 billion people to 2.4 billion. The dramatic rise in urbanisation means that we must provide food for a growing urban population. The challenge will therefore be enormous, as the majority of agricultural production has to take place in countries with the strongest population growth but the lowest level of resources to increase productivity in agriculture.

We must therefore highlight the role of the livestock sector as key to agricultural development and food security, which is what this discussion paper intends to do. This sector is crucial to achieving sustainable development in the entire agricultural sector. It accounts for one third of global gross domestic product from agriculture and is one of the fastest-growing economic sectors in the world's low-income countries. It is estimated that 600 million poor people, many of them women, earn the major share of their livelihood from livestock farming. In addition, livestock products provide essential protein and indispensable micronutrients. However, it is also important to draw attention to the negative effects of the livestock sector, such as greenhouse gas emissions, overgrazing, water consumption, spread of zoonoses and growing antimicrobial resistance. All of these aspects are raised in this paper.

How can Sweden help the important livestock sector to develop in a sustainable way? This discussion paper notes that Sweden has a strong and credible voice. Through various measures we have managed to combine high returns in production with low antibiotic use and a favourable level of resistance in animals. This development has taken place through a shared approach and close cooperation between industry, government agencies and academia, and can serve as a role model to other countries. The updated antibiotics strategy

reaffirms this and identifies Sweden's international efforts. Sweden wants to, and can, contribute know-how to global efforts against the development of antimicrobial resistance, which represents a fundamental risk to the opportunities of implementing the 2030 Agenda. There is a growing awareness globally that this requires rapid and common measures. The One Health perspective is key to this work and emphasises how important it is that measures adopted take place in collaboration between the animal sector, the human sector and other relevant parties. Sweden is actively taking part in this work.

The Committee on World Food Security (CFS) – the central forum for discussing food security at global level – has produced a report looking into the role of the livestock sector as a basis for discussions at the CFS meeting in October 2016. This paper should therefore also be seen as a contribution by the Swedish FAO Committee to the Government's positions in those discussions.

The paper was produced on behalf of the FAO Committee by Ulf Magnusson, professor in domestic animal reproduction at the Department of Clinical Sciences at the Swedish University of Agricultural Sciences and active within Agricultural Sciences for Global Development (SLU Global). The author is responsible for the content, and the Committee has not taken a position on the views expressed.

I hope that you will find this paper interesting, as it provides a valuable picture of how the livestock sector can contribute to the implementation of the 2030 Agenda, an undertaking that applies to all countries of the world, including Sweden. The Swedish Government will work actively and be a driving force for the fulfilment of the 2030 Agenda.

Elisabeth Backteman
Chair, Swedish FAO Committee

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Abbreviations

AMR	Antimicrobial Resistance
ASF	Animal Source Food
CFS	Committee on World Food Security
EC	European Commission
FAO	Food and Agriculture Organization of the United Nations
FSN	Food Security and Nutrition
GASL	Global Agenda for Sustainable Livestock
GDP	Gross Domestic Product
GHG	Greenhouse Gases
HLPE	High Level Panel of Experts
NGO	Non-Governmental Organizations
OEI	World Organisation for Animal Health
SDG	Sustainable Development Goal
SJV	Swedish Board of Agriculture
SSA	Sub-Saharan Africa
WHO	World Health Organization
WTO	World Trade Organization

Summary

There is a diversity of entry points, perspectives and narratives about the livestock sector. It is therefore important, and challenging, to have a common understanding of the underlying facts when moving into the discussion about sustainable development of the global livestock sector. The important role of the sector globally is reflected in that the first two Sustainable Development Goals (SDGs) relate directly to the livestock sector: *SDG 1*, *End poverty* – 600 million poor people in the world depend directly on livestock for their livelihoods. *SDG2*, *Zero hunger* – 14% of the total calories and 33% of the proteins in the world population's diets are provided by livestock and animal source food is crucial in combatting micronutrient deficiencies (hidden hunger) in women and children. Notably, 26% of the earth's ice-free land are pastures that can be used for food production thanks to the ability of ruminants to transform that biomass to edible food for humans.The livestock sector is very diverse so the challenges and opportunities vary by species reared, farm sizes, agro-ecologies, policy environment etc. The current review focuses on small-holders in mixed crop-livestock systems and pastoralist systems and stresses the importance on taking all the three sustainability aspects into account: social, economic and environmental. These systems have in general low productivity and the farmers in these systems are often politically weak, several of them poor and suffer from food insecurity and poor nutrition. However, technical and policy interventions – such as better animal health, feed, genetics combined with access to markets and improved land rights – can improve their situation. This so called *sustainable intensification* of the livestock sector contributes to more efficient use of natural resources, reduced green house gas emissions per unit food produced, increases the farmers incomes and ultimately improves their food security and nutrition. Thus, social, economic and environmental gains go hand in hand. In an international comparison, the Swedish livestock sector is environment and animal friendly and is in the lead regarding good animal health and productivity with minimum use of antimicrobials. This position in the international community has to a large extent been achieved by a long-term Private-Public Partnership where well-organized farmers have been key partners. Several of the Swedish successful policies and practices can be transferred to the global livestock sector. This is particular true for the Swedish approach to reduce the use of antimicrobials and the emergence of antimicrobial resistance in livestock. This best practise combines regulatory policies with animal health management where the non-rational use of antimicrobials has been replaced by disease-preventive measures and thereby safeguarding productivity. The latter is particularly important to secure a sustainable food security and improved nutrition in low-income countries.

1. Introduction

In contrast to today's Sweden, the agricultural sector including livestock is high on the economic and political agendas globally. This is in particular true in low-income countries and middle-income countries with emerging economies where food security and nutrition (FSN) is a highly relevant issue. The important role of the livestock the sector is for instance reflected in that the first two Sustainable Development Goals (SDGs) relate directly to the livestock sector: *SDG 1, End poverty* – 600 million poor people in the world depend directly on livestock for their livelihoods. *SDG2, Zero hunger* – 14% of the total calories and 33% of the proteins in the world population's diets are provided by livestock and animal source food is crucial in combatting micronutrient deficiencies in women and children.

The global importance of the livestock sector is further emphasized by that it accounts for about one-third of the global agricultural GDP, is the largest user of land resources in agriculture globally and it is one of the fastest-growing economic sectors in low-income countries worldwide. The opportunities and challenges for the livestock sector are thus substantial.

Given this and the recent launch of the SDGs, it is very timely that the High Level Panel of Experts of Food Security and Nutrition (HLPE) at the Committee on World Food Security (CFS) has published the report *"Sustainable agricultural development for food security and nutrition: what roles for livestock"* (HLPE, 2016). In the following the analyses, conclusions and recommendations in that report will be discussed with emphasis on the situation in low-income countries and on how Sweden can contribute to a sustainable development of the livestock sector.

The report defines sustainable agricultural development for food security and nutrition as follow: *"Sustainable agriculture development is agriculture development that contributes to improve resource efficiency, strengthening resilience and securing social equity/responsibility of agriculture and food systems in order to ensure food security and nutrition for all, now and in the future."* This definition is ethically reassuring as it puts human wellbeing in the front of the discussions about sustainability in the report. In such discussions in the privileged high-income countries, like Sweden, the concept of sustainability is often synonymous with and limited to environmental sustainability, forgetting or ignoring the two other pillars of sustainable development; social and economic which both are key to long-lasting human development and wellbeing.

Nutritious animal source foods (ASF) can originate from many different sources including livestock. It should be noted that in the HLPE report livestock is used to designate domesticated terrestrial animals raised for food production. This focus makes sense as within the livestock sector, still very

diverse though, one share similar social, economic and environmental issues. However, one should keep in mind though that ASF with sometimes-similar features may originate from other sources like wildlife, aquaculture or insects.

A third introductory point from the report is the typology used for different livestock farming systems. As the opportunities, challenges, sizes, agro-ecologies, etc. for farms vary a lot between and within regions and countries in the world, an attempt to categories the farms in some way is essential in order to be able to have a discussion that is not too general. Thus, the report has categorized global livestock farming rearing into four broad classes: smallholder mixed framing systems, pastoral systems, commercial grazing systems and intensive livestock systems. Given the Swedish FAO Committee's pro-poor approach, the current review will mainly elaborate on, but not be limited to, issues related to the smallholder mixed systems and the pastoral systems. Even so, it should be noted that the HLPE report fully recognize the diversity of entry points, perspectives, narratives and interpretations of data related to the livestock sector and has a strong ambition to build a common understanding about sustainable development of the livestock sector for FSN.

A final initial reflection is how the food security discourse nowadays fully embrace the nutrition aspect – i.e. we not only discuss hunger in the sense of lack of energy (i.e. calories) but also in the sense of lack of micronutrients, called "hidden hunger" to which women of reproductive age and young children are particular sensitive (von Grebmer et al., 2014). It should be noted though that the nutrition aspect was included already in World Food Summit Definition of food security 1996: *Food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life* (FAO, 2008). The current focus on "hidden hunger" that is estimated to affect 2 billion people worldwide (FAO, IFAD, WFP, 2014) reinforce the role and importance of the micronutrient rich ASF for these disadvantaged people and the livestock rearing for achieving FSN for all.

The HLPE report is structured in 5 sections: Chapter 1 that elaborates on a conceptual framework of livestock farming, Chapter 2 that describes drivers and trend of agricultural development, Chapter 3 identifies sustainability challenges for agricultural development, with focus on livestock, Chapter 4 that proposes pathways and responses to address those challenges and then concludes by presenting action-oriented recommendations to states and other stakeholders. The first part of the current review follows at large that structure, whereas the second part discusses aspects or issues where Sweden has particular expertise that can contribute to a more sustainable global livestock sector.

Niger. Dryland cows grazing in the dry Sahelian semidesert.
©FAO/Guilio Napolitano

2. Livestock for food security and nutrition – a background

2.1 Linkages to the Sustainable Development Goals

Given the importance to and emphasis on the UN SDGs in the contemporary international agenda, it makes sense to stress the strong linkages between livestock and the SDGs. The 17 SDGs are universal (i.e. relevant to all nations), indivisible and take all the three dimensions of sustainable development – economic, social and environmental – into account. A comprehensive overview of the livestock – SDG linkage is given by the Global Agenda for Sustainable Livestock (GASL, 2016) and summarized in table 4. Obviously the linkage to the SDGs varies in strength and the strongest linkages are, as mentioned above, to SDG 1 *End poverty in all its forms everywhere* and SDG 2 *End hunger, achieve food security and improved nutrition and promote sustainable agriculture*. All in all, the HLPE report is at the core of the SDG 2 about food security, improved nutrition and sustainable agriculture.

2.2 The role of livestock in the world

Livestock development contributes significantly to improved FSN along at least two tracks: it is increasing the quantity of highly nutritious ASF and livestock products perishable goods that is an important source of income for the world's poor enabling them to purchase food. Saying this, livestock is also linked to the feed crop sector, it provides manure as fertilizer for crops and vegetables, draught power and may serve as bank or safety net. The report very rightly discusses the asymmetry of consumption of ASF in the world. This imbalance is between countries as well as within countries – at large a difference between rich and poor even if the picture becomes more mixed in some countries.

Livestock has a particular role in the nutritional aspect of FSN as ASF is rich in essential micronutrients like iron, iodine, zinc and vitamin A. Most of the micronutrients in ASF are also present in plant foods, however their bioavailability and concentration is higher in ASF, making ASF an important source for groups with high needs such as women in reproductive age and young children (Gibson, 2011). Also, ASF is very energy-dense food - a feature that is beneficial for the undernourished but bad for the over-weighted-providing about 16% of total calories globally according to FAOSTAT per 2010.

Livestock is the largest user of land on the planet. In total it is estimated that 80 % of all agricultural land (arable land, permanent meadows and pastures and permanent crops; FAOSTAT definition) is used for feed production. It is further estimated that 26% of the earth's ice-free land are permanent meadows and pastures that can be used for food production thanks to the ability of ruminants to transform that biomass to edible food for humans.

Livestock also poses a threat to human health and the environment. Infectious agents like bacteria or viruses can be transmitted from livestock to humans (zoonoses) directly, via vectors or the food-chain and cause disease. It has been calculated that about 60% of the infectious diseases in humans are zoonotic (Taylor et al., 2001). Similarly, livestock may contribute to the spread of AMR to humans and the environment. Recent calculations suggest that 14.5 % of the anthropogenic GHG–emissions come from directly or indirectly from the livestock production chain (Gerber et al. 2013; Herrero et al. 2016) Other negative impacts on natural resources – mostly local and varying between and within regions are overgrazing, deforestation or excessive nitrogen effluents.

Livestock is one of the fastest growing sectors in global agriculture. The growth has been driven both by increasing incomes, wealthier households demand a more varied diet including ASF, and increasing populations, particularly in low-income and growing economies. Currently it is estimated that the livestock sector contribute to 30-40% of the global agriculture GDP and that 1.3 billion people's livelihood depends on livestock. Of these about 600 million are poor farmers.

The above facts that are extracted from the HLPE report do together with other evidence-based statements in the report give a comprehensive overview of the important and multifaceted global role of livestock for FSN, livelihood and other aspects of human wellbeing. The reading is particularly useful for those that are new to the subject or want to learn more about the global livestock sector. The HLPE itself states that their reports *"…serve as a common, comprehensive evidence based starting point for intergovernmental and international multistakeholder policy debates in CFS"*.

2.3 The diversity of livestock rearing

Livestock farming is a complex agricultural practice. Thus, there has evolved very different kinds and contextualized livestock rearing systems, depending on agro-ecological conditions, cultural and religious believes, the economical and political environment etc. The HLPE report acknowledges the diversity of practices and elaborates around this issue and discusses the need for a classification of livestock systems. Even though it sometimes might be difficult to see the precise boundaries between the different categories of farming systems,

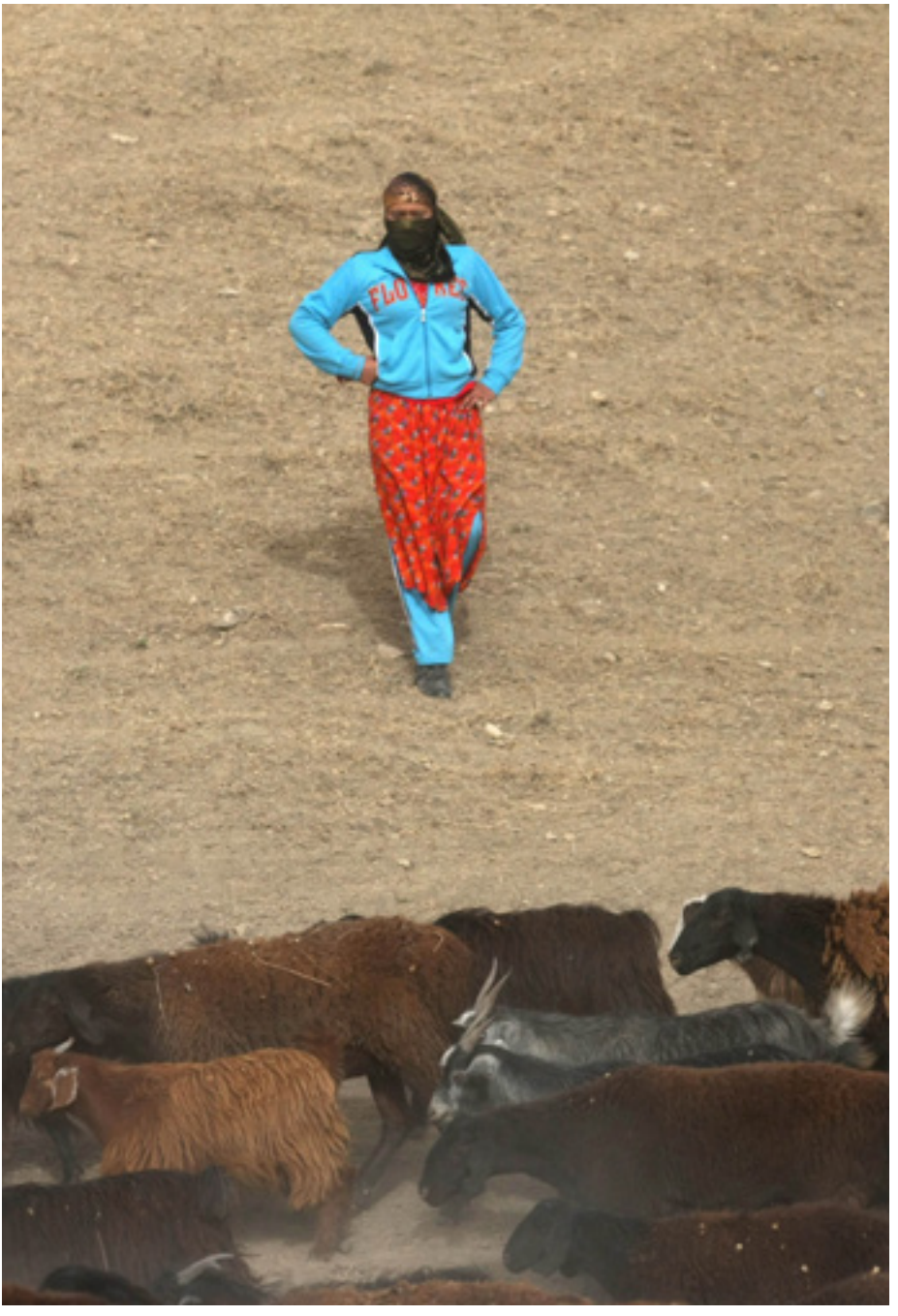
a classification is needed in order to be able to discuss livestock systems at the global level at all, but acknowledging that there are intermediates. Thus, the report discusses pros and cons with different classification schemes (FAO, 1996; Herrero et al., 2009; Robinson et al., 2011) and end up in the four main categories listed in Table 1. This makes it possible to have a reasonably structured and forwarding discussion about the sustainable development of the livestock sector. Some interesting figures presented in the report to be kept in mind that are of particular interest when discussing the social dimension of livestock keeping are that 45% of the pigs and 18% of the chickens in the world are kept in backyards, whereas 38 and 82% of them, respectively, are kept in industrial systems. Depending on species, 33-44% of the ruminants are kept in grazing systems only, whereas 56-64% of them are found in mixed systems. Three percent of the cattle are kept in feedlots.

Kenya. A livestock masai cattle market. ©FAO/Simon Maina

Livestock system	Livestock species	Geographical regions and land-use	FSN and economic role	Social features
Smallholder mixed farming systems	Mostly, pigs, poultry and dairy	Throughout the world, most concentration in Africa and Asia. Often mixed with crop production, rural, peri-urban and urban.	Produce more than 80% of the food consumed in SSA and Asia. Production on the local level, short market chains. Often low-input systems.	Family based. By large the most common type of farm in the world.
Pastoral systems	Cattle, sheep, goats, camels and camelids.*	Drylands in Africa and Asia and highlands in Asia and Latin America*.	Critical for FSN. Main economic activity in some of the world's poorest regions. Limited access to purchased inputs.	Mobile, common pool of resources, often weak land-rights. Family-based. Estimated to be 200 million pastoralists in the world.
Commercial grazing systems	Beef, dairy, and sheep	In high as well as low-income countries in all regions of the world. In grass-lands and pastures expan-ding into forests.	Major global food producer. Developed links to global value chains	Secured access to land and strong land rights. Hired labour.
Intensive livestock systems	Mainly pigs and poultry, but also feedlots for beef	Around urban conglomerates of East and South East Asia, Latin America or near feed- producing or –importing areas in Europe or North America. Landless.	Major food producer to high and middle income countries. Well integrated into input and output supply chains.	Hired labour.

Table 1. The typology of farming systems in the HLPE report. Note that reindeer herding – practiced in 9 countries in the world - is not included in the report.*

Clearly there are also links to plant-based systems, with an often high degree of complementarity, that must be taken into account when discussing sustainable development of agriculture as a whole. In the crop and feed – producing systems, with grain monocultures requiring intensive use of inputs, there is a link to the intensive livestock systems through trade, often global. In the plant-based smallholder systems, specialization into plant production is often a consequence of favorable agro ecological conditions or market access or demand. One link to livestock is for instance that one in peri-urban settings where livestock manure is needed for the cultivation of vegetables that are sold fresh to the city.



Tajikistan FAO Project: Improving food security in selected rural areas of Tajikistan through enhanced livestock production and pasture rehabilitation.
©FAO/Vasily Maximov

3. Current development of the global livestock sector

There is a set of changes in the world that last 50 years that has driven an increase in agricultural production including livestock. These changes have acted as drivers for a transformation of farming systems. The understanding of these changes and drivers and the trends they are generating is critical for being able to have an informed reasoning about sustainable development of the agricultural sector. The report gives a comprehensive and well-balanced picture of the trends and drivers of the current development of agriculture with emphasis on the livestock sector. Importantly, the HLPE report highlights the differences between regions, between high and low-income countries and between monogastric livestock species and ruminants. Globally aggregated data can be very misleading and cause confusion at its best and harm as its worst in policy or technical discussion. Particularly in too simplified reports in media.

3.1 Influence of demographic changes and economic growth

The report points out three main drivers for agricultural production over the last five decades. Most academics, policymaker and stakeholders agree that these three are the most important drivers for change in the agriculture sector in general and the livestock sector in particular:

- Population growth; from 3 billion in 1960 to 7.2 billion in 2015 (UNDESA, 2015)

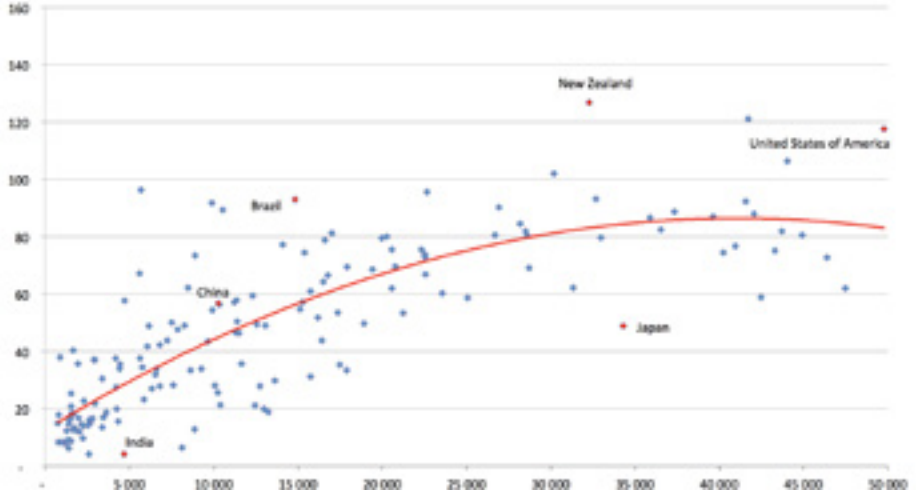
- Urbanization; in 1950, 30% of the world population lived in urban areas and in 2014, the corresponding figure was 54%

- Economic growth and increased incomes; from 1961 to 2010, the global GDP multiplied five times in constant 2005 USD and the proportion of people in the developing world living on less than USD 1.25 per day dropped from 47% in 1990, to 14% in 2015 (UN, 2015).

Most of the increase in population has been in low-income countries. The population growth in the world is projected to slow down. However, there are large regional differences and most of the increase will take place in Africa where, notably, the increase in agriculture production has been the slowest and where there is already a high degree of food insecurity.

The urbanization is projected to continue and by 2050, it is expected that 66% of the world's population live in urban areas. The rate of urbanization is supposed to be highest in Asia and Africa.

Obviously, the increasing world population is demanding more food and thus drives increased agriculture production. However, this increased demand will likely not be symmetric over all agricultural commodities. It is well established, from several parts of the world, that urban populations do have more varied diets including more fruits, vegetables and ASF in comparison to rural populations that rely more on staple food based diets. Interestingly, this opens for an urban agriculture sector. Worldwide, poultry is the species most commonly kept in urban areas, whereas pig-keeping is most common in South East Asia and keeping sheep and goats is most common in West Africa and the Middle East. Overall, most of the growth of the production of ASF in the recent years has been seen in the poultry and pig sectors and in East Asia. The demand for red meat (beef and sheep) has been shown a lower growth. Also, there is a strong positive relationship between increasing income (GDP per capita) and the meat consumption (Figure 1). However, note that the curve is flattening when the GDP per capita reaches about 35,000 USD per year. This slow growing or stagnating consumption in high-income countries has also been paralleled by the slower growth of production in these countries.



Source: Adapted from FAO (2009a). Based on data from FAOSTAT (FAO, 2015a) for per capita meat consumption and the World Bank for per capita GDP. Note: GDP per capita (horizontal axis) is measured at purchasing power parity (PPP) in constant 2011 US dollar. Per capita meat consumption (vertical axis) is measured by kg/capita/year.

Figure 1. The relationship between the per capita meat consumption and the GDP per capita (from the HLPE report). Sweden is just below the line with a GDP of 44 K USD and a per capita consumption of 82 kg. Source: Adapted from The State of Food and Agriculture 2009: Livestock in the balance (FAO, 2009). Based on data from FAOSTAT (FAO, 2015) for per capita meat consumption and the World Bank for per capita GDP.

There are also underlying health aspects to these drivers of changing consumption and consumption patterns. Currently, hunger (defined as too low intake of calories) is estimated to affect almost 800 million people and "hidden hunger" (micronutrient deficiency) is said to affect 2 billion people (FAOSTAT) – most of these affected people are living in low-income countries. At the same time, WHO estimates that 600 million adults in the world are obese (WHO, 2015a). Even though the latter is most common among people in high-income countries, it is an emerging health issue among some in low and middle-income countries as well.

All in all, these three drivers, population growth, urbanization and increased incomes are working together for a continuous increased demand of ASF - from 1961 to 2010 the global meat production quadrupled and milk production more than doubled, and there are few reasons to believe that this trend should change. However, there are though considerable regional differences as well as differences within and between countries. In the low-income countries where there is an increased consumption and demand for ASF, an increased consumption will contribute to reducing "hidden hunger" and lower the number of stunted children – currently 161 million in the world (WHO, 2015a). On the contrary, it seems to be good public health arguments for reducing the intake of ASF in several high-income countries.

3.2 Alterations in the agricultural markets

Over the last century there has been a steady decrease in food prices, albeit some 4 episodes of price spikes, the latest 2007-2008. The annual OECD–FAO Outlook assess that the commodity prices will continue to decrease in the short and medium long term (decades). The discussion in the HLPE report about prices, do very much refer to the latest edition of the OECD-FAO Outlook (OECD-FAO, 2015). Two sections in the report deal with price volatility and trade, respectively, in particular relation to FSN. Again, in order to participate in the discussion about sustainable agriculture development in an informed way, it is imperative to have insight in these alterations of the agricultural markets. The HLPE report gives a palatable introduction to the subject. In the following some particular interesting observations and thoughts related to low income-countries from the report are highlighted.

The recent price volatility for agriculture is lower in the recent years compared to the situation in the 70's. It is well established that price volatility relates to price levels and affects FSN. Interestingly, it is reported (Huchet-Bourdon, 2011) that beef and dairy show lower price volatility than staples as wheat and rice during a 50 years period. One way to explain this relative price-stability in some ASF is that livestock store calories when there is a lot of food

around and then return food (i.e. through slaughter) when crops fail. This is an important resilience-aspect of livestock, especially in pastoralist and smallholder systems. In low income countries with limited international trade, local factors that drives price volatility on foods are the most important, for instance weather and failure in domestic markets and policies. However, in countries with increased trade "imported volatility" has become more important.

The liberalization of agricultural markets and the ensuing increased international trade has had both positive and negative effects on FSN (FAO, 2015). The report states that "*The relationship between trade reform and food security has been a topic of long-standing debate among governments, stakeholders and in the academic literature…*" resulting in different strategies focusing on national self-sufficiency or reliance on free trade. It is challenging to come up with a firm, evidence-based, position in this matter.

The low and some middle income countries are currently net food importers and this has been steadily increasing the last decades. This increase is said to be driven by both bigger demand of particularly ASF in parts of Asia due to higher incomes and by a rising gap between larger demands from an increasing population in Africa and the Near East and a too slow rise in domestic food production. The OECD-FAO outlook states that still a very large proportion of AFS is produced and consumed locally but that international trade is increasing. The growing livestock production is also followed by an increasing importance of trade of coarse grain for feed. For instance, the imported of feed is essential for large parts of the livestock production in the EU and China.

The trade of livestock and livestock products are an area for national policies such as governmental subsides and import tariffs. This may of course have effects on FSN and agriculture performance domestically as well as on other countries' FSN and performance. Also, there are certain WTO standards for trade with animals or animal products (WTO, 1994; OIE, 2016) that are binding for WTO members and have significant influence for the possibility for low-income countries to export to international markets. In addition, there might also be private sector, e.g. from importing companies, standards that regulate this trade – these are often related to farm workers' working conditions, environmental and animal welfare aspects of the livestock production and ASF.

3.3 Transformation of the livestock systems

The HLPE report elaborates on three crucial aspects of the transformation of livestock systems:

- Over all structural transformation in agriculture
- Intensification and specialization of livestock farming systems
- Evolution of the crop-livestock link

The overall structural transformation in agriculture includes increased agricultural productivity combined with lowered share from agriculture in GDP and employment. This reduction in employment has in most regions of the world been associated with industrialization and a paralleled urbanization. This is not the case in SSA though, where there is urbanization without industrialization (Losh, 2014). Another, diverging, path is elaborated on in the HLPE, 2013: the per capita agricultural incomes are declining to other sectors of the economy at the same time as the proportion of the population working in the sector is increasing. The phenomena described here do of course generate severe social and economic challenges for many poor people in certain regions of the world.

When it comes to livestock production the increasing demand (FAO, 2012) in the world of ASF is of course a major driver for transition of the livestock systems. The increased livestock production is foreseen to rather come from an increased number of animals than from increased productivity, the latter though critical to take a larger share for the sake of natural resource use and environmental sustainability. It has been foreseen that the largest increase in the number of animals will happen in low-income countries (Thornton, 2010).

The land-use, not only directly for livestock but also for feed production and grain, is and will also be affected by the transformation of the livestock sector. As more the intensive livestock systems are increasing there will be a larger demand for feed. Already there has been a shift during the first decade of this century, where the 56 million more hectares have been used for feed typically used for intensive in intensive livestock systems and 57 million hectares permanent meadows and pastures, typically used in more extensive systems has disappeared (FAOSTAT).

Still, grass, mostly grown on non-arable land, including hill slopes, contributes to 48 % of the biomass eaten by livestock and grains contribute to 28%. Interestingly figures have been presented by Herrero and coworkers (Herrero et al., 2013), saying that in some low-income countries fibrous crop residues

may contribute to 50% of the feed in ruminants. Obviously this is a low-cost feed, but often with very low nutrient value.

Roughly, the increased production of ASF over the last 20 years has been achieved by a shift from mixed crop-livestock small-scale, subsistence systems to more intensive, specialized, large-scale and commercialized systems. Even so, also small-scale livestock keepers may intensify their production by several means: better management practices with respect to feed and animal health measures, using improved breeds. This may be exemplified by small holders in India, that increased their production by almost 50% in ten years, and still the average farm size is just on average 3.3 cows or buffalos.

So, there is a very critical question for the global livestock sector development: will the mixed livestock-crop systems in low income countries that contributes to the livelihood of estimated 2 billion people and a substantial part of the food security intensify within their systems or will the livestock systems in these countries specialized and industrialize in the same way as in many high income countries? Obviously, this will depend on economic drivers, policies and other factors as discussed in HLPE, 2013a.

Even if livestock can feed on a large variety of crops products, by products, residues, stovers etc., the trending specialized and industrialized systems have increased the demand for cereals. This has nourished an intensive debate about feed-food competition, some facts important in that debate is presented in the report:

- Ruminants can convert biomass on land non-suitable for crops to food for humans, but require larger land.
- Monogastric species (pigs and chicken), require feed from cropland, but their overall land-use is smaller.
- 34% of the world cereal production in 2010 was used for feed (mainly maize).
- The feed market is very international and specialized.
- In SSA and Asia more than 70% of plant food was in 2003 consumed by humans, whereas the corresponding proportion in OECD countries was 35%.
- It is estimated that livestock consume 45% of the global cropland products and occupy 80% of all agricultural land.

Also, there are crop-livestock links when it comes to draught power and manure as fertilizer. In the richer countries in the world the mechanization (introduction of tractors) of agriculture happened at scale after World War II, whereas this hasn't happened to the same extent in the low-income countries, for instance in SSA it is estimated that between 50 and 80% of cropland is cultivated by human power (FAO, 2013). At the end of last century it was estimated that 25% of cropland in SSA was cultivated by animal power and 35% in SE Asia. The use of draught animals is important – and sustainable – in small-scale mixed crop livestock systems as they don't need any significant external inputs, they may contribute with milk and off-springs and manure. The time-saving and productivity gains translate into improved livelihood and increased food security among these farmers. Still, the share of animal (and human) power in agriculture is expected to decrease globally, except in SSA.

Sixty, seventy years ago manure was almost the only fertilizer available in most countries. Fifty years later, in 2010 manure's share as plant nutrient was estimated to be 60% globally (Potter *et* al., 2010). Thus, manure is a major contributor to good cropland yields. Also, manure or dung, are used for producing biogas or used as fuel after drying in some countries, as well as construction material.

3.4 Projections and scenarios for the livestock sector development

Projections and scenarios for the future are of course of great value for trying to steer the development in a desired direction. However, the art of making solid prognoses is difficult. One of the most quoted and comprehensive ones is the *"World agriculture towards 2030/2050: the 2012 revision"* (FAO, 2012). These projections foresee a need for a 60% increase in agriculture production by 2050 – of course with considerable country and commodity differences. For instance the meat production is projected to increase by 76% in the same time period with most of the increase occurring in low-income countries. The FAO-projection includes population growth, income growth, urbanization and changing diets as drivers. Some questions have been raised about the magnitude of these drivers or additional factors that should be taken into account: UNDESA (2015) projects a larger population increase than the original FAO-projection, the effect of climate change on production was not that explicitly modeled in the projection; and the use of crops for biofuels might be greater than assumed.

There are also a set of other projections and scenarios that can be divided into three main types:

- Projections – often elaborating on the tension between "business as usual" and "what if" projections. One well known such projection is the *Agriculture at crossroads* (IAASTD, 2009) a multi-stakeholder initiative by the World Bank.

- Exploratory scenarios – designed to explore possible futures and emerging alternative issues. One example is the Swedish scientific report about the future of livestock, crops and land use for formulating research questions (Öborn et al., 2013).

- Normative scenarios – designed to develop narratives for specific targets. The French INRA/CIRAD scenario report *Agrimond* is such a one (Paillard et al., 2011)

The HLPE report comments briefly on the FAO-projections and some other projections and scenarios, and of course these are subject to debate within and between various stakeholders.

4. Challenges for livestock in sustainable agricultural development

The HLPE report lists a set of economic, social and environmental challenges that the sector is facing for a sustainable development. However, somewhat surprisingly, there is not a chapter about the opportunities for the livestock sector about how to contribute to a sustainable agricultural development FSN. Much of the data for such a chapter is already present in the report, embedded in the report's chapter 2 and 3. The omission of an "opportunity" chapter gives though the report a somewhat skewed view on the livestock sector.

Anyhow, the report presents firstly over-all global challenges and then specific challenges for the different livestock systems. Regarding the latter, the report put forward a "disclaimer" saying that challenges that are presented for one system are more visible or important there, but may be relevant in other systems as well. A summary of the key challenges listed in the report is presented in the following two sections.

4.1 Cross-cutting global challenges

An overview of these over-all challenges is presented in Table 2 below, and as shown in the table the report has grouped these challenges into five domains.

Overview of the cross-cutting global challenges for a sustainable development of the livestock sector presented in the HLPE report 2016

Environment	Economy	Social	Health	Animal welfare
Resource efficiency	Markets	Working conditions	Animal health	
Management of natural resources	Trade-related risks	Child labour	Human health	
Climate change	International trade integration	Gender inequalities	Antimicrobial resistance	Hired labour
Reduction of GHG	Small scale farm size	Ageing workforce		
	Low investment in R&D	Conflicts and protracted crises		
	Corporate concentration			

Table 2. Summary of the cross-cutting sustainability challenges for the livestock sector as identified in the HLPE report.

A woman milking a water buffalo. FAO Project: Reversing Environmental Degradation and Rural Poverty through Adaptation to Climate Change in Drought Stricken Areas in South India.
©FAO/Noah Seelam

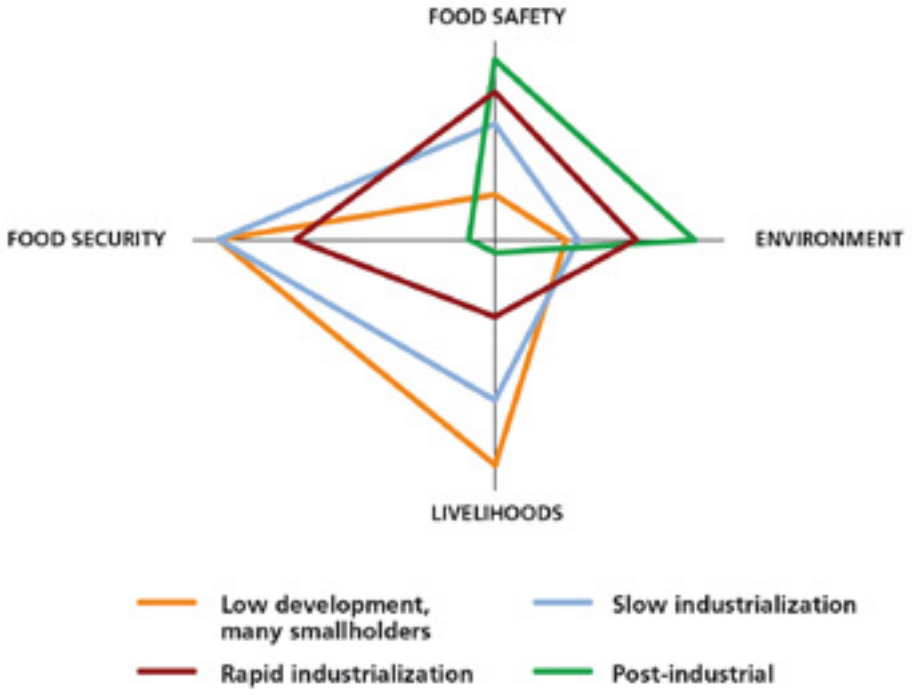


Figure 2. Diagram of different perspectives on livestock in different economies (from SOFA 2009, (FAO, 2009)

As described in the SOFA (FAO, 2009) (Fig 2), the perspective on livestock and connected opportunities or challenges vary between post-industrial, low-development (agricultural-based) or emerging economies. At large, the focus on the sustainability challenges for livestock in high-income countries like Northern and Western Europe are on the environment including reduction of GHG, animal welfare and health, whereas in low-income countries, the opportunities for economic and social contributions are more in focus. Still, all these crosscutting challenges are relevant for the livestock sector in almost all counties and on the aggregated global level. However, in the international discussion on priority settings it is important to be aware of and acknowledge the different perspectives pointed out above.

The environmental challenges presented in the report deals with the scarcity and efficiency in the management of natural resources, adaptation to or effect by climate change and the reduction of GHG. Some interesting – and less known to many stakeholders and the public – data about resource use efficiency of the livestock sector: 75% of livestock feed intake on the global level consist of products non-edible for humans (e.g. grass, leaves, crops

residues, swill) and grains represent only 12% of the livestock feed. It is also discussed how the current measures of carbon foot print for ASF don't take the quality aspect – protein and micronutrient content – into account, just weight. However, when it comes to production of calories, crops are more efficient than livestock with respect to use of land, water and carbon foot-print – looking into proteins and micronutrients the comparison is more balanced. Currently, the global estimates of GHG emissions from the livestock sector are 14.5% of all anthropogenic emissions. There are large differences between livestock species and farming systems, in general higher productivity gives a lower emission per produced product. Thus intensive systems do in general produce less GHG per kilo product than extensive systems. Moreover, the production of dairy products, egg and pork and poultry is more emission efficient than production of meat from ruminants. Improved efficiency or productivity, in order to better use of natural resources such as land and water and mitigate land degradation and biodiversity as well as reducing the GHG emissions per kilo ASF, may be achieved by improved animal health, better feeding regimes and suitable genetics of animals. The effects of climate change, such as altered access to water and feed, extreme weather events and spread of diseases and pest, are subject to many projections or forecasts with some times different outcomes. For most low-income countries, there seems though to be a net negative effect on the production of AFS, thus having a detrimental effect on FSN. The challenges will though vary between countries and regions and between livestock systems. Overall, the section "Environmental challenges" in the report present many options or opportunities for a sustainable development of the livestock sector for increased FSN.

The economic challenges pointed out relate to markets, trade, low investment in R&D, ant the corporate concentration in the sector and the small-scale farm size. When discussing markets it is both the access (or lack of access) to markets and the functionality of markets for livestock and livestock products that are critical for FSN. Three general aspects that contribute to poorly functional markets are discussed: i) information gaps and/or poor connection to supply chains ii) negative environmental and social externalities are not properly priced (or not priced at all) iii) government enforce badly constructed sub-sidies, taxes and trade policies. The trade-related challenges comprise unfair competition from subsidized import, differences in national production standards for use of antimicrobials, animal welfare and environmental impact, spread of disease via livestock or livestock products and the ever-ongoing political/economic discussion on the pros and cons for FSN in relation to international trade integration. There is also a discussion about the fact that the average size of small-scale farms has decreased in most low- and middle-income countries. At the same time there is a corporate

concentration in the livestock sector putting individual farmers in a difficult bargaining situation – this could however be rebalanced by farmer cooperatives. Finally, the report does stress again – as many other stakeholders – the overall investment in R&D for technologies and their adaptation for small-holders farmers remain inadequate (see also WDR, 2008).

The ***social challenges*** presented as crosscutting challenges are about working conditions including child labour, gender inequalities, an aging work force and conflicts and protracted crises. The social effects of the structural transformation of the agricultural and livestock sector going on in most parts of the world and in most systems are dealt with in the sections on system-specific challenges (see next chapter here, 4.2). However, it is somewhat surprising that this chal-
lenge (the social effect of the structural transformation) is not highlighted as a crosscutting challenge, given its generic nature and paramount impact on people's life.

The description of the ***health challenges*** very appropriately embrace the One world – One health concept and deals both with human health and with animal health and there is also a minor subsection on AMR – an issue that is gaining more and more attention internationally. Animal diseases that reduce productivity are a direct threat to FSN and/or livelihood. The cost for animal diseases may be immense and is a major reason for the low productivity in low-income countries. It is not only the large well-known contagious diseases that contribute to the low productivity, but also poor animal health in general caused by endemic or chronic diseases. Besides threatened FSN by the lower production and productivity, infectious animal diseases that are so-called zoonoses may pose a direct threat to human health. The risk for transmission of zoonotic agents (parasites, bacteria and virus) to humans is larger when people and animal live in close proximity, as is often the case in low-income countries. There is also reports that over-consumption of certain animal source foods may be a risk for human health.

Finally ***animal welfare*** is put forward as a crosscutting challenge for the global livestock sector. There are very divergent perspectives on animal welfare between countries and cultures. Balancing increased production and welfare in the emerging, and sometimes unregulated, intensive livestock systems around the world is thus a true challenge for the sector. Even so, in several high-income countries retailers and consumers do increasingly demand livestock-raising that is animal-friendly.

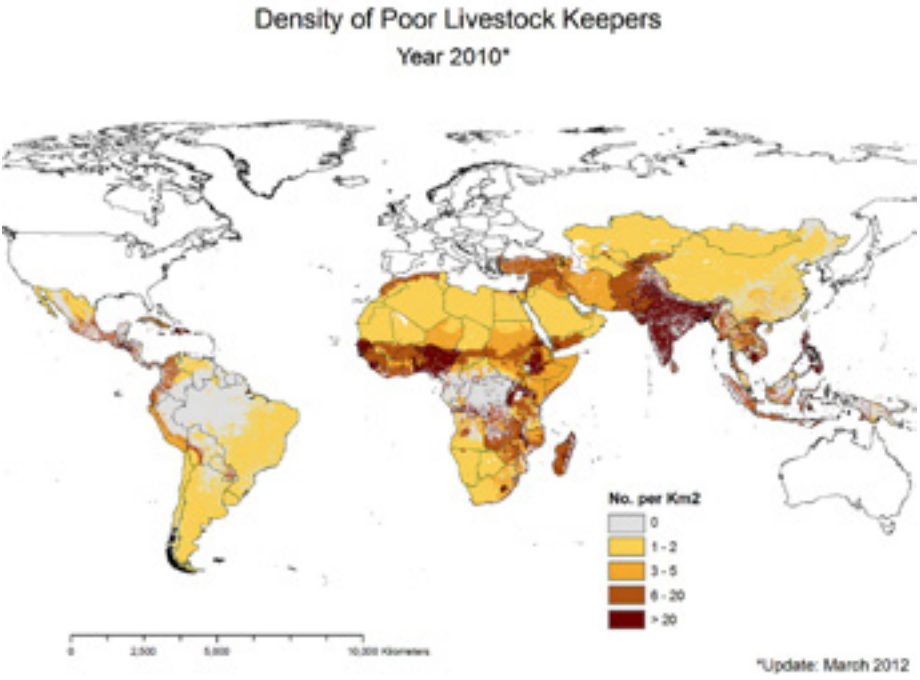


Figure 3. Map showing the distribution by density of poor (income less than 2 USD/day) livestock keepers in the world (FAO/ILRI, 2011).

4.2 Key challenges in the different livestock systems

Obviously the weight or importance of the different challenges varies between the four categories of livestock systems. In the report, the sections about challenges in the pastoralist and intensive systems are more extensive than the sections for the smallholder mixed system and the commercial grazing systems.

In the ***pastoralists system***, the key issues discussed are conflicts for land and water, as pastoralist systems need widespread land and water resources to be efficient. Another challenge is economic and policy discrimination related to market distortions due to cheap imports of meat, to emergency assistance where there is a poor understanding of the pastoralists need for early warning systems and to land competition for instance with larger infrastructure development. A third challenge is the social and gender inequity, as pastoralist societies often have a working and entitlement division that mostly favors men, also is child labor very common in these societies. Health is also an issue in pastoralist system – both animal and human health as is education underpinning most development . Pastoralist systems have the highest mortality of

livestock and the animals are very exposed and vulnerable to extreme weather events. Zoonotic diseases in humans are always a present risk in these systems as pastoralist often have a close contact with their animals and often have poor access to medical care.

The ***intensive systems*** have often not taken the negative environmental and social externalities into account, which has sometimes led consumption as well as production into unsustainability. Concentration of intensive livestock production around urban areas may for instance lead to pollution – sometimes very severe - of water around the farms, but also air and soil may be affected. The concentration of animal feeding is also mentioned in the report as a point source of pollution. Importantly, it is assumed that most of the future increase in arable land will be used for livestock crops and large proportions of native grassland have been converted to cropland in certain parts of the world. There is also an obvious risk and challenge in loosing genetic diversity among the livestock in the intensive systems. The emergence of AMR is correctly highlighted as the most prominent negative health impact from the intensive systems. It is estimated that most of the antibiotics used in the world are used in the livestock sector. Unfortunately, antibiotics are used as growth promoters and in other non-rational ways in the sector, which contributes to the emergence of AMR.

Further on, the intensification of livestock system may lead to rural abandonment and thus, sometimes, ruin the social benefits of agriculture. The working conditions for the farmers and others that have become workers in these intensive systems are often unsatisfactory. These workers have in many settings a low social and political status and the wages for many of the 500 million women and men employed as agricultural workers are relatively low. There is also a large proportion of migrant labour in the intensive livestock farming systems in low-, middle- as well as high-income countries and this labour is well known to be associated with poor working conditions. Working in the livestock sector poses a relatively high risk to be exposed to occupational hazards such as traumatic injuries and infections. This is also true for all kind of countries. The market concentration among the intensive systems, where larger farms tend to survive and smaller farms cannot compete, makes it – among other negative effects – difficult to generate decent incomes, employment and livelihood for many farmers and depopulation of rural areas. Another, perhaps more complex, economic challenge is the distorted price signal. In short may such signals not contribute to optimizing production and investment, ultimately challenging FSN. In the food supply chain do often processors and retailers have more economic power than the producers (farmers), which may generate vicious circles of competition among farmers. Related to this, there is also a concern that there is an inequitable distribution of value added, where large players in the agri-food business are winners and

livestock suppliers and consumers are losers. This unfair situation is again a phenomenon seen in all kinds of countries. Finally, the intensive systems are highly dependent on external inputs like feed and energy. Price volatility of these two products may of course reduce profitability and challenge sound investments for development of these farms.

In the ***small-holder mixed farming systems***, the challenges discussed are lack of tenure and access to land and water which is a major disincentive for these farmers to invest in their farms for development and is of course also a source of conflict. Another major challenge is the poor access to markets for most small-holders, this of course hamper development of their production and at larger scale the exclusion from higher value markets (such as international markets) due to retail chains' standards and as well as international/govern-mental standard requirement. Thus, these farmers do engage only little in commercial-activity, which contributes to lack of capacity to increase produc-tivity. There are well known and large yield gaps in livestock production, especially SSA is lagging behind (e.g. the milk yield is just 6% of that in high income countries). Smallholders are also exposed climatic events, animal and plant diseases or pest as well as price volatility. The HLPE report interestingly stress that modernizing production may actually increase vulnerability by the reliance on external inputs.

In the ***commercial grazing systems***, key issues discussed are the degradation of natural grassland as an effect of turning these grasslands into cropland and overgrazing. Moreover, the conflict over land and forests between large companies and ranchers is an always-present conflict with substantial social implications. In some countries in Latin America and southern Africa, farmers have become workers with poor working conditions and lost security. Finally, technical inefficiencies in the livestock production in these systems in tropical areas are hampering productivity.

A structured presentation of the sustainability challenges for the four livestock systems is presented in table 3, extracted from the report.

Table 3. Copied from the HLPE report: priority sustainability challenges for the four livestock systems.

Table 1 Priority challenges to attain SAD for FSN in different livestock systems

System	Scale and geography	Key health and One-Health challenges	Key social challenges	Key environmental challenges	Key economic challenges
Smallholder mixed farming	Around 600 million persons mainly in south and south east Asia, and Africa Around 30 million small farmers in developed countries	Endemic animal diseases Zoonotic diseases Food-borne diseases Contribution to NCD	***Farm fragmentation*** ***Lack of rights, entitlements, tenure*** Ageing workforce and exodus of young people Rural abandonment	Climate change; ***Land degradation;*** Loss of biodiversity	***Low economies of scale*** ***Exclusion from high-value markets and service*** ***Low productivity and high yield gaps***
Pastoral	Nearly 200 million pastoralists	Endemic animal diseases Zoonotic diseases	***Marginalization: lack of rights, entitlements, tenure*** ***Conflict over land and water*** ***Inequitable norms & institutions***	***Climate Change*** ***Extreme events (droughts, floods)*** ***Water scarcity***	***Lack of access to markets and services*** Low productivity
Commercial grazing	Hundreds of thousands of farmers in Latin America, parts of United States of America, Australia, and southern Africa	Emerging diseases Contribution to NCD	***Displacement of indigenous peoples and local communities*** ***Vulnerable groups*** ***Poor work conditions*** ***Rural abandonment***	***Deforestation;*** ***Contribution to climate change*** ***Land conversion***	Exposure to world price volatility International market access Low economies of scale
Intensive	Around 2 million intensive dairy farmers in United States of America, Brazil, Europe, New Zealand Several million intensive pig, poultry and beef/sheep feedlot farms, mainly in BRICs and high-income countries	***Emerging diseases*** ***Foodborne diseases*** ***Contribution to antimicrobial resistance and NCD***	***Poor work conditions*** ***Poor animal welfare***	***Air, land, water pollution*** High water use ***Contribution to climate change***	Exposure to world price volatility ***Price squeeze from input suppliers, processors and retailers***

Bold italics indicates highest priority; NCD = Non Communicable Diseases; BRIC = Brazil, Russian Federation, India, China

Tanzania. A man herding his cattle.
©FAO/Simon Maina

5. The way forward for a sustainable livestock sector

Given the facts and elaborations in the preceding sections, what does the way forward towards a livestock sector that contributes to sustainable agriculture development that provides FSN for all look like?

This is of course not any easy question. In the HLPE report the approach taken is structured in a tiered way: firstly, looking at operational principles for pathways, secondly looking at enabling environment and thirdly looking at farm practices in the different farming systems. This may be a sensible way to move forward on the global level. Interestingly, when the HLPE report discusses solution-oriented pathways towards sustainable development of the sector, one doesn't use the classical three dimensions of sustainability - economic, social and environmental. Instead the report is structured around "resource use efficiency, resilience and social equity/responsibility", recognizing that the same area of action may appear within several of these three domains (Figure 4). One may acknowledge the rational for this approach, however it adds a new typology to the discourse on sustainable agriculture that may confuse some readers.

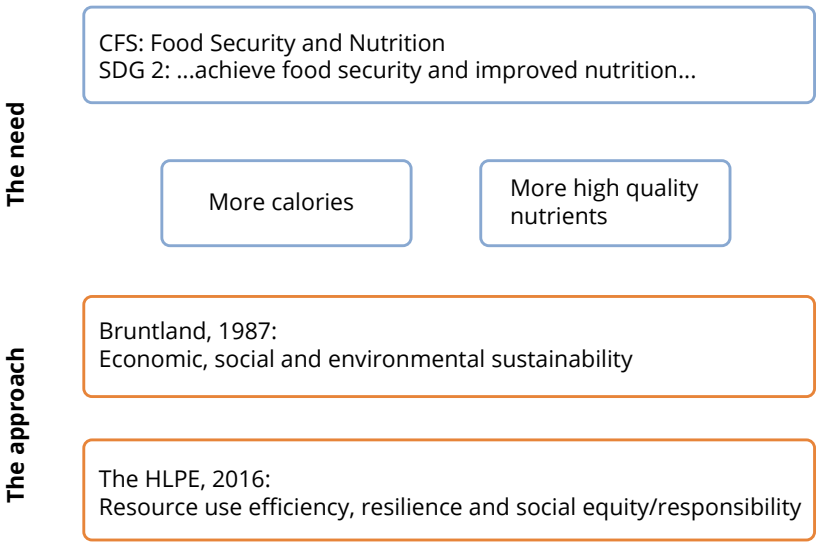


Figure 4. Sketch over the various terminologies used for the needs and approaches discussed in this review.

5.1 Politics, policies and opinions

The development towards a more sustainable livestock sector depends on several political and policy factors, some of them outside the livestock sector, or the entire agricultural sector. Many of these factors do influence trade and markets or are influenced by national or international economies. Their interactivity or mutuality makes policies moving targets that are hard to judge in a non-biased way. Taking decisions or standpoints in that ambience is often referred to as "politics", which is beyond the scope of this review.

When discussing the conditions for policies, locally, nationally or internationally one must be aware of at least two areas of considerable difference in positions or perspectives. They are simplistically described below.

The first is ideological, where "food sovereignty" is found in one end of the debate, focusing on the "right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems" (Nyéléni Declaration, 2007). This narrative argues for local, responsible and fair production and consumption of food. In the other end the "market-oriented" perspective is found, focusing on economic growth and income generation and open and deregulated markets to ensure FSN. This narrative has over time also – to various extent – developed ways to account for environmental impacts from agriculture. To judge on political issues without reasonably firm scientific evidence is as said above beyond the scope of this review. Where between the two "extremes" described above the optimal global FSN is to be found depend on the power-balance in the world, whether there are few (or no) conflicts between states, reasonably fair trade conditions etc. There is however, an association with the globally lowered food prices, reduced hunger and increased global free trade over the last decades. But there are also several concurrent factors that are changing.

A second tension is around the use of new technologies in food production and along food value chains (not particularly around ASF, but food in general) that influence the development of agricultural production and FSN for all. However, in this case it is easy and appealing to adhere to the wise reasoning in the HLPE 2016 report about this tension:

"Risk perception is complex and driven only partly by factual evidence. Food technologies often involve "fear factors" that make them seem more worrisome than other much greater risks – for example, travelling by car (Slovic, 2010). The factors include distrust of large companies, dislike of "unnatural" processes and uncertainty over unfamiliar dangers. The tension between consumer and expert opinions and between food access, quality and preferred production methods are also areas where risk assessment and impact evaluation can help to inform the debate on sustainable agriculture. (Expert opinion is generally the result of scientific consensus that, although the best guide for evidence-based advice, is liable to revision as the result of new research. For some issues (e.g. vaccination) there is no scientific justification for the public concern over safety. For other important issues, including chemicals and GM foods, a minority of the science community shares the concerns over safety commonly held by non-experts. In this report, we have followed the prevailing scientific consensus, while recognizing that this can evolve in line with newer evidence)."

One peculiarity in this context is the various kinds of certification or branding of foods, including ASF, and the production characteristics of these foods. Such certification or branding do often add an extra market value to the food, but there are substantial controversies whether some of these certifications contribute to a globally sustainable FSN or agricultural production. It is therefore reassuring that the work of FAO, the CGIAR system and others (Petersen and Snapp, 2015) has embraced the idea of "sustainable intensification" and that it is present in the EU agriculture policy Reform (EC, 2015). "Sustainable intensification" is a scientifically dynamic and open approach, without dogmatic blinkers, aiming to increase productivity and improve environmental management.

All in all, it's an immense challenge to make all stakeholders move in the same direction. One such attempt is, however, the Global Agenda for Sustainable Livestock (GASL, 2016), gathering members from intergovernmental organizations, CSOs, NGOs, governments, industry and academia. The GASL may be regarded as a consensus-based forum for creating an agenda for a sustainable livestock sector.

5.2 Actions and pathways

The following presents briefly a set of actions or pathways critical to achieve a sustainable livestock sector aiming to FSN for all. As mentioned before, these actions must often be tailored to the context where they are meant to take place – country, agro-ecological zone or farming system – in order to be effective. The presentations below are thus mostly generic with the option for context-specific adjustments.

Good governance is crucial for the realization of a sustainable livestock sector. Regardless the complexity in judge which policy or political direction for achieving FSN for all is the best as elaborated about above; there are some generic aspects of governance that are important. Food security and nutrition for all is the fruit of collective efforts of many stakeholders, thus must governance in this field be inclusive and enable all stakeholders engagement. Another governance aspect is the need for investment in R&D in agriculture in general. Currently, the private sector is in the lead of agriculture R&D globally (FAO, 2012). Since patents protect most of the private R&D, the dissemination of these innovations and new technologies is challenged. This in turn may exclude resource week smallholders from taking part in technical development; obviously this may apply to the livestock sector as well. Thus, the issue of (non -) public goods is a task for global governance. Another governance issue is how to internalize externalities in the livestock sector – i.e. the polluter/user pays principle. This includes pollution charges, remuneration for various kinds of ecosystem services, land and water use that don't have a realistic pricing. However, the attempts to establish these kinds of payments are based on an assumed private ownership and rarely take into account communal ownership, as seen for instance in pastoralist systems.

Improved market access for small holders and pastoralists, is a mean pushed for by most stakeholders (eg. WDR, 2008) for increased productivity, production and incomes leading to improved FSN for all. Access to international markets – or trade – has also been found to reduce poverty and improve food security (Andersson et al., 2011; FAO/OECD, 2014). However, when it comes to livestock products from low-income countries, these may not enter the high-end OECDmarkets or other international markets, as several of theses countries are not proven free from certain contagious animal diseases (WTO 1994; OIE 2016). Another word of caution is the reported mixed outcomes of trade liberalization as reviewed by McCorriston and coworkers 2013 (McCorriston et al., 2013). Again, as elaborated in the previous chapter (5.1), the picture is somewhat complex.

Diversification of livestock production is found both at the farm-level and among farm-systems. As shown in the introduction of this review, there is a range of different animal farming systems. In some parts of the world, mostly in high–income countries, there has been a movement away from the diverse mixed livestock-crop systems driven primarily by economics. These systems are highly efficient, but may be vulnerable to price volatilities and environmental degradation. In general the mixed livestock –crop systems, where we find the majority of smallholders globally, are far more robust and resilient to various external shocks, however often with a lower productivity. This is

simplistically sketched in figure 5. This reasoning may also hold true on a national level and there might also be a time dimension in this contrasting – the mixed systems may be more sustainable over time. Notably, more diverse production systems help to protect biodiversity, both in the ambient environment and among the livestock species reared.

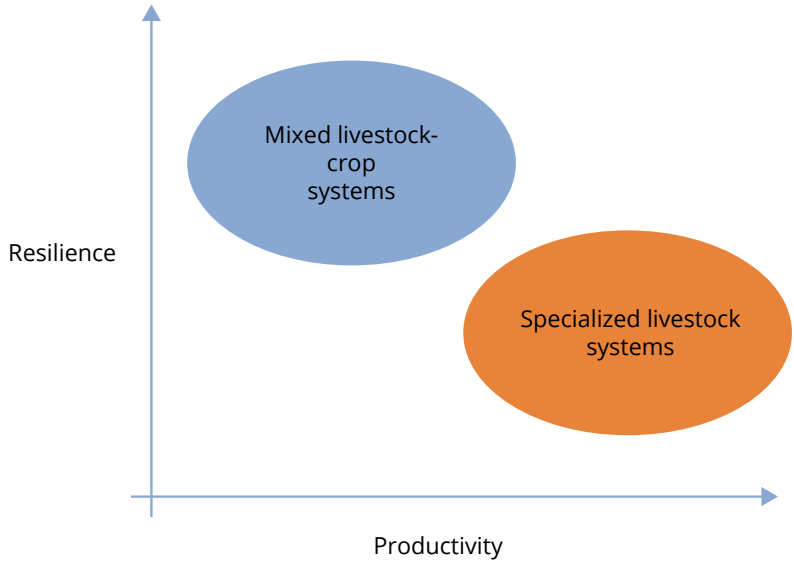


Figure 5. Conceptual sketch positioning mixed crop-livestock systems and specialized livestock systems along the resilience and productivity axes. Where along these two axes the most social, economic and environmentally sustainable livestock production should take place is to large extent a matter of context.

Improved resource use efficiency in the livestock sector is an approach that target environmental sustainability (including GHG-emissions) and often goes hand in hand with economic sustainability and if handled wisely that also may support social sustainability. One over-arching challenge is of course the cost of the investments needed for this improvement that must be taken into account for getting especially resource-weak farmers on board. However, the various external inputs needed range widely in cost and there are low-cost options. Moreover, when discussing applications of techniques to improve resource use efficiency, it is not fruitful to contrast "traditional" with "modern" techniques, it is rather how functional or efficient the technique is – based on evidence. Yield gap analysis is a useful approach to improve resource use efficiency (reviewed by Sumberg, 2012). In this approach the principle is to narrow the gap between the best and poorest performers in a

region by transferring (and adopting) existing practices and technologies as well as introducing new technologies. For instance, Gerber et al, 2013, calculate that GHG emissions in the livestock sector could be reduced by between 18 and 30% in a given systems if all producers adopt the practices used by the producers with the lowest emissions intensity in the same system. In the three following bullet-points, three areas (animal health, feed and pastures, animal genetics) are presented where the yield-gap approach can be applied to improve resource use efficiency.

Improving animal health will contribute to a sustainable livestock sector and FSN by increased productivity, lowered environmental footprint and GHG-emission per unit ASF produced. The approach for improvement is to strengthen animal health services at all levels with a focus on prevention, rather than cure diseases. This approach also includes animal management on the farm at low costs such as better reproductive management and introduction of biosecurity procedures. The preventive means for improved animal health will also reduce the risk for the occurrence of zoonoses (with their potential risk for transmission to humans) and the use of antimicrobials and thus the emergence of AMR (see further section 6.3).

Feed in livestock systems is often the input that is most of costly for the producer. Approaches to reduce the environmental impact from feed production – and hopefully also to a lower price – are to improve the efforts to convert waste and crop residues and other by-products into nutritious livestock feed and use plant breeding technologies to develop drought-tolerant, pest resistant and fast growing feeds. Also, for grassland systems there are options for narrowing the yield gap by better land management aiming to reduce over-grazing and soil degradation.

Animal genetics has historically been used for improving productivity. Nowadays breeding schemes may take other aspects important for livestock sustainability into account like disease-resistance, heat-stress endurance, reproductive performance and longevity. Still there are tragic examples where very high producing cattle breeds have been put in climate, disease and feed environments they cannot cope with, resulting in very low yields. However, one may look forward to a substantial contribution to the efforts in closing the yield gap from a genetic approach, taking a multitude of the animal's features into account.

Manure management is an area with a considerable potential for improvement globally. There are several approaches for better use of manure. There are two main paths where better manure management may contribute to a more sustainable livestock sector. One is the very handling of manure (when concentrated in large amounts), there are procedures in place that reduce the GHG emissions and even make use of the manure as a source of biogas. Another is using manure as plant fertilizer. This is of course well known historically, and is the only fertilizer in many low-income country settings. However, in some regions of the world, mostly around large-scale intensive livestock operation, the manure is wasted and causing severe nutrient pollution. Thus, there are options for improved manure management where its high nutrient value is used for plants instead of causing an environmental problem.

Protecting animal welfare. Even though the health of animals (freedom from disease is a central component in good animal welfare) may be equally good or better in the intensive livestock systems then in some extensive, more "primitive", systems", there are justified concerns among the public and various stake-holders about animal welfare issues in these intensive systems – sometimes called "industrial systems" in this context. Notably, there is also an ongoing discussion about productivity benefits from improved animal welfare (Mellor and Webster, 2014). Thus, "animal welfare" should not stand alone in the discussion about sustainable livestock systems, rather be strongly integrated.

Social and Gender equity and responsibility are both aspects of life that are prioritized quite different in different cultures and countries. Possible the most context-specific of all the aspects of sustainability discussed in this review, still one of the most important. However, too often is the social dimension neglected in the sustainability debate. The social responsibility becomes even more important when there are structural changes around, as in the case of the development of the livestock sector; in intensive large-scale farms there will be more workers with sometimes very hazardous working conditions. In the regions where farm-size will increase, small-scale farms will not be competitive and likely close down. To compare, in Sweden the number of dairy farms has diminished by more than 90% during the last 40 years from 56 492 to 4 161 (SJV, 2015). In addition, today is child labor very much present in small-scale and pastoralist farming systems and there are ongoing conflicts over land-use in several regions of the world. As agriculture in many countries is historically unregulated, enforcement of socially responsible regulations might be a challenge (Gerber et al., 2013). Still, the social equity and response must be assessed

and safeguarded when putting forward means or interventions contributing to a sustainable livestock sector. The ILO manual about improving agricultural work is one step in the right direction (ILO, 2014). Applying a gendered perspective on the livestock sector may have several positive development effects related to FSN: empowerment of women and investment in women's education has been shown to rapidly improve diets and nutrition within the household (Smith and Haddad, 2015). Also, in several cultures women in small-holder systems are responsible for the daily management of dairy, egg production and poultry meat – products that are consumed in the household or sold off for revenues managed by the women. Interventions to increase the productivity for these ASF should thus involve women in order to be optimal. Overall, a gendered perspective should thus be mainstreamed in the actions towards a sustainable livestock sector both for the sake of equity and for efficiency.

Adaptation to climate change is a significant upcoming challenge for the entire agricultural sector and thus threatening production sustainability and FSN as a whole. A risk-mitigating strategy for crop failures are to move into mixed crop-livestock systems. Within the livestock sector, adaptation includes selection and use of breeds that can endure the new conditions following climate change, altered and adapted housing systems, surveillance and preparedness for emerging diseases and exploration and use of new feeds and feeding strategies (ICEM, 2013; FAO, 2016).

5.3 Conclusions

The livestock sector is a major contributor to the livelihood of the world's poor and is the fastest growing sector within agricultural production globally and is projected to continue to grow. However, the ASF consumption and production differs very much between countries as well as within countries. This in turn mean that the challenges as well as the solutions for a sustainable livestock sector contributing to FSN may be very different among countries or farming systems. This must be considered when aiming for fair global solutions.

Below is a schematic table indicating where actions and pathways towards a sustainable livestock sector relate to the SDGs (Table 4).

SDG	Main links towards a sustainable development of the livestock sector for improved FSN
	– Livestock is a significant contributor to the livelihood of many of world's poor – Improved productivity and access to markets increases incomes
	– Livestock converts non-edible feed to human food – ASF are rich in high-value protein
	– ASF provides essential micronutrients, especially to children and women, reducing stunting among children – Good animal health reduces the emergence of zoonoses and AMR
	–The majority of poor livestock keepers are women but with poor access to resources. The sector may serve as a leverage to empower women and increase their income and improve FSN
	– The pollution by nitrates and microbes is locally substantial – The livestock sector is a large user of water – Both these aspects may be improved
	– The high risks of occupational hazards and large amount of child labour may be reduced – Contributes to 40% of the global Agricultural GDP and is fast growing
	– Provides an opportunity to market participation and increased political influence for rural poor
	– Rebalance and reduce global differences in consumption of ASF for the sake of FSN, health and environmental sustainability

13 CLIMATE ACTION	– Livestock keepers are among the most vulnerable to climate change – GHG-emissions from the sector is substantial but with a large potential to be mitigated
15 LIFE ON LAND	– The majority of the terrestrial surface of the planet is used for livestock – Livestock may contribute booth to loss of biodiversity as well as preservation of biodiversity
16 PEACE, JUSTICE AND STRONG INSTITUTIONS	– Conflicts over land and land-use (crops, forests, grazing) are a challenge for the sector, especially for pastoralists.
17 PARTNERSHIPS FOR THE GOALS	– Multi-stakeholder solutions and partnerships are imperative for developing a economic, social and environmentally sustainable livestock sector that delivers FSN.

Table 4. Indications of the main links between the UN Sustainable Development Goals (SDGs) and the paths toward a sustainable livestock sector.

Kenya. Community based irrigation. Women and children carrying sacks of rice fodder or livestock feed. ©FAO/Thomas Hug

In summary, this chapter shows that there are several potential approaches or pathways to achieve FSN from a sustainable livestock sector – several with proven solutions. The challenges are though mostly multi-faceted and the solutions may therefor diverge, e.g. paths toward social sustainability may point in another direction than paths toward environmental sustainability. Also, it must be acknowledged that these paths are often context specific (by country or farming system), even if the challenges are similar. Still, sharing best practices allows testing and adopting these in other places to progressively move towards increased sustainability. The bottom line is though that the paths chosen are science- and evidence-based and not based on ideologies or beliefs[1].

Sri Lanka: A GPS device is used by veterinarians to track and document locations of cattle herds tested for rinderpest. ©FAO/Ishara Kodikara

[1] One of the most prominent examples of the detrimental effects of ideologically driven agricultural development is that of the soviet plant geneticist Dr. Lysenko during the Stalin-era.

6. Swedish contributions to a sustainable development of the livestock sector

The pathway to a sustainable livestock sector for FSN doesn't only relate to our common SDGs, it also relates strongly to the core principles of the Swedish development policy:

- Human rights and democracy: The human right aspect is always present in structural changes. The effects on human rights by the structural changes needed for development of a livestock sector that is socially, economically and environmentally sustainable cannot be overestimated, prominently for workers' conditions and child labour. There are also several land-use issues or conflicts between urbanization, cropping, forestry and livestock around the world with strong bearing on human rights.

- Gender equity: Women are very much present in the livestock rearing in most low-income countries and are crucial for the FSN at the household-level. However, they often don't have the same access to various kinds of resources for rearing animals nor to the benefits from rearing livestock as men have. Adopting gender-sensitive approaches for livestock development will thus significantly increase the FSN from livestock sector as well as being a powerful way to empower rural women and improve gender–equity.

- Environment and climate: The livestock sector may be locally detrimental to the environment as well as being a significant source to GHG-emissions globally. However, due to the inefficient use of natural resources and low productivity in several regions of the world, there is a huge potential to reduce the environmental impact and mitigate GHG-emissions. At the same time, poor livestock keepers in low-income countries are regarded as the most vulnerable group to climate change.

In the following three specific areas are discussed where Sweden has a strong comparative advantage internationally and where the above-mentioned core principles should be taken into account. In these three areas can Sweden make a substantial contribution to the development towards a sustainable livestock sector for FSN.

6.1 Public-Private Partnership in the livestock sector

For at least hundred years there has been strong interaction and cooperation between the public and private actors on the livestock arena in Sweden The cooperation has been tight between farmer's organizations, governmental agencies and academia. Important factors enabling this cooperation are likely the well-organized farmers that organized themselves into cooperatives for dairy, slaughter, breeding and animal health services and thus became a body that had a common voice in discussions and negotiations with a well-developed and present public sector. Historically there have also been political goals for self-sufficiency of foods as preparedness for international conflicts with potential disruption of food imports. One may say though that the abandoning of the self- sufficiency goal for food in the early 1990's, joining the European Union in the mid 1990's and an altered domestic political landscape towards a more market-oriented economy have to some extent challenge this Public–Private Partnership. For instance, in a recent official governmental report, the question was raised on how much responsibility the public sector should have for controlling and fighting animal diseases that are not zoonotic (i.e. only affecting the productivity of livestock) (SOU, 2010).

Positive outcomes from this partnership are the successful eradications of bovine tuberculosis and brucellosis in Swedish livestock, both in the late 1950's. These diseases are still present in several other high-income countries. Other more recent examples of successes for this public-private partnership where other high-income countries have failed, are the eradication of the highly contagious swine disease PRRS in 2007 (Carlsson et al. 2009) and Aujeszky's disease in 1996 (Robertsson & Wierup M, 2000).

The flagship for this partnership is the internationally leading Swedish position in livestock rearing with low use of antimicrobials and the exceptional low AMR in the sector (see section 6.3 below).

Similar examples are found within the realms of animal breeding and artificial insemination where farmer's organizations and governmental bodies have together set up standards and regulations for these activities with advice and support from academia. One interesting outcome is the breeding of the Swedish Red and White dairy breed, for which health and reproduction traits have been included in the breeding goals complementary to conventional production traits. This has resulted in a breed that now is very much asked for internationally due to its good fertility and robustness in comparison to other breeds on the international market with declining fertility and longevity.

Another recent example of multi-stakeholder engagement is a Swedish long-term action plan for sustainable management of animal genetic resources (SJV, 2009), involving NGOs farmers' organizations, private enterprises, academia and government.

In modern development cooperation, public private partnership is often suggested as a mean for achieving successful action. Also in the livestock sector multi-stakeholder initiatives are suggested as the way forward towards a sustainable sector. Obviously such arrangements must take cultural and historical aspects into account to be prosperous. Still, the successful Swedish public-private partnership within the livestock sector over the years may provide inspiration and example of options for others who want to strengthen such partnerships.

6.2 Animal welfare

According to the NGO World Animal Protection that classifies 50 countries worldwide according to the countries commitments to protect animals and improve animal welfare in policy and legislation, Sweden is top-rated regarding efforts for good welfare for livestock, their transportation and slaughter (WAP, 2014). In an academic analysis of animal welfare in eight EU countries, Keeling and coworkers (Keeling et al., 2012) rates Sweden as number one regarding "perception of animal welfare among stakeholders" followed by the UK. These top ratings are the fruit of efforts over long time where legalization, researchers, farmers and NGOs have interacted. One cannot exclude that the dominance of family farming in Sweden, often with a comparably low number of animals (rather than larger company–owned livestock operations) where humans are closer to the animals has contributed to shaping the farmers commitment to good animal welfare. Sweden has more strict animal welfare legalization than the EU-directives, which may incur higher production costs. This in combination with a national tradition of enforcing legalizations, made many Swedish farmers less competitive when entering the open EU market in the mid 90's. To put it simple, the citizens of Sweden supported strict animal welfare legalization via the parliament, but when they became consumers they were not willing to pay the higher price for ASF produced in Sweden. However, during the last year, there is a tendency that more and more Swedish consumers are willing to pay for the added value of ASF produced with the stricter domestic standards. One lesson learned – related to a sustainable livestock sector including animal welfare - is that improved animal welfare often comes with a cost that must be covered by someone in order to be competitive on an international open market and thus lasting. Depending only on the consumers' willingness to pay can be precarious.

Examples of specifics in the Swedish animal welfare legalization for livestock are that in dairy farming units build after 2007, cows being kept in loose housing and cows must also be allowed to be outdoor for 2-4 months for at least 6 hours. Further on, in the egg and broiler productions are for instance bill-trimming forbidden. Regarding the legalization for the welfare of pigs,

Sweden has indeed been in the fore-front; for instance sows had to be loose housed already 25 years before corresponding EU directive (Einarsson et al., 2015). Moreover, Sweden has been among the leading countries in the EU to implement the directive on the protection of pigs to be enforced 2013 and has moved beyond that by for instance banning tail-docking and requiring that pigs must have access to bedding material (LRF, 2016). This work has recently been acknowledged as best-practice by the EC (EC, 2016).

A final reassuring – and very important – aspect of the Swedish livestock production under this legalization is that several production traits, like kg milk per cow per year, number of egg per hen-year or growth rate of pigs are internationally very competitive. This proof of concept, thanks to skilled farmers and professional extension services backed up by committed researchers, may serve as a role model or source of inspiration for best practices when including the animal welfare and animal health aspects into sustainable livestock farming.

6.3 Anti-microbial resistance

The emerging issue of AMR is the quintessence of One world-One health, as AMR respect neither national nor species borders (Robinson et al. 2016). The Swedish livestock sector is in the lead regarding low use of antimicrobials combined with competitive productivity. In the EU Sweden has the lowest use of antimicrobials per animal unit which is combined with a very low prevalence of AMR among livestock (ESVAC, 2015; Chantziaras et al., 2014, Figure 6). Sweden may thus provide examples of actions or approaches to the global livestock sector about how to mitigate the emergence of AMR. This will be discussed in the three following sections.

New York. High-Level meeting on AMR, organized by WHO, FAO and the World Organization of Animal Health. ©FAO/Sudeshna Chowdhury

As described in previous chapters there is an increasing demand for ASF, particularly in low-income countries and emerging economies. This increase is at large met by intensification in raising poultry and pigs. This intensification is often using antimicrobials to maintain animal health and productivity. The use of antimicrobials in current intensified systems and upcoming ones are thus considerable. Use of antimicrobials exacerbates the natural phenomenon for microbes to develop AMR, particularly if the use is non-rational (without proper diagnosis, too short or too low-dosing, use for prevention instead of cure, use for growth promotion and herd treatment instead of individual treatment). This led to poor efficiency of antimicrobials in fighting livestock diseases and reduced productivity. Recent estimates indicate that the livestock production in low-income countries will be reduced by 4 to 10% the coming decades if the AMR emergence continues like today (World Bank, 2016). Most of the public concern is though related to the fact that resistance genes as well resistant microbes may be transmitted to humans (Robinson 2016; O'Neil, 2016). Thus making antimicrobials for human medicine useless.

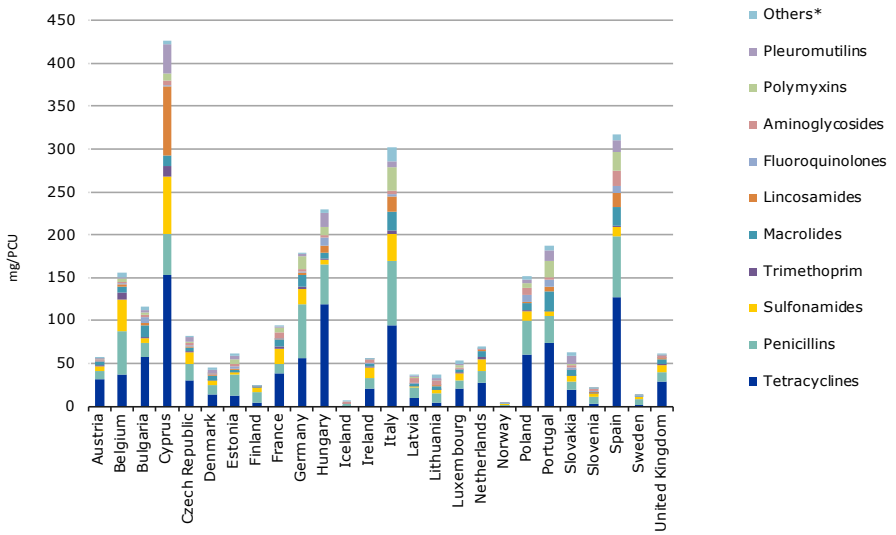


Figure 6. Sales of veterinary antimicrobials for food-producing species including horses, in mg/PCU, in 26 EU/EEA countries in 2013, Fifth ESVAC report, 2015). Sweden second from right.

It is estimated that about 700 000 deaths are attributable to AMR globally (O'Neil, 2016). Corresponding data on the production losses in the livestock sector due to AMR caused treatment failures are not available.

Generally the global data on the use of antimicrobials as well as on the prevalence of AMR is very weak both in human medicine and veterinary medicine (O'Neil, 2016). In the livestock sector, efforts to estimate the global use have been done (van Boeckel, 2014). However, about the prevalence of AMR there are just scattered data from different farms or regions in a country and the data are often based on different, not standardized, methodologies. In the EU, there is now a common monitoring system in place both for consumption of antimicrobials as well as for monitoring the prevalence of AMR in the livestock sector (EFSA, 2012; ESVAC, 2013) Today, it is estimated that half of all antimicrobial used globally is used within the livestock sector, in the US and Sweden the corresponding figures are 70% and 15%, respectively (Figure 7).

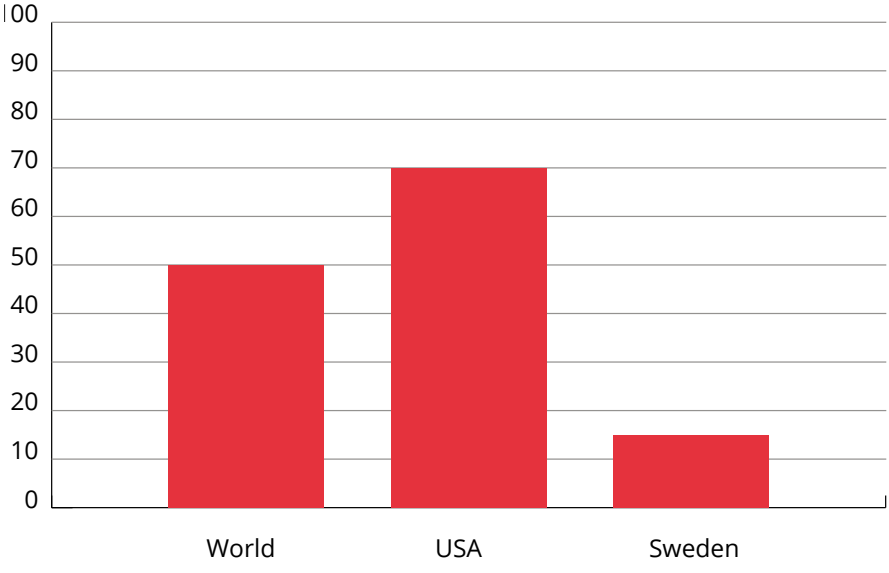


Figure 7. Approximate percentage of the overall use of antimicrobials that are used in the livestock sector. Note that data are compiled from different sources; World estimate (van Boeckel 2015); USA (FDA, 2010); Sweden (National Veterinary Institute, 2016).

Notably, also legalisation about requirement for veterinary prescription of antimicrobials vary a lot, not only between high and low-income countries but also among OECD-countries (Maron et al., 2013) In several low-income countries there are no legalisation related to antimicrobial use in the livestock sector and if so, the enforcement of it is a challenge. Given this, a discussion has started about the responsibility of the pharmaceutical companies for mitigating the misuse of antimicrobials.

The relative weight of the routes of transmission of AMR from livestock to human (direct contact, foodborne or via the environment) or in the other direction (via direct contact or via the environment) is not really known. Thus there is an urgent need to fill this knowledge gap. However, there is proof-concept evidence that these routes exist. Likely, their relative importance is depending on farming procedures and handling of ASF along the production chain.

Despite all the uncertainties, we may conclude that the livestock sector contributes to the emergence of AMR and actions must be taken now by the sector.

It is reassuring that some key international agreements are in place; in 2015 both the FAO and WHO of the UN decided about action plans/strategies to mitigate the emergence of AMR (FAO 2015b; WHO, 2015b). This is a good precondition for global action.

How to mitigate?

To reduce the use of antimicrobials in general in the livestock sector and ban the use of certain kinds that should be reserved for humans is the logic way to mitigate the contribution from the sector to the overall emergence of AMR. Still bearing in mind that there are large uncertainties regarding the magnitude of the contribution – that likely vary by country and other factors.

National regulations and legalisations are important as is international agreements. However, they are not enough and it might also be contra-productive. An extensive use of antimicrobials may shade poor animal health that worsens when antimicrobials are taken away leading to decreased or collapsed production (see figure 8). In high-income countries where these conditions prevail, farmers or the livestock industry may fear this would happen if restrictive regulations are implemented, and thus there is a strong and organized opposition against these regulations in some countries. In low-income countries, where there is a nutritional need for ASF, would reduce productivity and production be the effect of harsh and restricting regulations alone. This in turn would severely jeopardize FSN among poor and vulnerable groups in the

society. Also, one may of course question the likelihood of the ability to enforce such regulations in countries with weak institutions.

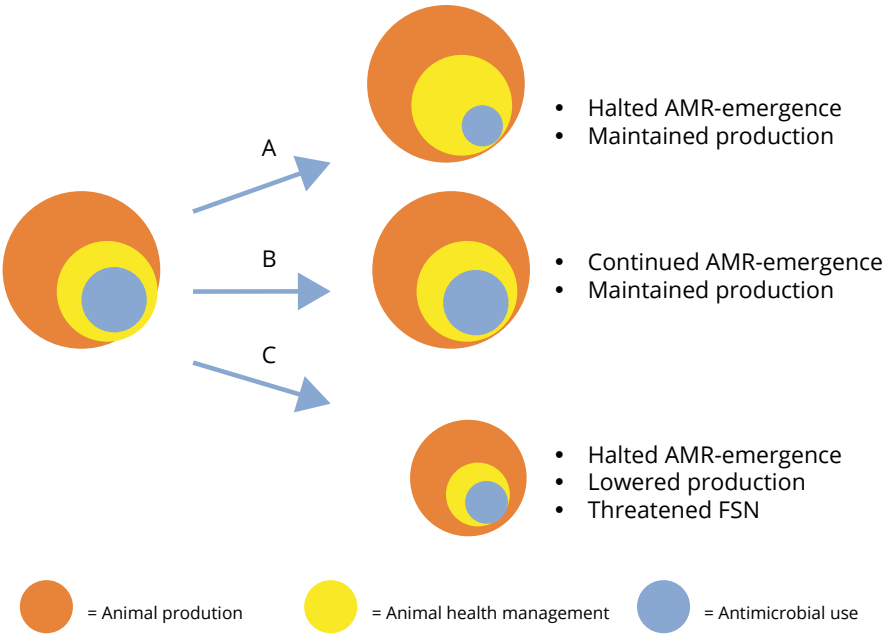


Figure 8. Conceptual sketch showing animal productivity and the risk for AMR-emergence in three scenarios: A.) Antimicrobials are replaced by efficient disease-preventive practices B) Business as usual C) Regulations enforced without introducing efficient disease-preventive practices.

Therefore it is crucial that regulations regarding the use of antimicrobials are matched by efficient animal health management procedures to prevent infectious diseases that make the use of antimicrobials unnecessary. For the high-income countries, several best practices are available as shown when Sweden phased out antimicrobials as growth promoters 30 years ago (Wierup, 2000). In contrast, in low-income countries are often animal health services weak and the disease preventive means applied in high-income countries may not be directly transferrable without adjustments due to resource constraints. However, it is reasonable to assume that a more professional animal health management that replace the non-rational use of antimicrobials in low-income countries may very well improve productivity beyond the original. Thereby increasing the availability of ASF.

Table 5 shows preventive animal health management procedures at intensive farms that have been proven to reduce the need for and use of antimicrobials in the livestock sector in Sweden and subsequently in other

northern European countries. The implementations of the procedures are assessed as needing primarily skills or costly inputs. Both types of procedures are facilitated by, or do require, educational efforts and functional extensions services combined with information campaigns. In general one may assume that the procedures that need skills should be easier to implement in low-income countries and would be more sustainable. Notably, some of these procedures may also be used in mixed farming systems and there improve animal health and productivity.

Disease preventive procedure	Requires mainly additional skills	Requires mainly additional costly inputs
Improved biosecurity, all-in-all-out systems, quarantine, AI instead of natural breeding	X	
Improved housing, lowered stocking densities, age-sectioning of animals		X
More use of vaccines and vector control		X
Better diagnostics, including testing for sensitivity to antimicrobials		X
Rational use of antimicrobials (correct kind of antimicrobial, length of treatment, correct dosing, individual treatment)	X	
Better sanitation	X	
Use breeds adopted to the disease-environment without hampering genetic improvement	X	

Table 5. Preventive animal health management procedures at intensive farms proven to reduce the need for antimicrobial use in the livestock sector (column at the left). Assessment of whether the implementation of these procedures is mainly a matter of skills or costly input (middle and right column, respectively.)

In addition, an enabling environment including good institutions and rational policies contribute to a reduction of the use of antimicrobials at the farm. For instance, interventions like establishing animal health services/extension that focus more on disease prevention than cure, strengthen laboratory services for diagnosing antimicrobials and determination of their AMR-profiles; policies for reducing the market for counterfeit drugs are important elements in such an environment.

Antimicrobial use is an integrated and often interchangeable element of animal health management. To replace the non-rational use of antimicrobials with preventive animal health management has proven to be an efficient and practical way to reduce AMR in the livestock sector.

Incentives for change

Sweden banned the use antibiotics as growth promoters in 1986. The ban was based on demand from the Federation of Swedish Farmers. This demand, in turn, was based on a concern that consumers feared "additives" in their food, and not primarily the concern of AMR. Note though that animals were, and are, slaughtered after a science-based and regulated withdrawal time. When Sweden joined the EU in 1995, the Swedish market became open for ASF produced from animals given antibiotics as growth promoters. Therefore an official Swedish governmental report was compiled gathering scientific evidence about antimicrobial as feed additives to livestock (SOU, 1997). This and other early policy-elaborations about antimicrobials as growth promoters have been extensively reviewed by Edqvist and Pedersen (Edqvist & Pedersen, 2001). In 2006, the entire EU banned the use of antibiotics in animal feeds (EC, 2005). During the last years also large livestock producing countries like Denmark and Netherlands have started to reduce their use of antimicrobials in the livestock sector (Aarestrup et al., 2010; Speksnijder et al., 2014; figure 6).

The lesson learnt from the EU is that in high income-countries incentives for change may be driven by consumers' opinion, farmers response to markets and by in parallel presenting science-based evidence to policy makers. This may also hold true for the emerging middle-income countries, where richer consumers may demand the same standards for ASF as in high-income countries (however, see the reasoning above about the reluctance among consumers' to pay more for animal friendly-produced ASF).

In low-income countries the awareness about, or priority for, the AMR-issue may look different and is generally weak. Therefore the consumers' influence on the production systems regarding this aspect of AFS must be judged as small. Whether policy makers – perhaps through influence by inter-governmental agreements - decide to prioritise the AMR-issue and being prepared to put forward a regulatory legalisation is difficult to tell. If they do, but if institutions are weak, the enforcement capacity will be low and there will be a very limited effect of such legalisation. This is not an unlikely scenario in most low-income countries. Instead, improved animal health services including competent extension service and education (i.e. Figure 8 a) may help to reduce the use of antimicrobials at the same time as productivity increases. The latter is a strong incentive for farmers.

6.4 Concluding remarks about Sweden's role in the development of a sustainable livestock sector

In an international comparison, the Swedish livestock sector is environment and animal friendly and is in the lead regarding good animal health and productivity with minimum use of antibiotics. This position in the international community has to a large extent been achieved by a long-term private-public partnership where well-organized farmers have been key partners. Several of the Swedish policies and practices can be directly transferred to middle- and high-income countries for the sake of a sustainable livestock sector. Needless to say though, not all of these can be applied in low-income countries without adjustments. However, in the three areas discussed above, there are elements that may be used around the world for development of a sustainable livestock sector. Sweden can thus contribute to this development by:

- Share experiences in establishing the asked-for multi-stakeholder cooperation in the sector,
- Provide practically useful knowledge about improvement of the welfare for livestock,
- Show best practices for minimising the use of antimicrobials in the livestock sector with maintained animal health and productivity.

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This report from the Swedish FAO Committee discusses the role of the livestock sector for sustainable agricultural development, and improved food security and nutrition in the world. The sector's important contribution to implementing the first two Sustainable Development Goals – End poverty and End hunger - is highlighted. Livestock has a crucial role in providing nutritious foods contributing to children's cognitive and physical development. Economic, social and environmental challenges to the sector are discussed, for example that it contributes to livelihoods for 1.3 billion people world-wide and that the consumption of animal source foods increases with increasing incomes and urbanization. It is also linked to the crop sector, for example by providing manure as fertilizer, and it may serve as a safety net enabling poor farmers to overcome crises. At the same time, the livestock sector is the largest user of land – 80% of all agricultural land is used for feed production – and accounts for around 15% of the anthropogenic green-house gas emissions. Livestock also poses a threat to human health by transmitting infectious diseases to humans directly, and by contributing to the spread of antimicrobial resistance to humans and the environment. But the report also shows the opportunities how these environmental and other challenges can be mitigated, and how actions towards a sustainable livestock sector relate to the Sustainable Development Goals.

Compared with other agricultural activities, the livestock sector is very diverse and complex with a variety of different farming systems throughout the world. This report focuses on conditions and options for the sector and farmers in low-income countries, and how a sustainable intensification of the livestock sector contributes for example to more efficient use of natural resources. Still, several experiences and skills from Sweden may be transferred to the sector in low-income countries. Sweden has managed to develop a livestock sector with high productivity in which good animal health management, efficient feeding and breeding systems and well organized farmers play important roles, while at the same time also environment friendly. The report furthermore reflects on the role of animal welfare, an area where Sweden has more strict legalization than the EU. The Swedish livestock sector stands out in using the least antimicrobials in the EU and only 15% of the antimicrobials used in Sweden.

FAO, the Food and Agriculture Organization of the United Nations, is the UN specialized agency for agriculture, forestry and fisheries. The organization was founded in 1945. Its mandate is to contribute to global food security and the eradication of hunger and malnutrition, and the sustainable management and utilization of natural resources.

The Swedish FAO Committee was formed in 1950, the same year that Sweden became a member of FAO. The task of the Committee is to assist the Government in its work for food security for all, while taking account of global development and the preservation of biodiversity in the areas of agriculture, forestry and fisheries. It is also to spread knowledge about and raise interest in the work of FAO. The Committee comprises 12 members and its chair, Ms. Elisabeth Backteman, State Secretary to the Minister for Rural Affairs at the Ministry of Enterprise and Innovation.

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