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ANIMAL HEALTH IN DEVELOPMENT – ITS ROLE FOR POVERTY REDUCTION AND HUMAN WELFARE

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Abbreviations and acronyms

ADB – Asian Development Bank
AfC – Agenda for Change
AfDB – African Development Bank
AMR – Antimicrobial resistance
AU – African Union
AU-IBAR – African Union Inter-African Bureau f. Animal Resources
CAADP – Comprehensive Africa Agriculture Developm. Programme
CGIAR – Consultative Group for International Agricultural Research
CSO – Civil society organizations
GDP – Gross domestic product
EAC – East African Community
EU – European Union
FAO – Food and Agriculture Organization of the United Nations
IDB – Inter-American Development Bank
IFAD – International Fund for Agricultural Development
IGAD – Intergovernmental Authority on Development
IICA – Inter-American Institute for Cooperation on Agriculture
ILRI – International Livestock Research Institute
LICs – Low income countries
MDG – Millennium Development Goal
MTP – Medium term plan
NEPAD – New Partnership for Africa's Development
OECD – Organization for Economic Co-operation and Development
OIE – World Organisation for Animal Health
OIRSA – Regional International Organization for Plant Protection and Animal Health
PRSP – Poverty Reduction Strategy Papers
SDG – Sustainable Development Goal
Sida – Swedish International Development Cooperation Agency
SADC – Southern Africa Development Community
SSA – Sub-Saharan Africa
UN – United Nations
UNECA – United Nations Economic Commission for Africa
USAID – United States Agency for International Development
WB – World Bank
WDR – World Development Report
WHO – World Health Organization
WTO - World Trade Organization

Vocabulary

Adverse selection: a situation when asymmetric information (one party has more information than the other) leads to an inefficient participation in market transactions, usually phrased as bad risks driving out good risks. Think of a livestock market in which healthy and unhealthy animals are traded, and where the information of the animals' health status cannot be fully verified. Not being able to obtain a price high enough, owners of healthy livestock would then choose not to participate in the market, resulting in a market trading only disease-prone livestock.

Antimicrobial: a biological or chemical agent that kills microorganisms and/or inhibits their growth, such as antibiotics, anthelmintics and disinfectants.

Cysticercosis: a tissue infection caused by larval stages of the pork tapeworm that can occur in humans.

Endemic infection: an infection that is maintained in a population without the need for reintroduction of the disease agent from external sources.

Externality: the consequence of an activity that is experienced by others who are not involved or in control of that activity. These third parties may be positively affected (a person or a group manages a disease) or negatively affected (a person or a group generates a contaminant that affects others). Production externalities are usually unintended and can have economic, social and environmental side effects.

Livestock: domesticated animals raised to produce commodities such as food, hide and power and to serve as a source of investment. They are distinct from domestic animals kept for recreation. Specific issues related to aquaculture are not considered in this report.

Livestock systems: ways livestock are kept and animal source food is produced. A common categorization is: mixed livestock-crop smallholding systems, pastoralist systems, commercial ranching systems, specialized intensive systems.

Market failure: a situation where the production and consumption of goods and services in a certain market is not optimal for society as a whole.

Micronutrients: nutrients required in small quantities, including dietary trace minerals, vitamins and other elements necessary to keep up physiological functions.

Moral hazard: a situation under asymmetric information (one party has more information than the other) in which the more informed party, after an agreement has been reached (such as a contract, or a transaction) acts to the detriment of the other party. Think of a farmer having obtained a lower insurance premium under the provision of some health investments (that cannot be verified by the insurance company) choosing not to undertake them.

One Health: a concept recognizing that the health of humans, animals and ecosystems are interconnected. One Health involves applying a coordinated, collaborative, multidisciplinary and cross-sectoral approach to address risks originating at the animal-human-ecosystems interface.

Pandemic: an epidemic of infectious disease that has spread among human populations across, for instance, multiple continents or even worldwide.

Pathogens: proliferating infectious agents such as virus, bacteria and parasites.

Private good: a good or service that cannot be used over and over again (its consumption is rival: one person's consumption restricts other persons consumption of the same good or service) and where individuals can be excluded from using it. Think of livestock, meat, milk, skins and manure.

Public good: a good or service that is non-rival (one person's consumption does not reduce the availability of consumption by others) and non-excludable (individuals cannot be effectively excluded from using it). Think of an infectious-free environment, the consumption of which leads to good health for all individuals, not only for those investing in control of contagion.

Stunting: occurs when a child fails to grow as expected for her or his age as a consequence of severe and long-lasting malnutrition.

Vector: an organism – e.g. a malaria mosquito, another insect or a tick – that transmits a pathogen between hosts.

Zoonosis (plur. zoonoses): an infectious disease that can be naturally transmitted from animals to humans, and vice versa.

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Preface

The majority of the world's poor live in rural areas. Around seventy per cent of them are directly dependent on animal keeping for their survival. When up to a fifth of their livestock dies of diseases it pushes them deeper into poverty. Despite this fact, animal health is far from being a main concern in development cooperation.

Animal health deserves more of our attention. The absence of adequate animal health systems places a heavy burden on individual animal farmers, who, on their own, might find it hard to take necessary action to prevent the spreading of diseases. Animal diseases spread not only to other animals, but also to human beings. Investing in animal health can thus also be considered a global public good.

Animal health is, however, not only about containing diseases. Unhealthy animals are unproductive, in terms of output per animal, and are risky savings. This reduces the potential private gains to be made from animal keeping. Animal keeping often have clear gender implications. The level of greenhouse gases per unit of production is also larger than from healthy animals. Animal health thus has a significant bearing on the possibility to meet several of the Sustainable Development Goals; most obviously goal 1 (no poverty) and goal 2 (zero hunger), but also goals 3 (good health and well-being), 5 (gender equality), 8 (decent work and economic growth), 13 (climate action) and 15 (life on land).

The EBA has commissioned Jonathan Rushton, Arvid Uggla and Ulf Magnusson to undertake this review on the importance of animal health for economic development. The authors point at the need to build proper control and surveillance systems and provide a review of the existing strategies and policies of Sweden and international donors. They conclude that Sweden has the potential to fill investment gaps in collaboration with other international and national actors, including Swedish universities and public authorities.

It is my hope that this report will contribute to implant the importance of animal health into the broader discussion on how to reduce rural poverty.

The authors' work has been conducted in dialogue with a reference group chaired by Gun-Britt Andersson, member of the EBA. However, the authors are solely responsible for the content of the report.

Stockholm, February 2017

Lars Heikensten

Sammanfattning

Utveckling av lantbruket är en grundläggande förutsättning för inkluderande ekonomisk tillväxt i låginkomstländer och djurhållning spelar här en central roll. Omkring 750 miljoner djurhållare i världen lever på mindre än 2 US dollar om dagen. Begränsad tillgång till djurhälsovård gör att infektioner och andra djursjukdomar orsakar betydande och oförutsägbara störningar i djurhållningen för dessa resurssvaga bönder. En ökad produktivitet inom djurhållningen, tillsammans med ökad motståndskraft mot chocker, kan därför ha stora fattigdomsminskande effekter. Denna studie visar på betydelsen av tillförlitliga djurhälsosystem för en hållbar djurhållning i låginkomstländer inkluderande god djurvälfärd. Särskild vikt läggs i studien vid Afrika söder om Sahara. Översikten ligger till grund för rekommendationer om prioriteringar och strategier för vetenskapligt baserade djurhälsoåtgärder. En huvudslutsats är att Sverige har potential att fylla ett flertal investeringsluckor inom djurhälsoområdet. Sida kan här spela en stor roll, i samarbete med andra internationella och nationella aktörer, inklusive svenska universitet och myndigheter.

I regeringens policyramverk för utvecklingssamarbete framhålls att initiativ som rör förbättrad djurhälsa och djurproduktion kan bidra till effektivare resursutnyttjande, ökade exportmöjligheter och positiva hälsoeffekter för människor. För att uppnå detta behövs kontinuerlig forskning och utveckling, utbildning och kapacitetsutveckling.

Investeringar i uthålliga djurhälsosystem utgör en möjlighet för låginkomstländer att närma sig flera av FN:s globala mål för hållbar utveckling (SDG). Detta gäller särskilt för målen relaterade till fattigdomsbekämpning och ekonomisk tillväxt, livsmedelsförsörjning och nutrition, hälsa och jämställdhet:

- Friska djur innebär ökad tillgång på livsmedel av animaliskt ursprung - en viktig källa till oumbärliga mikronäringsämnen (SDG 2 och 3);
- Friska djur är mer produktiva än sjuka, och produktionen är utsatt för mindre variationer. Detta ger den enskilde lantbrukaren högre och mer stabil avkastning (SDG 1 och 8). Det innebär också ett mer effektivt utnyttjande av naturresurser samt minskade utsläpp av växthusgaser per producerad enhet av mjölk, ägg eller kött (SDG 13 och 15);

- Friska djur överför inte infektioner (zoonoser) till människor och behöver inte antimikrobiella läkemedel (SDG 3);
- I många delar av världen är kvinnor direkt ansvariga för hushållens djurhållning. Genusmedvetna djurhälsoinsatser kan ha viktiga effekter vad gäller kvinnors egenmakt (SDG 5).

Investeringar i djurhälsosystem i låginkomstländer, med bättre djurhälsovård på medellång och lång sikt, förbättrar såväl försörjning som välfärd hos fattiga djurhållare, av vilka många är kvinnor. Sådana investeringar bidrar också till att försörja en växande stadsbefolkning med näringsrika livsmedlen av animaliskt ursprung till överkomliga priser. Det finns många hinder på vägen mot effektiva och hållbara djurhälsosystem i låginkomstländer. Mot denna bakgrund föreslås tre områden där svenskt bistånd kan bidra till ökade investeringar:

1. Bedömning av effektivitet. Det finns ett stort behov för insamling och analys av data för att bedöma kostnader för djursjukdomar och behandling eller kontroll av dessa. Målet är att utveckla verktyg för att analysera hur effektiva djurhälsoinsatser är. Sverige har en enastående position inom övervakning, förebyggande och kontroll av djursjukdomar. Dessa färdigheter bör användas i samarbete med institutioner som CGIAR, FAO och OIE.

2. System baserade på effektiv leverans och offentlig-privata partnerskap. ”Att förebygga är bättre än att bota” är en bra grundprincip när det gäller hälsofrågor. Sverige kan ses som en förebild där samarbeten mellan myndigheter, forskare och näringen bl.a. drivit fram en unikt låg användning av antibiotika inom djurhållningen kombinerad med hög produktivitet och god djurvälfärd. På den internationella arenan bör den svenska resursbasen stärka sitt stöd till organisationer som FAO, OIE och CGIAR för att främja mer hållbara djurhälsosystem. För att göra detta behövs en positiv och stödjande politisk miljö från svensk sida.

3. Att bygga professionell kapacitet. Sverige har under årens lopp utvecklat en avancerad utbildnings- och träningskapacitet inom området djurhälsa och djurproduktion. Aktiviteterna är och har varit riktade mot både praktiker och akademiker, oftast från låginkomstländer i Afrika och Asien. Stöd till utbildning och forskningsinstitutioner i dessa länder har bestående långsiktiga effekter och bör förstärkas.

Summary

Agricultural development is the basis for economic growth in low-income countries, with animal production constituting a major component of their agricultural economies. Around 750 million livestock keepers in the world are living on less than 2 US dollars a day, suggesting a substantial opportunity to lift people out of poverty by increasing livestock productivity and resilience. However, infections and other animal diseases cause substantial, unpredictable disturbances to the livelihoods of resource-poor livestock farmers who have limited access to animal health services. This study presents the significance of reliable animal health control systems in relation to a sustainable and resilient livestock sector including animal welfare, in low-income countries, with particular attention to Sub-Saharan Africa. It provides a basis for recommendations on priorities and strategies regarding a science-based animal health management, and concludes that Sweden, with Sida, has the potential to fill investment gaps in collaboration with other international and national actors including Swedish universities and public authorities.

In the current Aid Policy Framework of the Swedish Government it is acknowledged that initiatives related to improved livestock health and production can contribute to more efficient utilization of resources, increased export opportunities and positive human health effects. To achieve this, continuous research and development as well as training and capacity development are essential.

Investments in animal health systems offer low-income countries opportunities to reach several of the UN Sustainable Development Goals (SDGs), particularly for those related to poverty reduction and economic growth, food security and nutrition, human health and gender equity:

- Healthy livestock means increased availability of food of animal origin – an important source of essential micronutrients for large parts of humanity (SDGs 2 and 3);
- Healthy livestock are more productive than diseased livestock, and production is exposed to less fluctuations. This gives the individual farmer higher and more stable returns (SDGs 1 and 8). It also reduces the use of natural resources and greenhouse gas emissions per produced unit of milk, egg or meat (SDGs 13 and 15);

- Healthy animals do not transmit infections (zoonoses) to humans and do not need antimicrobials (SDG 3);
- Gender-sensitive animal health interventions support women in particular, who in many parts of the world are directly responsible for on-farm livestock management (SDG 5).

Investments in animal health systems thus form the basis for a productive and resilient livestock sector. Enhanced animal health will directly improve the livelihood and welfare of resource-poor livestock keepers – many of whom are women. It also provides growing urban populations with more affordable highly nutritious animal source foods.

Creating effective and sustainable animal health systems in low-income countries remains a challenge. Three areas are recommended for Swedish assistance and increased investment in animal health systems:

1. Assessment of efficiency. There is a great need for data collection and analysis to determine the burdens of animal disease and costs of disease management. The aim is to develop tools for analysing how efficient health interventions are. Sweden has an outstanding position in surveillance, prevention and control of livestock diseases and antimicrobial resistance in animals. These skills should be used in cooperation with institutions related to CGIAR, FAO and OIE.

2. Systems based on efficient delivery and public-private partnerships. 'Prevention is better than cure' is a good basic principle for health issues. Sweden could be seen as a role model, since it combines a uniquely low use of antimicrobials in the livestock sector with high productivity and good animal welfare. On the international arena, Swedish professionals should strengthen their support to organizations like FAO, OIE and CGIAR promoting more sustainable animal health systems. A positive Swedish political environment is needed to make this happen.

3. Building human capacity. Sweden has over the years developed an advanced educational and training capacity in animal health and production. Efforts are directed towards both practitioners and academics from low-income countries in Africa and Asia. Support to training and research institutions in these countries has enduring and self-sustaining effects and should be reinforced.

1 Animal health and the Sustainable Development Goals

The report sets out to demonstrate that good animal health status and effective animal health service delivery will contribute substantially to achieving the newly adopted 17 Sustainable Development Goals (SDGs). Two goals are standing out: "no poverty" (SDG 1) and "zero hunger" (SDG 2). Animal health, and specific interventions to improve livestock health, relate directly to these goals and contribute significantly to others (for an overview, see Figure 1 and Table 1). In short:

- Healthy livestock increase the availability of food of animal origin, which is an important source of essential micronutrients for large parts of humanity (SDGs 2 and 3);
- Healthy livestock have a higher productivity and less variable production than diseased livestock, giving the farmer higher and more stable returns (SDGs 1 and 8). They also reduce the use of natural resources and greenhouse gas emissions per produced unit of milk, egg or meat (SDGs 13 and 15);
- Healthy animals do not transmit infections (zoonoses) to humans and do not need antimicrobials (SDG 3);
- The design of gender-sensitive animal health interventions supports women in particular, who in many parts of the world are directly responsible for on-farm livestock management (SDG 5).

The Millennium Development Goals Report 2015 (UN, 2015) provides evidence of positive global trends over the last decades. In 1990, nearly 50 per cent of the population in the developing world lived on less than 1.25 USD a day, whereas the corresponding figure in 2015 was 14 per cent. The proportion of undernourished people in developing regions has fallen dramatically since 1990, from 23 per cent in 1990–1992, to 13 per cent in 2014–2016. One third of the rural population in LICs was classified as extremely poor in 2010, down from more than 50 per cent in 1988; and the 2-dollars-a-day poverty rate in rural areas was just above 60 per cent, down from over 80 per cent in 1988 (UN, 2011).

More than 70 per cent of the world's extremely poor live in rural areas, and many of them are children and young people (IFAD, 2011).

The World Bank (WB) and the United Nations (UN) have defined poverty as "a multidimensional phenomenon leading to pronounced deprivation of well-being" (WB, 2000). The monetary dimension is important, but poverty is usually associated with poor nutrition, an issue of increasing concern in both urban and rural areas (Dominguez-Salas *et al.*, 2016).

Despite significant progress, an estimated 800 million people are still living in extreme poverty and suffering from hunger. More than 160 million children under the age of five are being stunted due to insufficient food. To place this into perspective, the EU houses 500 million people, of which 70 million are well-nourished children who will achieve their physical and mental capabilities.

Figure 1. Animal health. especially in low income countries, relates to several of the 17 SDGs

Note: See Table 1 and the running text for details.

LICs are often characterised by low-performing economies primarily based on agriculture with large knowledge gaps and few technological innovations. Malnutrition is common and there is a lack of food and micronutrients in particular. Africa, and especially Sub-Saharan Africa (SSA), is heavily reliant on domestic animals. Livestock production is

important in meeting the growing demand for animal source products that are rich in nutrients – and as a means of increasing incomes, nutrition and welfare for the rural poor (Upton, 2012). Agricultural performance has improved since 2000 but is still not adequate to meet growing demands (Wirsenius *et al.,* 2010; OECD/FAO, 2015).

One critical problem is that Africa has the lowest agricultural productivity in the world; and the insufficient speed of improvement regarding food security and economic stability means that this will remain a constant challenge due to population growth and societal change (WB, 2013a; von Grebmer *et al.*, 2015). If productivity issues are not met, the negative impacts on both income and nutrition in rural areas, and on nutrition in growing urban areas, will continue. The burden will fall more heavily on the poor in both areas (Alarcon *et al.*, under review).

To achieve the SDGs, LICs globally and SSA in particular need healthy and productive livestock. Development support is essential to explore questions on how to achieve improvements in animal health, and where and how to get the best leverage from investments. These issues are becoming increasingly critical, as livestock systems and their value chains adapt to growing demands for livestock products, and are coinciding with – and impacting on – climate change. The climate is a thoroughly discussed topic in Sweden and in several other high-income countries, characterised by very high emissions of greenhouse gases (GHG) and a very large consumption of meat – in contrast to LICs. There are also new challenges of emerging and re-emerging diseases, some of which are zoonotic while others are causing epidemics that compromise food supply.

This review surveys the importance of animal health for poverty reduction, economic growth and improved nutrition, and discusses Sweden's engagement in these areas. It identifies potential gaps in the current investments that Sweden is able to fill, ideally together with other national and international players. In cooperation with others, Sida is implementing Sweden's official Policy for Global Development. Its support is focused on economic and political development in poor countries. The ultimate goal is to strengthen democracy and create conditions for people to lift themselves out of poverty.

Most Swedish development cooperation is focusing on Africa and especially SSA. These countries will be in focus in our review. The

study provides guidance on animal health improvements through targeted investments that hopefully lead to poverty reduction, economic growth and improved nutrition. The information generated provides a basis for our science-based recommendations to Swedish and international actors regarding strategies, priorities, investments and positions in international dialogues.

How can investments in animal health contribute to reduced poverty and economic growth in LICs? The report elaborates on this topic and discusses the relationship between animal health and aspects of development cooperation. This is used to assess the support given by key international stakeholders and donors. The analysis leads to a set of recommendations for Swedish investments in animal health systems.

Table 1. Overview and guide to the reader.

SDG	Target	Section
1. End poverty in all its forms everywhere	1.1 By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than 1.25 USD a day	4
	1.2 By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions	4
	1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance	4
	1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters	4
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture	2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round	5.1
	2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons	5.1
	2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment	4
	2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality	5.3
	2.a Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order	4

	to enhance agricultural productive capacity in developing countries, in particular least developed countries	
3. Ensure healthy lives and promote well-being for all	3.2 By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births	5.1
	3.3 By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases	5.1
	3.d Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks	5.1
5. Achieve gender equality and empower all women and girls	5.a Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws	4.2
	5.b Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women	4.2
	5.c Adopt and strengthen sound policies and enforceable legislation for the promotion of gender equality and the empowerment of all women and girls at all levels	4
8. Promote inclusive and sustainable economic growth, employment and decent work for all	8.2 Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labour-intensive sectors	4.4
13. Take urgent action to combat climate change and its impacts	13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries	5.3
15. Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss	15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods; and strive to achieve a land degradation-neutral world	5.3

2 Livestock in low-income countries

The World Development Report (WDR) 2008: Agriculture for development (WB, 2007) classifies countries into three categories based on the economic importance of agriculture: agriculture-based, transforming, and urbanized.

In agriculture-based countries, roughly one third of GDP growth comes from agriculture, and more than two thirds of the poor are living in rural areas. Most of these countries are found in SSA. Transforming countries are to a large extent found in Asia, where agriculture contributes to less than 10 per cent of GDP growth on average. Still, more than 80 per cent of the world's poor live in rural areas (Alkire *et al.,* 2014). In total, it is estimated that 75 per cent of the poor in agriculture-based countries are, directly or indirectly, dependent on agriculture. The trend is clear though: people continue to move from rural to urban areas.

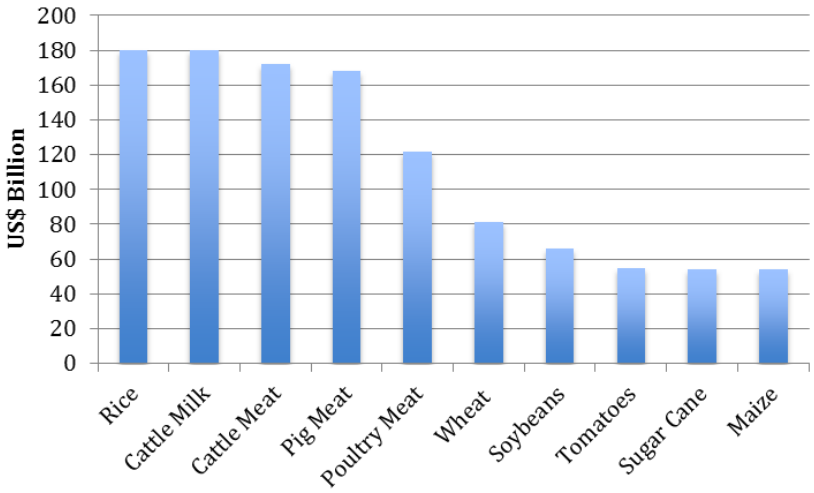
The WDR 2008 states that a dramatic increase in productivity among smallholders would move people away from mass poverty and food insecurity. However, the WDR is focused on crop productivity. It makes no reference to the fact that improved crop productivity often leads to surplus grains being consumed by livestock to add value. In transforming countries, a shift is needed towards higher-value agriculture as one of the means to reduce rural poverty. In both country categories, livestock are presently an important – but largely ignored – component of economic activity. They are providing hundreds of millions of consumers in rural and urban areas with food, clothing and critical micronutrients.

According to estimates, forty per cent of the global agricultural GDP comes from the livestock sector which is the most rapidly growing high-value commodity subsector (FAO, 2009; Pradère, 2014). In LICs, its contributions and growth rates are even higher. Otte *et al.* (2012) calculated that there were 750 million livestock keepers worldwide living on less than 2 USD a day. There is substantial opportunity to move them out of poverty by increasing productivity and resilience. The challenges and conditions will vary considerably between countries and within regions of countries. Progression can be difficult where farmers live in geographically

isolated regions or live in social isolation, yet livestock still play a significant role in improving livelihoods at both intragenerational and intergenerational levels (Rushton *et al.*, 2005).

Figure 2 indicates the relative importance of livestock products globally. The production of meat and milk alone represents approximately 650 billion USD, a sum which does not include the significant production of eggs, fibre, manure and draught power. In addition, it does not take into account that families across the world have their investments in livestock – an ideal way to provide a return on savings through natural reproduction and growth.

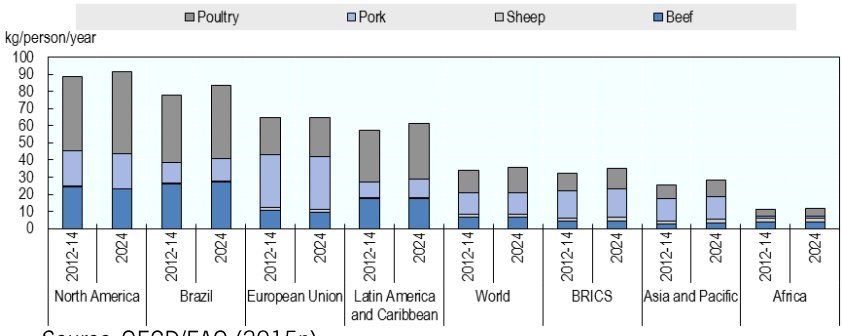
Figure 2. The value of selected agricultural products generated globally



Note: In comparison, the contribution from wood and manufactured forest products to the global economy is USD 450 bn (World Bank, 2006). Source: FAO (2010).

How does this massive contribution of livestock production relate to consumption? According to the Agricultural Outlook 2014, consumption per capita will continue to grow throughout the world, but in Asia and Africa, where most of the poor live, the growth will be slow and is starting from a very low level (Figure 3).

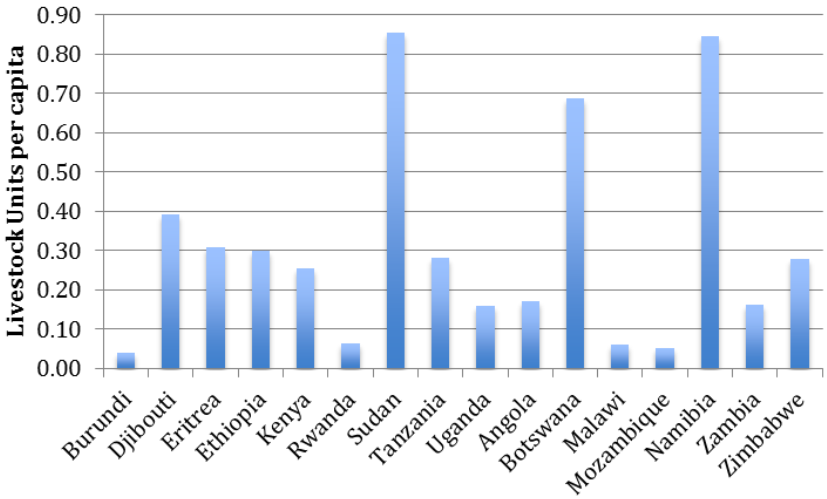
Figure 3. Livestock meat consumption per capita



Source: OECD/FAO (2015n)

What is the reason for the low availability of livestock products in many LICs that ultimately leads to shortages of micronutrient-rich foods? The actual number of animals could be one aspect. SSA countries certainly have relatively low numbers of livestock units per person, with the exception of Sudan, Botswana and Namibia (Figure 4).

Figure 4. Number of livestock units per capita in selected African countries



Source: FAOSTAT (2014; authors analysis). Corresponding figures for the UK and Sweden are 0.21 and 0.18, respectively (EUROSTAT, 2013; authors analysis).

However, scale is not the only issue. There is also a gap between output per animal in LICs and the global average (see Figure 5). To

close this gap, a set of critical supportive actions are required – linking smallholders to input and output markets; providing an enabling agricultural policy environment; increasing feed and forage quality; using animals with a more favourable genetic potential; and providing information on management and marketing. Underpinning such measures is the need to improve prevention and control of animal diseases and to handle the overall assessment and management of animal health with improved skills. Livestock systems that continue to suffer from endemic contagious diseases, or are at risk from incursions of such diseases, will always place the owners in vulnerable situations. This makes additional investments less attractive.

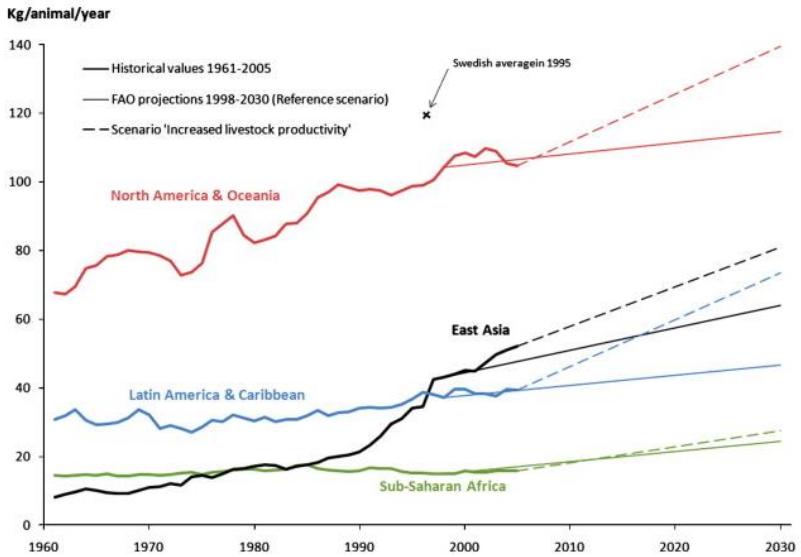
Figure 5 shows output per animal in different regions. In East Asia, there was a sharp rise in this productivity measure, which has to do with the adoption of intensive poultry production. No similar shift has been noticed in SSA. However, a word of caution is needed. Output per animal does not take into account the inputs per animal – most livestock in Africa are dependent on low-input and low-output systems (mixed livestock-crop systems). Such systems are ideal in regions where diseases are circulating and remain uncontrolled. Moving on to high-input and high-output systems (intensive systems) requires a broader range of investments in animal healthcare and control measures – and, where possible, in eliminating major animal disease pathogens.

The most common livestock system in LICs is family-based smallholder farming where crops and a few animals are integrated. These systems are low-input and low-output. They produce the vast majority of the food consumed in their countries and account for approximately 50 per cent of the global beef and milk production (Box 1 and FAO, 2013a). Pastoral livestock systems (extensive systems) are also present. They are found in almost one third of the planet's ice-free areas, where crop farming is difficult and unreliable, making it environmentally, socially and economically impossible in many situations (FAO, 2001). About 10 per cent of the world's meat is produced in pastoral systems (FAO, 2001).

Finally, intensive livestock systems are emerging in LICs as farmers adopt methods from other countries. But these systems are more common in transforming or urbanized countries. Robinson et al. (2011) report that intensive livestock production is largely based on pigs (58 per cent) and poultry (70 per cent). Yet this ignores the growing global importance of dairy systems and aquaculture.

Therefore, we must recognize that cattle are also found in intensive dairy systems and in feedlot beef systems, both of which play a role in changing output per animal and in modifying resource use and disease challenges. In a much less prominent way, small ruminants are found in such intensive systems.

Figure 5. Cattle productivity, in terms of output per animal



Source: Wirsenius et al. (2010). Reproduced with permission.

The shift from rural to urban life probably makes intensified livestock production increasingly important, as food systems must provide accessible animal source foods to growing numbers of city dwellers around the world. From an OECD perspective, a discussion is needed about our diet and the level of animal source foods we consume.

The situation in LICs is very different. Here, the current consumption level of animal source foods is inadequate to meet nutritional and physical development needs of millions of poor people. However, new intensive livestock systems are actually capable of solving these problems. They pose new research and policy challenges regarding the distribution and management of externalities relating to disease, antimicrobial resistance and waste management.

Box 1. Wealth and health for smallholders in Kenya

-– Now I can sell goat's milk and give my children good food, says Lucy Wairimu, farmer in Kisumu, Kenya. Today, she has ten goats producing milk for both domestic use and for sale. She has invested to make life better for her family…...

For almost one-and-a-half year, Lucy Wairimu put aside portions of the family's modest means to save up for her first goat. This goat had kids who later produced another generation of kids, so she could use the milk in her household and occasionally even sell a goat.

……

Lucy leans her head against the goat's stomach and holds a jar underneath the teats while milking. She gets approximately three or four litres a day. She keeps one litre for the family and sells several litres every day. Milka, her daughter, is warming the milk on the stove for the six grandchildren. Even though all of Lucy's children are grown up now, there are, except Milka and her daughter, another five grandchildren living at the farm since their parents died.

……

Three years ago, Lucy received information about meetings for people interested in becoming goat farmers. Lucy did not have a job at the time. It sounded interesting, so she went to a meeting the following Monday. An agricultural expert told the audience about the many advantages of goat rearing.

….

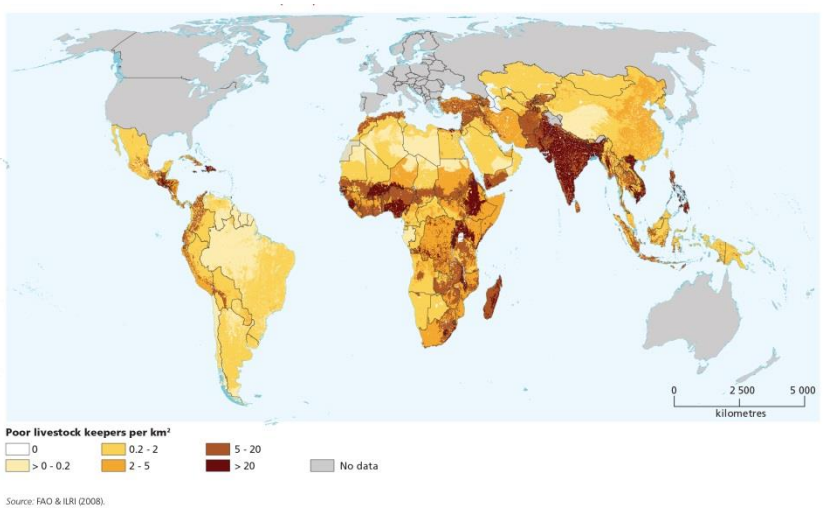
Martin Ng´ang´a is responsible for this sector within the National Agriculture and Livestock Extension Programme, NALEP. He is one of their 7,000 agricultural experts around the country. NALEP is receiving support from Sida. The basic idea is that farmers with mutual interests shall form groups, and then ask for support and aid regarding, for instance, the best methods for different forms of agriculture and livestock rearing. This enables small-scale farmers to become more efficient and get better returns on their products. The groups of farmers specify what they want to learn, and they are managing the work themselves, says Martin Ng´ang´a. This commitment, and the strength that comes from being able to bring change, is the backbone of the goat farmers' success. Together they have managed to make poverty more bearable for millions of families.

(From www.sida.se)

The geographical location of various livestock systems depends on the level of economic development, on agro-ecological factors (Figure 6) and cultural or religious traditions. This context is essential when assessing the demand, challenges and opportunities to provide adequate animal health services for improved productivity and animal welfare. The context varies both between countries and within regions of individual countries. There will also be issues of social and gender access to animal health services – the challenge is to make it easier especially for women and children to secure nutrient-rich foods. In

addition, the animal disease landscape is constantly evolving due to a range of drivers (FAO, 2013a).

Figure 6. **Densities of poor livestock keepers in rural areas**



Source: FAO (2013). Reproduced with permission.

The global demand for animal source food is increasing owing to a mix of growing human population and increased wealth. Urbanization, which is at the highest rate in LICs, also increases the demand for more varied diets, with less staple-based aliments and greater inclusion of animal source foods. In response to this, the livestock population is growing in size and density. The number of poultry has tripled over the last thirty years (FAO, 2013a), followed by a substantial increase in pig production and more recently in aquaculture. Access to relatively cheap feed grains and oilseed cakes (the basis of the animal diets) and access to housing and management technologies are behind this new pattern. However, new technologies in order to maintain high animal health and production status have not always been available (Fornace *et al.*, 2013). Even though intensive systems are becoming more important, large parts of the animal source food in LICs are still produced by smallholders.

Generally, number and densities of animals are critical determinants of the epidemiology of infectious diseases – growing populations and higher densities generate new dynamics (FAO, 2013a). Another driver of the changing disease landscape is

accelerating globalization. We are travelling more frequently, and trading more. Infectious diseases are spread more frequently and faster between countries and continents through human activities and our use of livestock and livestock products. Finally, a changing climate could alter the distribution pattern. The conditions for disease-vectors become different as they may move into new areas. Similarly, infectious agents find opportunities to survive in new geographical environments.

Interventions to enhance access to effective animal health systems should reflect changes in human populations and the ways animals are raised, traded and processed. Surveillance should be aimed at modifying these systems to match the challenges emerging from the new disease landscapes. Consequently, it is important that the above-mentioned aspects are taken into account when informing politicians about the need for policies and investments to direct public and private resources.

Notably, there are very strong arguments for a gender-sensitive approach when it comes to LICs. Women constitute the majority of poor livestock keepers, but the current priority setting for interventions only rarely take their experiences and needs into account. Thus, there is both an efficiency issue and an equity issue justifying a gender dimension in animal health interventions.

The snapshot presented above indicates a significant gap between what the livestock sector is currently generating in terms of income and food and what it is able to achieve. Yet today's globalised world is characterised by greater demand for animal protein, intensified livestock production, and increasing trade in livestock and livestock products (Cheneau *et al.*, 2004). The annual demand for meat and dairy products in LICs is expected to amount to over 210 million tons in 2020, compared to about 110 million tons in 1997.

In SSA alone, the human population is projected to grow from some 900 million in 2013 to 2.2 billion in 2050 (Haub and Kaneda, 2013). In the 1990s, its population was estimated to grow at 3.1 per cent per year, while meat and milk production was predicted to lag behind at between 1.4 and 2.3 per cent (de Haan and Bekure, 1991). More recent estimates indicate that the population growth has slowed somewhat to 2.4 per cent (World Bank, 2016), yet livestock production continues to vary across the region.

Despite this bleak picture, livestock in the SSA countries actually contributes significantly to agricultural GDP. In Ethiopia and Tanzania, for example, the sector is estimated to contribute to almost 50 and 30 per cent of the agricultural GDP, respectively (IGAD, 2013; FAO, 2005). This contribution comes from meat, milk and other livestock products, as well as manure and draught power. In many areas, livestock-related activities are one of the most important sources of employment and cash income, providing money to purchase inputs for crop production, and securing an outlet for surplus grain.

One obvious conclusion drawn from statistical facts is that African agriculture needs a healthy livestock industry to achieve viable economic growth. At present, livestock diseases stand in the way. In SSA, estimated cattle losses due to the contagious bovine pneumonia (CBPP) alone amount to 2 billion USD a year (Brownlie *et al.*, 2006). Other disease and health problems are also causing a range of losses, affecting growth, fertility and work output. In addition, approximately 10 million square kilometres of land in SSA cannot be adequately used for livestock production due to the presence of disease vectors. With regard to trade, the value of the sector is severely affected by transboundary diseases – restricting access to EU, USA, Japan and other high-value markets.

A way forward

This section has identified why livestock production is so important. It raises the question of how to support livestock producers seeking a stable and improved livelihood and better prospects for their families. *Box 2* gives an example of a similar process from a European perspective, showing how life in rural areas has changed dramatically over the last fifty years through highly positive societal actions.

Box 2. A vision of hope

In the 1950s, it was possible for a person in the UK to move from being a farm labourer who kept poultry broilers as an additional source of income to running his own farm. These social opportunities allowed people to move upwards in their own lifetimes, and encouraged them to continue doing agriculture or seek alternative economic activities.

What do livestock producers in today's LICs need to be able to experience the same type of dynamism that created so many opportunities in Europe? Six critical elements are identified: (i) good education of livestock producers; (ii) strong extension service; (iii) strong public research to improve livestock and land productivity; (iv) subsidies to promote new technologies; (v) agricultural price support; and (vi) a growing economy that creates jobs and brings people from the land.

Not all of these factors are realistic, particularly not in LICs. But in an increasingly connected world, where technologies – from market management to scientific nutrition investigations – can be rapidly transferred and used, we need to investigate how to help livestock producers in changing environments. We have to look forward and avoid rooting ourselves in strategies that were developed for limited markets many years ago. If the Sustainable Development Goals are to be achieved, we need to act as scientists in bringing technologies to producers, helping them to adapt and improve their strategies in an era of new market opportunities.

(Adapted from Rushton, 2006)

3 Animal health leads to poverty reduction and better human nutrition

What are the gains from investing in animal health systems for poverty reduction and nutrition security? A review has been carried out to address this question. We have gathered data and information from scientific publications, official reports by major organisations, as well as information gathered directly from websites of various organisations. Books were consulted as reference materials.

3.1 How can public goods be funded?

Animal health services include disease surveillance, control and prevention in livestock (Umali *et al.,* 1994). In SSA, control of the major contagious diseases was influenced strongly by the public sector until the late 1980s (de Haan and Bekure, 1991). During a more recent period of structural adjustments, most governments implemented drastic budget cuts, and the quality of publicly provided services was affected (Cheneau *et al.,* 2004). Animal health services, being essential for disease control (Holden, 1999), were redirected towards a model of privatisation in many LICs (Cheneau *et al.,* 2004).

Economic theory supporting this drive was based on the idea that efficiency and effectiveness of veterinary services were likely to improve if the private sector could supply both private and certain public goods (Holden, 1999). However, the role of the private sector has remained largely unchanged in many LICs, and there is relatively little evidence suggesting that the delivery of veterinary services has improved (Holden *et al.,* 1996; Onono, 2014; Ilukor *et al.*, 2015; Suleiman, 2015).

It is recognised that improvements cannot be made solely through privatisation. Instead, efficient delivery requires a degree of "organisational pluralism", involving both the public and the private sectors (FAO, 1997). The state may support an efficiently operating private sector by setting, monitoring and enforcing standards, and by making this information available to the public. On the other hand, the public sector can retain responsibility for planning the delivery of

public good services, and for its management through private suppliers (Holden, 1999; Ahuja et al, 2009).

Due to this drive for change, the veterinary services in LICs were subjected to structural and fundamental alterations, resulting in privatisation and decentralisation (Cheneau *et al.,* 2004). With varying degrees of success, governments promoted a shift towards privatisation and removed barriers to entry. They established effective legal frameworks to enforce particular activities, subcontracting services to the private sector, promoted livestock insurance plans and created an enabling environment for smallholder producer organisations.

Targeted subsidised delivery has been explored in areas where animal health services are necessary but unprofitable to private providers. Community animal health workers can provide most tasks in preventive services, and perform simple clinical procedures. They cost less than veterinarians, their services are more affordable to farmers, and they can provide LICs with more veterinary personnel (Cheneau *et al.,* 2004). In reality, this also seems to be the norm, yet adequate provision of technology and knowledge to farmers remains a problem (Onono, 2014; Ilukor *et al.*, 2015; Suleiman, 2015)

For countries where privatisation has not been yet fully or partially implemented – i.e. cases where "private" animal health are still being provided by the government – Holden (1999) proposed three ways to control the consumption of publicly provided private goods: rationing through user charges, uniform provision, and queuing. Farmers' organisations can play a valuable role in financing and delivery of a range of toll good services (Holden, 1999). Membership fees allow an association to hire veterinarians (and community animal health workers) to provide animal health care to all members (Umali *et al.,* 1994). Dairy cooperatives in particular often have a sufficiently large capital base enabling them to provide diagnostic laboratories, veterinary clinics, and other toll good services. Pastoral associations have been particularly successful in delivering veterinary drugs and health care in remote areas that might not otherwise attract private practices (Holden, 1999).

Interestingly, these theoretical views have not necessarily been translated into adequate service provision over the last two decades. In Uganda, Ilukor and Birner (2014) found that service delivery could be effective when community animal health workers identified diseases

and prescriptions. But they needed much closer working arrangement with veterinarians who performed the actual treatments. In Kenya, most of the advice sought came from pharmacists who often had inadequate supplies of medicines and poor levels of knowledge (Onono, 2014). The management of technologies such as vaccines through the public sector was part of the problem.

The financing of public goods must be of public origin, even if the actual delivery of goods or services may be subcontracted to private providers (Riviere-Cinnamond, 2004). At this level, regulation and enforcement is of crucial importance to guarantee the quality. Overall, there is still much discussion on how veterinary services can be updated and improved. Ilukor *et al.* (2015) found that problems of salaries undermined effective delivery in Uganda. In Kenya and Nigeria, government's role in the manufacture and provision of vaccines is limiting supply at points of need; governments are therefore strongly recommended to focus on coordinating disease control programmes rather than on acting as sole providers of technologies (Onono, 2014; Suleiman, 2015).

In terms of essential investment, there is room for reflection on how veterinarians are educated on disease management, both at the undergraduate and continuous professional development level. This education must reflect the demands of public administration to get budgets accepted by the government, and ensure that budgets are maintained and increased in pace with inflation. Without these basic administration skills, a public veterinary service will always have difficulties in retaining good people – and rewarding them adequately with work and salaries that reflect their importance as coordinators of disease management in society. Investment in people and their skills is a critical aspect of any veterinary service, without which there is little possibility of managing contagious disease (Rushton, 2008, Tisdell, 2009). It requires significant financial and logistical support to develop a cadre of educated animal health specialists who can carry out research and implementation. Specialists also need a functioning infrastructure to be able to coordinate surveillance, prevention and control of contagious and zoonotic diseases. This control generates significant public goods, and affects the health, nutritional status and welfare of citizens in LICs.

3.2 Poor farmers investing in animal health

Animal diseases are a major constraint on income generation for the poor. Their financial resources for health measures are limited due to low incomes, few assets, and limited access to credit or insurance leave (FAO, 2002; Upton, 2012). In low-income settings the death of a single animal can have dramatic consequences for a vulnerable family. Animal diseases are killing around 18 per cent of the livestock population in these countries (Pradère, 2014), compared to 5 per cent in young animals and 2–3 per cent in adult animals in the UK (Nix, 2015). One could assume that farmers' willingness to invest into animal health is being hindered only by a lack of funds. Although financial resources appear to be the main factor influencing coping capacity and willingness to pay for animal disease problems a range of other factors also seems to be at work.

Farmers' willingness to invest in animal health has been ascribed to sex, age, education level and preferred means to receive extension services (Mwaura *et al.,* 2010). These aspects probably have an effect on a seemingly primary causal factor: how benefits are perceived (FAO, 2002). For example, if farmers do not understand the potential benefits, they might demand less services than anticipated. Education is often a major constraint on the uptake of extension services and disease control. Demand could therefore be increased if governments or other agencies ran these programmes with educational components.

Furthermore, farmers' reluctance to invest in animal health increases in travel distance. Accessibility seems to be a determining factor for the demand of veterinary services (FAO, 2002; Mwaura *et al.,* 2010; Umali *et al.,* 1994). Transport infrastructure is often poor in LICs, and many farmers, especially in remote rural areas, do not have smooth access to animal health services. Transport costs are quite high for livestock owners bringing animals to veterinarians, and for providers travelling to inspect animals (FAO, 2002). Africa's road density is sparse. In rural areas, only one third of the population live within two kilometres of an all-season road, compared to two thirds in other LICs (WB, 2013a).

Other non-demographic factors influencing farmers' willingness to pay for animal health include the quality of veterinary services, animal species and breed, herd size and the nature of a potential or actual disease, production systems, and the relation between possible benefits and actual costs (Mwaura *et al.,* 2010; Umali *et al.,* 1994).

A study from Nigeria showed that farmers were willing to spend money on extension services for homestead fish production and in poultry and piggery, but they were not inclined to pay for techniques in animal feed formulation and in sheep and goat production (Mwaura *et al.,* 2010). Farmers seem more concerned and more motivated to reduce the effects of endemic diseases, and less concerned about occasional epidemics (Leidl *et al.,* 2004). Farmers in high-density, cattle-fattening areas are more inclined to demand preventive services, because the risk of disease outbreaks seems higher (Umali *et al.*, 1994).

The size of a farm has an impact on the willingness to pay. Often, for example, only large-scale farmers can afford private veterinarians to vaccinate their animals, while small-scale farmers still rely on governments. Farmers' decisions also depend on whether the service is perceived as a public or a private good (Umali *et al.,* 1994).

When focusing on SSA, however, demand for veterinary services was increasing during the major rinderpest control campaigns, according to reports, as traditional herders became more aware of the benefits of disease management (de Haan and Bekure, 1991). Livestock have become more diversified, and nowadays the importance of disease control is recognised. Animals have also been moved to more disease-prone regions, a fact that has increased farmers' willingness to pay for health services. Finally, a steadily rising demand for milk and meat has led to intensified production which seems to have increased demand for veterinary services.

The above evidences the importance of farmers' access to technology and information and their willingness to pay for such goods and services if available. In many situations access is hindered by public policy, and farmers need to perceive benefits of investing into animal health. The willingness to pay might therefore be increased by setting up veterinary centres run by community animal health workers, centres that also could specialise in the problems and diseases of the home region. Yet, as Ilukor *et al.* (2015) have indicated, supervision is needed in order to uphold appropriate levels of treatment delivered by paraprofessionals. Additional local centres make it easier to gain farmers' trust and easier to educate them on the benefits of animal health services.

Effective coordination between public and private sectors is very important. This comes out clearly in studies from India (Ahuja *et al*., 2009) and more recently from Africa (Ilukor and Birner, 2014; Ilukor

et al., 2015). People working in the veterinary services must understand their critical roles, and comprehend that effective implementation of disease management is generating both private and societal benefits. Achievements will be undermined, however, if salaries and budgets are inadequate, making it hard for public veterinary services to deliver the critically needed coordination.

3.3 Economic gains from investments in animal health

The gains from investments into animal health are not always apparent and not always monetary. Farmers may enhance their own production by ensuring their animals are healthy and by taking preventive measures (de Haan and Bekure, 1991). Treatment costs are usually exceeding prophylaxis costs, but the risk of disease in their home region will influence to what extent preventive measures are cost-beneficial.

Very few attempts have been made to calculate the economic benefits of disease management and improved animal health. A study by the WB (2011) documented losses by counting how many animals that died due to disease. Yet these estimates were based on official data held at global levels, and they were heavily skewed by reporting bias and owing to a focus on notifiable diseases. There is a dearth of information on endemic, non-notifiable diseases that are of great concern for many small-scale poor producers.

Despite this lack of hard evidence, we know that diseases do have a major impact on resource-poor livestock producers, and that zoonotic diseases (spreading from animals to humans) present particular risks (Upton, 2012). Zoonoses can cause fatal or disabling sickness in human livestock producers, they can impose costs through losses in animal productivity and costs of veterinary interventions – and lead to lower producer prices (Rushton, 2013; see also section 4.1.1 in this report). Overall, by preventing animal disease through investing into animal health measures, the farmers' personal health will improve; it will also be beneficial to further livestock production, and to consumers, traders and labourers (Omore *et al.,* 2000; Randolph *et al*., 2007). The risk for diseases is preventing poor farmers from making the modest investment required to take advantage of technological advances and improve the productivity of animals (Pradère, 2014).

Health investments will also have positive impacts on trade; while trading sick animals from a single farm might result in an overall ban for a whole country (Pradère, 2014; FAO, 2002; see also section 4.2 in this report). A ban would be especially damaging for SSA, where live ruminant export are a major source of trade (Upton, 2012), albeit not to EU countries.

Further gains can be obtained through production increases: healthy animals give more meat, milk, or eggs and have superior reproductive capacity. Animal health investments will thus result in increased household income. Combatting animal diseases with their multiple direct and indirect effects on human welfare (FAO, 2002) requires that farmers take into account the risks, adapt their own behaviour accordingly, and invest in animal health.

3.4 Food security in vulnerable communities

The World Food Summit of 1996 defined food security as existing "when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life" (Njuki and Millar, 2012). Livestock play an important role through the production of meat, milk and eggs. They also deliver non-edible products, such as hides and skins, and provide animal draught, manure and other critical inputs to crop production (Knight-Jones *et al.*, 2016). Overall, livestock contribute to food security in a number of ways. Their ability to do so is compromised by the presence of disease.

Some products are sold and others are consumed within the household. The income from sales may be used to buy food (Upton, 2012). Non-food items provided by livestock draught power and manure make it possible to sustain crop production. The animals also help to maintain soil fertility (Pradère, 2014). Hence, animals are not only a guaranteed source of protein. They also impact on the availability and sustainability of other food items, either produced by the livestock keeper or purchased. A continuous production of meat, milk and eggs provides some assurance against failure of other food resources (Upton, 2012). Therefore, the death of one single animal can have dramatic consequences for a vulnerable family, especially in LICs where poor farmers are pastoralists or living off a mix of crop and livestock farming (Pradère, 2014). Thus, crop production is closely interlinked with livestock production.

One of the main purposes of animal health systems is to improve animal health in order to increase production and hence human nutrition and welfare, as well as ultimately contribute to human health (Riviere-Cinnamond, 2004; Holden, 1999). Thus, livestock and hence healthy animals are keys to food security, directly or indirectly, especially in LICs. Subsequently, the benefits of healthier animals would have far-reaching consequences for food security in those countries.

3.5 Micronutrient deficiency, women and children

Micronutrient deficiency – "hidden hunger" – afflicts 2 billion people, mostly in SSA and South Asia, but has over the years been overshadowed by hunger caused by lack of calories (FAO, IFAD, WFP, 2014). However, in the SDGs, specifically SDG 2, the nutritional aspect of food security is stressed by the words "… *and improved nutrition*". Animal source food is not only rich in proteins and energy, it is also a major source of essential micronutrients. Diseases that lower animal productivity and production, and thereby reduce access to such food, are thus a significant driver for hidden hunger among the poor.

Hidden hunger occurs when the intake of vitamin A, zinc, iodine, iron and other micronutrients is too low for human well-being and good health. This happens especially at certain life stages, such as pregnancy, lactation and infancy (Darnton-Hill *et al.,* 2005). Micronutrient deficiency causes, for instance, 1–3 million deaths among children every year, according to estimates (Black *et al.,* 2008). In addition, lack of zinc, iodine and iron reduces growth and leads to stunting in children and prevents them from reaching their intellectual potential (for an overview, see von Grember *et al*., 2014, and WHO, 2016). Impaired learning is not only an individual tragedy. It is also something that affects society as a whole, an economic toll that perpetuates poverty. India, for instance, is probably losing around 1 per cent of its GDP due to micronutrient deficiency (Micronutrient Initiative and UNICEF, 2004).

Animal source foods contribute to healthy and balanced diets for producer households, adding to the supply of food energy, digestible animal protein and micronutrients (Upton, 2012). Eighteen per cent of global consumption of calories and 25 per cent of global protein

consumption come from these foods (FAOSTAT, 2012; Rushton, 2013), resulting in better food security, and less frequent cases of anaemia, stunting, blindness, illness and even death, when fewer families are deficient in protein, energy and micronutrients (Njuki and Millar, 2012). Children in particular seem to benefit from home consumption of livestock products such as milk, eggs and meat occasionally (Upton, 2012). Milk from ruminants, for example, increases linear growth and reduces stunting after weaning (Njuki and Millar, 2012).

However, Africa is one of the world's most food-insecure regions, and malnutrition is a heavy burden (WHO, 2015b). WHO (2016) has defined nutrition as "the intake of food, considered in relation to the body's dietary needs". Poor nutrition can lead to reduced immunological competence, increased susceptibility to disease, impaired physical and mental development, and reduced productivity. As mentioned earlier, livestock keeping contributes to increasing crop yields and production. Healthier animals will produce more and prices will be lower. Affordable food improves nutrition in more low-income households. Consumers may strengthen their welfare by facilitating livestock farming that delivers stable and safe food supplies (Rushton, 2013).

One of the main purposes of animal health systems is to increase animal production and thus human nutrition and welfare, and ultimately strengthen human health (Riviere-Cinnamond, 2004). Having proper animal health services in place will ultimately lead to improved food safety and thus better nutrition for women at reproductive age and children during development.

Malnutrition is also caused by other factors, for example non-wholesome food, so increased food production is not the only solution. Surveys have found that inadequate nutrition knowledge and traditional methods of food preparation and preferences by women lead to poor-quality feeding practices in both rural and urban areas (Njuki and Millar, 2012). It is therefore essential to target resources and to give proper training. Women's role as producers, processors and especially purchasers of family food and preparers of animal source foods means that they are a natural target group for nutritional campaigns. Especially since women and children are also in charge of the management and care of livestock (FAO, 2002), and since they often belong to established community groups, allow for effective

communication on animal health extension. Training them will have a positive snowball effect on nutrition.

Strengthened dietary diversity – i.e. moving away from food from a few staple crops to a more varied diet with fruits, vegetables and animal source foods – is put forward as one of the most sustainable and effective ways to prevent hidden hunger (Thompson and Amoroso, 2010). Access to animal source food is a major element in this quest. Once again, reassuring good productivity in the livestock sector – for smallholders as well as for larger operators – through good animal health is crucial to making this food more available.

To conclude, investments in an animal health system pave the way for livestock productivity gains and for a more stable agricultural production in general. The animal products provide a basis for economic activity. Jobs are created, wealth is generated and poverty is combatted. Animal products also mean that food containing important macro- and micronutrients becomes available, and that nutritional security is enhanced.

4 Other aspects of animal health and human development

4.1 Consequences for human health

Livestock health is related to human health, both directly and indirectly. Animal health, including transmission of zoonotic agents and antimicrobial resistance between animals and humans, is embraced by the "One Health" concept (for an overview, see OIE, 2014). Human health is affected when animal diseases are impairing livestock productivity and production, thereby reducing access to highly nutritious animal source food, especially for households dependent on self-sufficiency that are common in LICs. Micronutrient deficiencies have detrimental health effects, especially for women and children. Obviously, poor animal productivity is thus a driver of poverty and ill-health for families depending on livestock.

4.1.1 Zoonoses: many routes of transmission

Zoonoses are infectious diseases that can be transmitted from animals to humans and vice versa. The infectious agents – parasites, bacteria or virus – may reach humans via direct contact, respiratory droplets, vectors (i.e. insects or ticks), food, water, or through the environment in general. Two-thirds of our infectious diseases originate from animals, and a recent estimate states that three-quarters of emerging human infections have their origin in animals (Cleaveland *et al.,* 2001; Woolhouse and Gowtage-Sequeria2005; Jones *et al.,* 2008). Generally, people in LICs are most at risk for zoonotic diseases, as they are in closer contact with livestock and often live under poor sanitary conditions.

Some zoonotic agents are more relevant in LICs than in high-income ones and they may have different routes of transmission. For instance, diarrhoeal diseases may be contracted via consumption of food or water contaminated with salmonella or campylobacter, tuberculosis or brucellosis from consumption of milk containing bacteria, and different parasitic diseases from consumption of meat, vegetables or water containing the parasites. The risk of attaining food- or water-borne zoonoses can therefore be reduced by public and individual safety measures along the food chain. Such measures are typically applied in high-income countries, but less so in LICs.

Another infection route is the inhalation of respiratory droplets produced by coughing or sneezing. Influenza virus is transmitted in this way, and the risk of transfer to humans is higher if animal and human populations of high densities are living closely together, which is not an uncommon situation in LICs.

Zoonotic agents may also be transmitted by direct contact. The main groups at risk here are farmers, veterinarians, butchers and slaughterhouse personnel. Typical bacterial diseases spread by this route are leptospirosis and brucellosis that cause fever, joint lesions and kidney illness.

Other important routes of transmission are via arthropod vectors such as insects and ticks. A significant mosquito-borne viral zoonosis is the Japanese encephalitis in the southern and eastern parts of Asia. Pigs are important hosts for the virus, and the combination of pigs and mosquitoes is a requisite for posing humans at risk. This occurs in

rural areas and in cities where urban animal farming is practiced – the latter is more frequent in economically less advanced regions.

Finally, zoonoses may originate in ambient environments that have been contaminated with infectious agents from animals. The mortal and highly resistant bacterium anthrax, which can survive in the soil for decades, is a classic example. Farmers exploiting the land in areas where the disease has killed livestock, and where the animals are buried, are those most at risk.

There are several factors that may increase the risk of transmission of zoonozes. One driver – not specific for LICs – is changing farming practices or localization of livestock operations. This was probably a major factor behind the Q-fever outbreak in humans in The Netherlands around 2007. This outbreak was associated with increasing density of goats in some areas of the country and with expanding goat farms over several years (Roest *et al.*, 2011). Another example is the Nipah virus epidemic in Malaysia in the late 1990s, in areas with fruit trees and where intensive pig farming had developed more recently. Bats that are natural reservoirs of the virus were attracted to the farms and ate the fruit in the trees. Partly eaten and virus-contaminated fruits fell down into the sties, the pigs ate them and some contracted the Nipah infection. Infected pigs could then transmit the virus to farm labourers who developed a mortal neurological disease (Ksiazek *et al.*, 2011).

Urbanization is another driver of disease emergence in LICs. Rural dwellers often bring some of their farming practices when moving to cities where they may continue to keep livestock (including poultry). This has positive implications as it improves food security and provides an income (Magnusson and Follis Bergman, 2014). However, since the food market is often local, products reach many customers through informal urban markets where poor hygiene heightens the risks for transmission of zoonotic agents. This is not true for animal source food only, but also for vegetables contaminated by manure or wastewater.

Keeping livestock at high densities in urban areas and in close contact to humans creates additional risks. As mentioned, pigs are a reservoir of the mosquito-borne Japanese encephalitis virus in Asia. By keeping pigs in urban areas, the density of mosquitoes carrying the virus may increase, thus putting humans at risk (Lindahl, 2012). Similarly, the practice of raising, marketing and slaughtering poultry in

urban areas has created major concerns about how to manage highly pathogenic avian influenza (ElMasry *et al.*, 2015).

In some cases, as with the severe acute respiratory syndrome (SARS), which emerges from wildlife, and the so-called swine influenza (H1N1) derived from domesticated animals, globalization is a major factor. In 2003, SARS was reported in more than two dozens countries on four continents before it was contained (CDC, 2004). The H1N1 virus spread quickly across the world, generating a range of responses and ultimately establishing itself in humans.

The means to reduce risks of transmitting zoonotic infections to humans are similar to those for infections between animals. Reducing disease in livestock populations is a primary task as this has been proven highly cost-effective (Zinsstag *et al.*, 2007). However, in addition it is critical to bring down the risk of human exposure – through improved risk management at farm level, greater understanding of the hazards faced by veterinarians and auxiliary animal health staff, and keeping livestock and their wastes at a distance from human living spaces. Transport, marketing and processing systems must maintain high levels of health management and hygienic practices as regards food safety.

At the end point of the system, catering establishments and households need careful handling, preparation and storage of foods. The rising importance of food-borne pathogens (for example salmonella and campylobacter) must be recognized. Lessons from the management of food-borne zoonotic agents in high-income countries could be translated into LICs in order to avoid potential new problems and to address existing ones.

One major aspect of zoonoses is the level of impact they cause in livestock populations. For example, cysticercosis in pigs does not cause clinical disease or significant production losses. Presence of the parasite is discovered on inspection of the meat, and this information should be transferred to the consumers to urge them to thoroughly cook the pork before eating. Usually, in LICs the incentives to manage zoonoses are low at farm level. Even a clinical disease such as brucellosis in cattle, may have insufficient farm-level impacts to economically justify investments in disease management. This zoonosis is generated in the livestock and may cause severe disease for workers in the food system and for consumers of animal source foods.

These negative externalities need to be recognized across the food system, either by government regulations and enforcement or through private standards. Farmers should feel the pressure to manage the zoonotic diseases in a way that limits wider social damage. Institutional changes often need support from technical interventions – such as vaccination, biosecurity measures, and removal of diseased animals in certain cases.

Coordination of disease control is a complex matter. It generates public goods for society as a whole. Consumers are provided with healthier food, processers and traders are less exposed to biological and financial risks. Producers will probably benefit in terms of productivity change and from reduced personal risks. A successful campaign against zoonoses often demands public funding and coordination. Swedish support for the management of the avian flu (H5N1) a decade ago is a good example, as it contributed to reducing the consequences of the flu (FAO, 2013b).

It is generally agreed that zoonoses with a potential to spread over several countries and even larger regions (pandemics), are most effectively managed and controlled at the source, i.e. in the animal populations and in the countries most badly affected. Thus, there are many good reasons for investing in control of zoonotic diseases in livestock in LICs.

4.1.2 Fighting antimicrobial resistance

Since their discovery last century, antimicrobials have had tremendously positive effects on the health status of humans and domesticated animals. In the livestock sector, antimicrobials may be used for prevention and cure of infections as well as for general growth promotion. Improved animal health has contributed to better productivity, and hence more accessible and affordable foodstuffs (Rushton *et al.,* 2014). The latter has been particularly prominent in LICs, where improved food and nutrition security, at least partly, is a result of consumers' access to highly nutritious animal source foods (Pingali and McCullough, 2010).

However, there have been rising concerns about the gradual evolution of antimicrobial resistance (AMR) threatening the ability to fight infections (Nathan and Cars, 2014). The resistance respects neither national nor species borders (Laxminarayan *et al.,* 2013;

Robinson *et al.,* 2016). Today, AMR is an urgent global and cross-sectorial issue, as reflected by a tripartite agreement in 2015, between WHO, FAO and OIE, on adopting action plans for fighting AMR (WHO, 2015a; FAO, 2015; OIE, 2015).

There is considerable evidence of a relationship between antimicrobial use in livestock and AMR, even though a few researchers are challenging this link (cf. e.g. Hao *et al.,* 2014). A European report based on data from seven countries described a direct correlation between antimicrobial use and AMR (Chantziaras *et al.,* 2013). Data on antimicrobial use in livestock in LICs is either not available or sparse, and associated data on AMR are also poor (Rushton *et al.,* 2014). Still, there is an urgent need for a moratorium on non-rational use of antibiotics in animals. Regulations must be combined with improved animal health services, improved herd management for biosecurity, and disease-prevention and related actions (Wierup, 2000; Postma *et al.,* 2015). If these measures are not implemented together, livestock productivity will risk falling, especially in intensive poultry and pig production systems (Van Boeckel *et al.,* 2015). An even greater concern is that disease control will be affected. Overall, the combined impacts of emerging AMR, reduced livestock productivity and higher levels of diseases will have severe consequences across the livestock sector – and for the health, nutritional status and welfare of humans.

In 1986, Sweden was the first country in the world to ban the use of antibiotics as growth promoters in animal feed. Other European countries eventually followed suit, and in 2006 antibiotics as growth promoters were banned across the EU. Today, Sweden has the lowest consumption of antimicrobials per unit of livestock biomass in the EU, and a relatively low frequency of AMR (Garcia-Migura *et al.,* 2014). However, after the ban in Sweden, there was a temporary increase in the rate of infections in pig herds, followed by increased therapeutic use of antibiotics and lowered productivity. These negative effects were transient, and a recovery was seen after a few years (Wierup, 2001). Similar observations have been made in Denmark (Aarestrup *et al.,* 2010).

One lesson from this success story is that a reduction in antibiotic use can be implemented without severe long-term effects on poultry, beef or pig production – if matched by appropriate management and disease-preventive measures.

Before beginning to implement change, data on the current levels of antimicrobial use in livestock are needed. As mentioned above, there are major limitations on the data available for most countries in the world. Even in countries where data exist, there are difficulties in establishing standardized systems of monitoring, and how the results should be expressed. The EU is leading the way (ESVAC, 2013; EFSA, 2012) but is also showing shortcomings in resolution (Rushton *et al.,* 2014).

At a global level, an OECD-funded study has attempted to estimate the use of antimicrobials in livestock, and the findings have been visualized in maps (Van Boeckel *et al.,* 2015). This attempt is based on data from only 32 countries but the study also makes significant assumptions on other countries where most of the global livestock are found.

It is extremely difficult to get a reliable global picture of the prevalence of AMR in livestock. Data are incomplete, different microbe and livestock species are investigated, and different methodologies are applied for detection.

General statements about AMR are also hampered by the fact that resistance is varying with each individual pharmaceutical. There are gaps in the scientific literature around links between farming practices, animal health systems, antibiotic consumption and occurrence of AMR. Despite the lack of reliable data, AMR must be combated on a global scale. Microbes and genes may well travel from one country or continent to another. National and regional actions are necessary, but far from sufficient; there has to be coordination. Furthermore, regulations must also be nationally feasible as implementation and enforcement is frequently a challenge (Pagel and Gautier, 2012).

Successful global actions – involving the LICs – are hampered by severe knowledge gaps due to the lack of global, uniformly applied methodology for detecting AMR. The scope of currently available data does not allow for any analysis of the impact of specific knowledge, or analysis of attitudes or practices at farm level related to the use of antibiotics and to resistance. Even so, one may assume that risks are much higher in low-income and middle-income countries – where there is an increasing and intensifying livestock sector and frequent use of antibiotics – than in LICs with extensive livestock systems.

In conclusion, more global data are urgently needed. Still, reducing AMR and the risk involved for human and animal health should be viewed as an integral part of animal health systems. Cost-efficient livestock health management and biosecurity measures reduce non-rational use of antibiotics. These measures must be made available also to LICs as they are imperative for human and animal health on a global scale.

4.2 Consequences for international trade

The global food economy and trade are to a large extent driven by a diet-shift away from staple foods towards consumption patterns that include livestock products. For instance, in the emerging economies of Asian LICs meat consumption has increased considerably in the last decades. In Vietnam, poultry consumption has increased by more than 300 per cent just in the last ten years, and pork consumption by almost 50 per cent. However, such dramatic changes are not seen in SSA (OECD, 2016). These figures may be translated into an enormously expanded trade – the global export volume in poultry meat increased by 750 per cent from 1967 to 2007 and in pig meat by more than 3 000 per cent (FAO, 2011).

The most recent estimates (for 2013) of the value of trade in livestock and livestock products amount to 234 billion USD (FAO, 2016). The top beef exporters in 2015 were India, Brazil and Australia, the leading pork exporters were the EU, the United States and Canada, and the top exporters of chicken broiler meat were Brazil, the United States and the EU (USDA, 2015). Figure 7 shows the major trade routes.

Figure 7. Major livestock product trade routes

The increasing international trade by emerging and transition economies, such as Brazil, China, India, South Africa and Russia[1], will undoubtedly alter the rank of importers and exporters in coming years. Notably, the position of India is mainly due to inclusion of buffalo meat on export to Southeast Asia, the Middle East and North Africa.

Most of this trade in livestock and livestock products are regulated by the World Trade Organization (WTO) agreement on application of sanitary and phytosanitary measures (WTO, 1994). One statement says: "…no Member should be prevented from adopting or enforcing measures necessary to protect human, animal or plant life or health…"

The WTO is aiming for a multilateral framework for sanitary standards, but it acknowledges that several trade relationships are based on bilateral agreements or protocols. The organization and its member states have two assisting organizations in the sanitary safety area. One is "The Codex Alimentarius", established by FAO, and WHO to develop harmonized international food standards in order to

[1] Prior to political embargos.

protect consumer health and promote fair food trade. The second is OIE, which safeguards world trade by publishing health standards for trade in animals and animal products. OIE produces normative documents and serves member countries wanting to protect themselves from diseases and pathogens without setting up unjustified sanitary barriers. Its efforts may also serve as a basis for multilateral and bilateral trade negotiations.

As there are substantial differences among countries regarding their animal health systems and animal disease status, WTO/OIE agreements may create issues for exporters of livestock or livestock products. Typically, an African low-income country affected by the highly contagious foot-and-mouth disease is not allowed to export livestock or livestock products to the EU (where this particular sickness is absent) without creating disease-free zones and deboning the beef.

Access to markets with better prices therefore requires investments in animal health systems, and in the proper processing of animals and carcasses. In addition, livestock and production systems need to be upgraded in order to produce animals able to achieve weights and carcass qualities that would provide the high-value cuts demanded in lucrative (higher-income) markets. Such major changes are definitely possible, as demonstrated by exporting countries in South America and by the success of a few African countries such as Botswana. However, they require medium- to long-term commitments: exporters must make investments in people, systems and infrastructure to support the livestock sector.

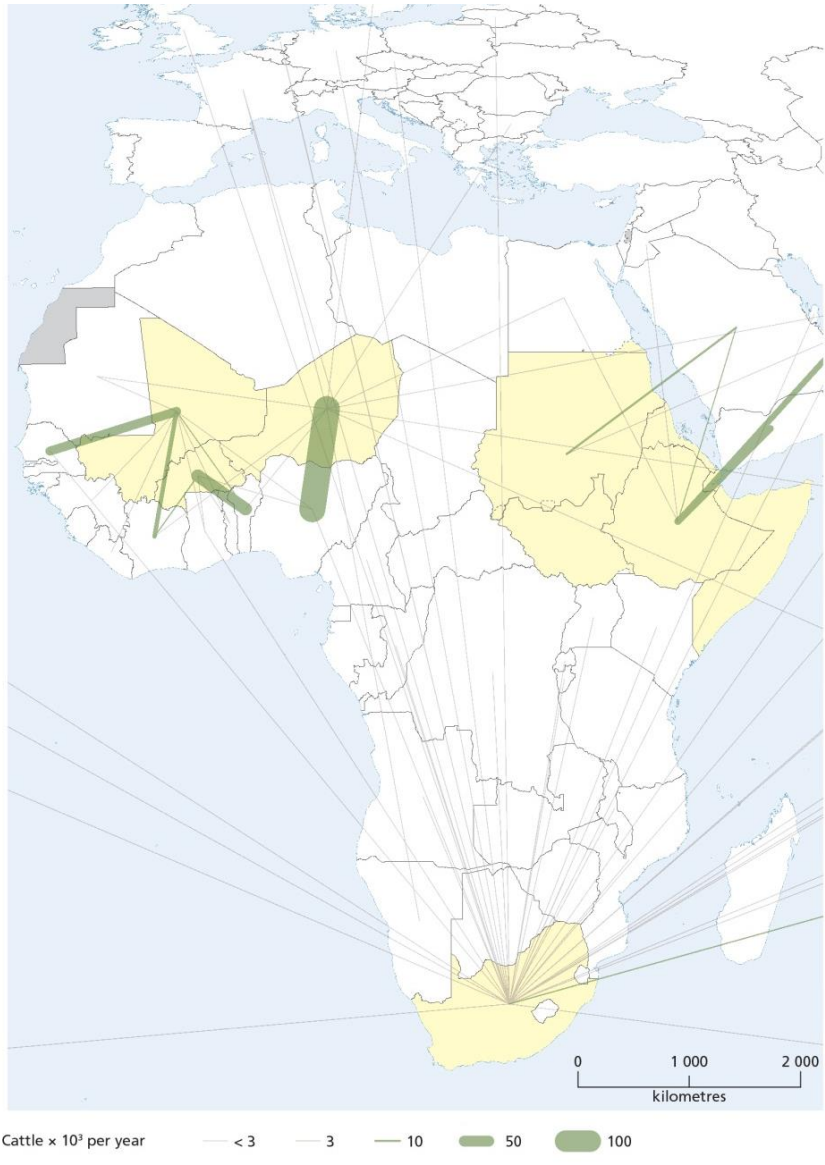
Without investments, the foot-and-mouth disease will continue to cause production losses and costs of vaccination amounting to between 6.5 and 21 billion USD annually, according to estimates (Knight-Jones and Rushton, 2013). Most of this impact occurs in LICs.

Countries that do not meet the animal disease status for export to lucrative markets in Japan, North America and the EU are involved in regional trade of livestock and livestock products. As these countries have a similar animal disease status, the question is whether this trade is hampered by the regulations. In Africa for instance (with the exception of South Africa, where foot-and mouth-disease is absent), there is considerable trade in live cattle between countries (Figure 8).

There is also some informal trade not reflected in official statistics. One example is the cross-border trade between Ethiopia and Somalia, claimed to be an important part of the livelihood for millions of people, where pastoral communities, traders and intermediaries are exchanging 2 to 3.5 million ruminant livestock per year (FAO, 2012). This regional trade in the Horn of Africa is one of the largest global movements of live animals for export. Transmission of infectious animal diseases is an apparent risk in such unregulated environments.

All in all, there appears to be a potential for increased exports of livestock and livestock products – and for economic gain – for LICs that manage to eradicate and control diseases found on the OIE "blacklist" – i.e. diseases that are legitimate causes for banning import of livestock and livestock products (OIE, 2016b). This demands, however, strengthened animal health services and institutions including operative border control, functions that are typical public goods. Notably, fulfilling these requirements is not an absolute guarantee for being able to export. Importers often have their individual requirements on the product, "private standards" that must be met by the exporter.

Figure 8. Export of live cattle within Africa and African export to other countries, 2007–2009



Source: FAO (2013a). Reproduced with permission.

4.3 Consequences for, and of, climate change

Climate change can impact on animal health, and animal disease may influence the climate. Consequently, livestock health interventions must include impacts on climate change as well as protecting animals to improve productivity and welfare (Forman *et al.*, 2008). Higher productivity per animal could have a positive, general impact on emissions of greenhouse gases per unit milk, meat or egg produced (Steinfeld and Gerber, 2010). Notably, the social, economic and food security dimensions of livestock in LICs may encourage governments to turn a blind eye on emissions. Navigating between different objectives in low-income versus high-income countries is not a simple task (Herrero *et al.*, 2013). Yet improved animal health status should, in all cases, be a point of departure for improving output per animal and thereby reducing emissions of greenhouse gases.

The spread of infectious diseases – or transmission dynamics – can be affected by climate change in several ways (Lubroth, 2013). Modifications in infectious agents' host or vector distribution are critical factors. Changes in the density and number of vectors causing an animal disease in new regions open the potential that diseases will emerge in more aggressive clinical forms in non-immune livestock populations. Infectious disease is not the only concern here; heat stress and other metabolic diseases can also affect reproduction (Renaudeau *et al.*, 2012). In times of drought, minor or severe, there will be reduced access to feed or water – with obvious negative consequences for animal production and welfare; with possibly greater problems of animal health; and with impacts on food supply and wealth generation.

The conclusion is clear: when considering interventions to improve animal health in LICs, climate change must be taken into account.

The contribution from the livestock sector to anthropogenic emissions of greenhouse gases is probably considerable; recent calculations suggest 14.5 per cent of the total (HLPE, 2016). Hristov *et al.* (2013) indicates, in an extensive review, that enhancing livestock productivity would be the most efficient strategy to reduce emissions from this sector in most countries. And improved animal health has recently been assessed as one of the most effective approaches for reducing emissions per unit of product (Herrero *et al.*, 2016).

The relation to climate change has perhaps been oversimplified in the current discussion on emergence of animal diseases. Several other drivers for altering the disease landscape are acting in parallel – globalization, urbanization, altered human diets, and changing farming practices, etc. – so it might be difficult to dissect the climate dimension. Still, there is no doubt that climate change is a game changer for agriculture at large, including livestock production and health (Thornton *et al.,* 2014; World Bank, 2012). And the challenges – including that of animal health status – are probably greatest in LICs, where agriculture is the mainstay and where the adaptation to a changed climate need to be substantial (Thornton *et al.,* 2011). Increased economic, policy and institutional support will demand a considerable resource mobilization in these countries.

5 Overall assessment

Sections 3 and 4 provided a broad background showing the importance of livestock to people in LICs, and underlined the need for a health service system to ensure animals are sufficiently free of disease and as healthy as possible. Answering a series of questions, it becomes clear that public investments are needed to support effective services. Recent policy experiments with privatization of animal health service delivery have not resolved perceived system inefficiencies, nor have they improved the management of contagious diseases in animals (Ilukor *et al.,* 2015; Ahuja *et al.*, 2009).

In addition, after the major push towards private service delivery other important developments have occurred. We have seen major changes in the numbers of livestock, in the species balance, systems in which they are kept, and the value chains they are associated with. This has generated a series of disease issues. Some are re-emerging problems, while others are new and affect not only animals but also the health of many people across the world. The most obvious example is the highly pathogenic avian influenza. Yet this flu will become insignificant if there is no response to the constantly emerging antimicrobial resistance.

An adequate provision of animal health goods and services frequently requires government action, as they generate benefits that cannot be entirely captured ("internalized") by the provider (positive external effects). For example, the control of a contagious condition

like foot-and-mouth disease generates benefits to the owner of cattle, sheep and pigs where the control takes place. At the same time, this control reduces the likelihood that this medical condition will affect neighbours, trading partners and those linked through input chains. In addition, an infectious-free environment – the consumption of which cannot be restricted only to some individuals, and where consumption of one individual does not preclude consumption by another – benefits everyone, not only those who pay for the investments leading to it. Such goods and services are known as public goods.

The corollary of public goods are those which when generated can be sold, and where the proceeds and benefits are captured by the provider. The use and consumption of these goods also affect the ability of others to obtain them; there is competition for their purchase. They are called private goods.

Since incentives of private individuals and companies to generate goods and services in a free market are limited to their private benefits, goods carrying positive external effects and public goods are in general underprovided. This is an example of a market failure. For a government, the problem is to ascertain how to support control at a societal level, to ensure that the control becomes sufficiently attractive to overcome the market failure.

Some argue that all other goods and services will be provided efficiently if they are left to private providers through the market, unless, of course, there is some significant market failure. Sometimes governments provide animal health services as an act of equity – not as a matter of efficiency. Such reasoning goes beyond neo-classical economic analysis and could be justified if – but only if – goods with externalities that affect the poor are adequately provided first by government. These services have a greater impact on the poor and are more efficiently provided by public authorities. In the real world of development, this condition is usually not met. There are many examples where governments provide services that favour those who are better off (Rushton and Leonard, 2009).

Table 2 provides a summary of functions, appropriate delivery channels and economic characteristics, along with a commentary of what is required. It shows that many services delivered by animal health professionals constitute a mix of public and private goods. As mentioned above, it is best to think about externalities.

Table 2. Channels for animal health functions

Animal health function	Appropriate delivery channel		Economic characteristic
	Public	Private	
Disease surveillance, prevention, control and eradication:			
Highly contagious disease with serious socio-economic, trade and public health consequences	✓	✓	Largely a public good, with the level private good dependent on the nature of a disease
Diseases of low contagion		✓	Private good with externalities
Farm-level biosecurity:			
Exclusion of diseases		✓	Private good
Containment of disease	✓		Largely a public good
Quarantine and movement control	✓		Measures to correct for externalities
Emergency responses	✓		Public good
Veterinary inspection	✓		Measures to correct for asymmetries in information and potential market failure
Wildlife disease monitoring	✓		Public good
Zoonosis control	✓		Measures to correct for externalities
Disease investigation and diagnosis	✓	✓	Private good with externalities – for highly contagious diseases, public and private goods.
Clinical diagnosis and treatment		✓	Private good
Drug/vaccine quality control	✓		Requires measures to correct for asymmetry of information when solving problems of "Moral hazard" and/or "Adverse selection"
Production and distribution of drugs and vaccines	✓	✓	Private good largely with externalities regarding antimicrobial resistance
Vaccination and vector control	✓	✓	Private good with externalities
Research, extension and training	✓	✓	Public and private
Food hygiene and inspection	✓		Measures to correct for asymmetry of information when solving problems of "Moral hazard" and/or "Adverse selection"
Residue testing	✓		Public good
Food safety tasks	✓		Public good
Compliance and monitoring	✓		Public good

Source: Ahuja, 2004; modified

The delivery of services is also highly dependent on cultural norms in societies, and there is an obvious need for sensitivity when it comes to aid investments. One should recognize that some roles performed well by private practitioners in a specific country do not necessarily work well in other countries. This would be particularly important where levels of education and general support for using animal health technologies are inadequate.

In the last three decades there has been a dominant narrative claiming less government action than was previously typical, and referring to a record of government failure. Most observers concede that market-driven private enterprise should undertake the main part of economic activity. However, well functioning governments are vital. They correct market failures – by providing public goods, correcting for externalities, lowering transactions costs, providing institutions, ensuring a stable macro-economy, and set social priorities.

In preparing livestock disease prevention, control and eradication programmes must be adopted in order to identify key actors in product chains and examine their incentives to participate in these procedures. Planning, based on reliable data and information on the sector, will show the importance of various government interventions. It will also point out essential gaps to be filled by governments intending to help the livestock sector develop.

Many of the most fruitful interventions in the management of animal diseases originate from rich countries. The foot-and-mouth disease control programmes in Europe were publicly supported – with development and distribution of vaccines and by monitoring their effectiveness. They reached out to farmers, and their success was built on partnerships (Garland, 1999).

In the UK, the successful brucellosis eradication programme was based on public-sector coordination of testing and removal of animals, and incentive payments to farmers whose herds risked contracting the disease (Hugh-Jones *et al.*, 1975). In Sweden, the campaign to eradicate bovine virus diarrhoea virus was organised by the farmers' organisation on a voluntary basis, and was brought under governmental control only in the final stages (Moennig *et al.*, 2005). For endemic disease problems, the five-point plan in the UK provided farmers with information on how to manage bovine mastitis; it was

very successful and well received by farmers who had to make changes in management and investments in infrastructure (Asby *et al.*, 1975).

From South America, we find control programmes of foot-and-mouth disease in all cloven-hooved species and classical swine fever (CSF) in pigs. Governments provided coordination, surveillance and vaccine development, while farmers purchased vaccines and showed compliance (Naranjo and Cosivi, 2013). These programmes have successfully managed diseases on an entire continent, and are leading the way towards eradication.

The greatest global victory in the control of animal diseases is the eradication of the devastating viral infection rinderpest (*Box 3*). It is the second disease that mankind has managed to eradicate (the first one was small-pox in humans).

The key aspect of every successful campaign is long-term commitment and the unwavering goals of improving animal health for the benefit of farmers, for food supply and ultimately for consumers. The value of public and private sector coordination is clearly demonstrated in these cases.

Box 3. A success for veterinary services

"Today, 198 countries have been recognised as rinderpest-free by the OIE, with permanent support from the FAO, which represents all countries that have animals susceptible to the disease. This painstaking work was accomplished by OIE experts and officers in charge of recommending rinderpest-free recognition, who systematically verified the absence of rinderpest viral circulation in all countries concerned. This constitutes a major breakthrough, not only in the scientific field, but also for the policies of cooperation and coordination amongst international organisations and between those and the international community as a whole. It is, however, above all a success for veterinary services and the entire veterinary profession, especially since the scarcity of resources available to veterinary services in many infected countries constituted a major obstacle to the implementation of effective control strategies.

In many countries that have recently suffered from rinderpest, economic development was often affected by way their livestock sector performed in terms of production, animal health, and the quality and safety of their animal products; this performance is directly dependent on the quality of their national veterinary services. Over the years, the various successful rinderpest control campaigns have served to convince national and international decision-makers of the importance of reinforcing veterinary services in order to make them more effective in combating not only rinderpest but also all other animal diseases. Thus, the OIE is endeavouring to achieve recognition of veterinary services as a global public good, and to make their compliance with international standards a priority public investment area."

Quote from *The Odyssey of Rinderpest Eradication*, (OIE, 2016d).

Public sector investments in order to stimulate livestock producers to invest in animal health interventions are evidently needed. Governments may also ensure that the livestock sector is able to manage and control contagious and zoonotic disease burdens. They have to address the fact that some people in society will be geographically and socially isolated, and that this isolation is related to ethnicity and gender biases in many cases.

Dealing with animal health means tackling complex issues. It requires a combination of technical solutions and a profound understanding of the social, economic and political context in which society is managing animals and their health problems. Government interventions must contain a mix of adequate regulatory and enforcement polices, overarching programmes and specific projects.

Section 6 will explore the current donor landscape in terms of supporting animal health systems in LICs with a focus on Swedish contributions.

6 International support of strategies and policies

The review of policy and position documents from Swedish and international aid donors make one thing obvious: animal health is not a primary target. At best, it may appear subordinate to agriculture in a broad sense. In some cases, the links between human and animal health are pointed out, but usually from a human perspective and including the role of animals in the transmission of zoonotic and drug-resistant microorganisms to humans. Thus, the "One Health" concept is increasingly referred to.

The role of animal-derived aliments for the maintenance of food and nutrition security is rarely recognized. Environmental aspects of animal production are regularly brought up, and then implying that animal husbandry in LICs would have to be restricted rather than developed. Nevertheless, African countries themselves are emphasizing agricultural development for economic growth and human welfare through the African Union (AU), and also point out the necessity of developing the livestock sector in this context.

6.1 The African Union, NEPAD and CAADP

The New Partnership for Africa's Development – NEPAD – is an economic development programme, adopted by the AU in 2001. NEPAD provides a policy framework for accelerating economic cooperation and integration among African countries. It has developed partnerships with a host of international development finance institutions, including the World Bank (WB), the G8, the EU and the United Nations Economic Commission for Africa (UNECA) as well as with the private sector.

In 2003, the AU endorsed the "Maputo Declaration on Agriculture and Food Security in Africa". The declaration contained several important decisions regarding agriculture. Most prominent was the "commitment to the allocation of at least 10 percent of national budgetary resources to agriculture and rural development policy implementation within five years" (AU, 2003).

Under the framework of NEPAD a number of programmes have been developed, including the Comprehensive Africa Agriculture Development Programme (CAADP) adopted at the AU Heads of State summit in 2003. CAADP is assisting the launching of a "green revolution" in Africa, based on the key role of agriculture in development. The goal is to "help African countries reach a higher path of economic growth through agriculture-led development, which eliminates hunger, reduces poverty and food insecurity, and enables expansion of exports". The programme has no doubt raised the profile of the agricultural sector in African politics, and has facilitated donor coordination, harmonisation and alignment to country priorities (AU, 2015).

In its action plan, CAADP is stating: "Enhancing productivity requires access to appropriate technologies and support by sound policies and functioning institutions." The main challenges for the livestock sector include access to appropriate breeds, feeds and animal health services. Lack of functioning institutions for the delivery of advisory services remains a major obstacle; access to productive resources by the majority of African smallholders is another problem (AU, 2014).

6.2 The Swedish Government and Sida

The Ministry for Foreign Affairs (UD)

The overarching objective of Swedish aid as established by the Parliament is to create better conditions for people living in poverty and under oppression. In its Aid Policy Framework of December 2016 (Government Offices of Sweden, 2016a), the Swedish Government sets out the detailed directions for Swedish aid. These are based on current international development policies, and relate to Agenda 2030, commitments in development funding and the Paris climate agreement. It is stated that Swedish development cooperation should be knowledge-based, well coordinated and relevant to prevailing needs of today's world. The importance of international collaboration and partnerships to reach established goals is emphasized.

When dealing with health issues in the Policy Framework, it is recognized that human infectious diseases is a global problem where international travelling and global trade have weakened the natural barriers for transmission of infections. However, although the majority of emerging global infections have their origin in wild or domestic animals, the need to include this aspect in programmes against infectious diseases is not considered in this context. Nevertheless, AMR is recognized as an increasing threat to health and sustainable development, not least in poor countries. To prevent further spread of resistant microbes, the importance of accurate infection control, also including livestock, and the value of sound animal husbandry is expressively mentioned. Sweden aims at continuing to show leadership in the fight against AMR, as one of our greatest challenges where our country has a unique experience.

As access to nutritious and safe food is a fundamental prerequisite for a decent life, Swedish aid should contribute to agriculture in poor countries becoming more productive. Responsible investments to develop a sustainable agriculture are presented as a powerful instrument to attain poverty alleviation, food security and a viable economic development. Notably, in the newly adopted Aid Policy Framework it is clearly expressed that initiatives related to improved livestock production and health can contribute to more efficient utilization of resources, increased export opportunities and positive human health effects. To this end, support to continuous research and

development as well as training and capacity development is essential (Government Offices of Sweden, 2016a).

The new Aid Policy Framework of the Swedish Government will be in place during 2017. By this, the role of animal health investments in Swedish aid has been clearly acknowledged.

The Swedish International Development Cooperation Agency (Sida)

Sida receives its appropriation and instructions from the Swedish Parliament and Government. According to Sida's own summary from 2015, the disbursements to agriculture, forestry, fishery and rural development amounted to 910 million SEK, around 5 per cent of the Agency's total disbursements. Out of this amount, agriculture received 72 per cent, rural development 15 per cent, forestry 11 per cent, and fishery 2 per cent, respectively. Agricultural research received a considerable slice of the portfolio, equaling 163 million SEK, 18 per cent of the 910 million (Sida, 2015).

Sida's contributions to agriculture include support to technological development and agricultural extension services, research and efforts for mitigation and adaptation to climate change, and environmental issues. The Agency (2015) states that agriculture, as part of sustaining food and nutrition security, has gained momentum and received considerable attention during the year. But in what way this is met with Swedish initiatives is not specified.

The largest share of the agriculture disbursement portfolio was allocated globally – it amounted to 447 million SEK, equivalent of 49 per cent of the total disbursements. CGIAR (the global agricultural research partnership), including e.g. the International Livestock Research Institute (ILRI), received the major part of the global research funding. Sida is also supporting FAO.

SSA is the most important beneficiary. Sida is working with selected countries, together with African regional organizations where co-ordination of efforts between countries is needed. The Agency has established specific country and regional strategies that contain information about Sweden's relations with different countries and regions of relevance for Swedish development cooperation. (Government offices of Sweden, 2016b)

Between 2010 and 2015, Sweden's regional development cooperation with SSA covered five thematic areas: peace and security, environment and climate, economic integration, combating corruption, and institutional capacity building (Government offices of Sweden, 2014; Sida, 2016). Assistance in some of these five areas may ultimately have an effect on the livestock sector including animal health, but nothing is expressly mentioned.

Close collaboration with African inter-governmental organizations is a cornerstone, and the AU is one of Sida's most important regional partners. The East African Community (EAC) and the Southern Africa Development Community (SADC) are other partners – and the Intergovernmental Authority on Development (IGAD), a regional economic organisation that brings together the countries of the Horn of Africa, is a fourth one. In addition, a number of civil society organizations (CSOs) are important partners, such as the Swedish Society for Nature Conservation and We Effect.

For a donor organization it is important to put targeted countries and regions in the "driver's seat". Donors should relate to the countries' own priorities as expressed in their Poverty Reduction Strategy Papers (PRSPs) and, for instance, in the CAADP (see above). Sida may then choose the projects most aligned with Sweden's strategies.

6.3 International agencies and major donors

Ambitions of the international community

It seems difficult to find activities and ambitions that are specifically centered on animal health among members of the international cooperation community. Some large-scale activities probably contain such components, but specified information is scarce. Furthermore, the livestock sector looks as the biggest loser in the currently changing international aid strategies – and in the poorest countries' economic policies (Pradère, 2014).

Aid budgets have been cut. In 2012, for example, direct assistance for development of livestock production was only 1.5 per cent of the global aid to agriculture. This was mainly the result of governmental policy changes in LICs regarding livestock production. There was also

another reason for this collapsing support. Most international aid was channeled towards the social sector after the establishment of Millennium Development Goals (MDG) and the introduction of Poverty Reduction Strategy Papers (PRSPs) issued by IMF and the WB. The consequences were clear-cut: a sharp reduction in government support and international aid for economic infrastructure and the productive sectors, including agriculture (Pradère, 2014).

Burgos and Otte (1999) provided an overview of the global landscape of animal health actors: national institutions and international organizations, as well as private sector actors, some of which operate transnationally. National public and private animal health systems are the main actors. Support is coming from global or regional organizations, such as the African Union Inter-African Bureau for Animal Resources (AU-IBAR), the Regional International Organization for Plant Protection and Animal Health (OIRSA), the Inter-American Institute for Cooperation on Agriculture (IICA), animal health networks, multinational livestock producers, and from civil society organizations.

Most activities are funded by national governments. Core and peripheral funding of international and regional organizations comes from annual contributions by member countries, as well as from specific project funding by specialized finance institutions – such as the WB, the ADB, the African Development Bank (AfDB), and the Inter-American Development Bank (IDB) – by multilateral (e.g. the European Commission) and bilateral agencies for international development of high-income countries. Philanthropic foundations, including Rockefeller, Ford, Paul Allen, and Bill and Melinda Gates, are also contributing to an increasing extent.

Some CSOs – such as Oxfam in Kenya and ActionAid in Somalia – are running small-scale integrated rural-development programmes in pastoral areas that are people-orientated approaches to building veterinary services for the poor. They have been described as time-consuming, however, and requiring a lot of supporting organization (FAO, 2002).

Agendas of FAO, OIE, WB and other donors

Animal health services in many LICs seem highly dependent on foreign aid from different donors and development agencies. The

agendas of most organizations are focused on the empowerment of women and on sustainable agricultural development. Again, few of them are referring specifically to animal health.

The Food and Agricultural Organization of the United Nations (FAO)

FAO regards animal health as a necessary tool for a more sustainable livestock production (FAO, 2013c). Animal products are a source of high-quality food, FAO claims, and a source of income for small farmers and animal holders in LICs. Economic growth is accompanied by an increasing consumption of animal products and higher livestock contribution to agricultural GDP.

According to FAO, changes in livestock production are strengthening the potential of new pathogens to grow and jump from animals to humans on a global scale. Healthy animals are closely related to healthy people and healthy environments. FAO thus claims that the comprehensive "One Health" approach is needed for dealing with the complexities of changing disease landscapes where early detection and reaction are essential (FAO, 2016). Through its international and regional networks, FAO implements animal health programmes to prevent and control priority diseases that are threatening animal production, public health and trade (FAO, 2013c).

The Medium Term Plan (MTP) 2014–2017 highlights the importance of nutrition for a sustainable, healthy and productive future for all. At present, FAO is trying to enhance support to countries on this issue and mainstream its nutrition work as a crosscutting, strategic theme. Focus will be on promoting policy and institutional change, and on nutrition-sensitive investments in agriculture, livestock, forestry, fisheries and aquaculture, social protection and education, for example (FAO, 2013d).

In the MTP, FAO is also concentrated on preventing and responding to transboundary animal diseases, plant pests and food safety hazards. It states that these pests and diseases arise from environmental factors, including climate change, trade or other human-induced migration and movement of pathogens.

From a global perspective, controlling zoonotic diseases and emerging threats at the human-animal-ecosystem interface demands

an integrated and multidisciplinary approach. Different sectors must work closely together to attain healthy people, animals and environments. In the One Health Agenda, FAO, WHO and OIE have integrated this approach in a joint vision for sustainable livestock development. FAO is also, together with partners, addressing the complex challenges and growing threat of AMR. (FAO, 2013d)

The World Organization for Animal Health (OIE)

The intergovernmental OIE includes 180 countries and is a key player responsible for improving animal health and animal welfare (OIE, 2016a). Sweden is sending one national representative to OIE's annual world assembly, but has currently no representation in either the council or the regional commissions. OIE is active in different areas, including sanitary safety, in order to safeguard trade by publishing health standards for international trade in animals and animal products. It develops normative documents relating to rules that member countries may use to protect themselves from diseases and pathogens, without setting up unjustified sanitary barriers (see also section 5.2).

OIE is also promoting veterinary services in order to improve the legal framework and resources of national animal health. In many low-income and middle-income countries these services and laboratories are in urgent need of support providing necessary infrastructure, resources and capacities so that they can benefit more fully from the WTO Sanitary and Phytosanitary Agreement (SPS Agreement). At the same time, veterinary services must be able to offer greater protection for animal health and public health, and reduce the threat to disease-free countries. OIE considers veterinary services as a global public good, a public investment priority that should be brought into line with international standards as regards organization, resources and capacities.

OIE also provides a better guarantee for food of animal origin and promotes animal welfare through a science-based approach. Its activities in this field are focusing on eliminating potential hazards existing prior to the slaughter of animals or the primary processing of their products (meat, milk, eggs, etc.) – risks that could affect consumers.

In 2004, the OIE World Animal Health and Welfare Fund was established "for the purpose of projects of international public utility relating to the control of animal diseases, including those affecting humans, and the promotion of animal welfare and animal production food safety". The fund has several main objectives: to improve governance of animal health systems including veterinary services; to modernise national veterinary legislation and education; and to develop tools that empower member states to deal with urgent situations linked to prevention and control of animal diseases (OIE, 2016c).

The World Bank (WB)

WB is a major global supporter of agricultural development. When discussing the importance of reducing risks and vulnerability in agriculture, specifically risks of outbreaks of livestock diseases, the WB states that global trade and climate change probably will increase the incidence of zoonotic and vector-borne diseases. Therefore, it supports strengthening animal health systems, including disease surveillance, prevention and control, especially in high-risk areas in Africa and South, East and Central Asia. The Bank is also making efforts to improve veterinary services and develop livestock insurance. A WB allocation to OIE and WHO has supported the development of assessment tools to help countries improve their veterinary and human health systems and their cooperation (WB, 2014).

On the global arena, WB is promoting – along with many partners – progress on trade reform in OECD countries, and agricultural technology through CGIAR. At the regional level, WB is the single largest donor for improving the agricultural sector in SSA – coordinating its activities through NEPAD/CAADP and the AU Commission.

The International Fund for Agricultural Development (IFAD)

IFAD is dedicated to eradicating rural poverty in LICs. This UN agency was established in 1977 as a response to food crises of the early 1970s that primarily affected the Sahel region in Africa. An important insight at the time was that food insecurity and famine were not only caused by failures in food production; one could also identify

structural problems relating to poverty, and to the fact that a majority of the developing world's poor were concentrated in rural areas (IFAD, 2016).

As regards animal production, IFAD has two specific priorities: to foster investments in sustainable livestock development, including promoting livestock keepers' participation, and empowerment focusing on the poor and on women. IFAD is concentrating its efforts in regions with strong pro-poor livestock development needs, i.e. in SSA. Another aim is to strengthen international cooperation and strategic working relationships among development partners, including support to research programmes and technology transfer (IFAD, 2015).

The European Union (EU)

Sustainable agriculture and food and nutrition security are at the top of EU's long-term development cooperation agenda, and are important aspects of the Union's dialogue with partner governments. Within its new framework, the Agenda for Change (AfC), it is stressed that the EU development policy should focus on sectors with strong multiplier impact on developing countries' economies. Agriculture is one of those sectors, and sustainable agricultural development is viewed as a key driver for growth and poverty reduction (European Commission, 2010).

The food security policy focuses on smallholder farmers, one of the cornerstones of the EU agricultural development cooperation. EU supports LICs to advance their agricultural sector through various programmes and initiatives, including demand-driven agricultural research and innovation (European Commission, 2016b). AfC concludes that international research in agriculture and sustainable management of natural resources has had a positive impact on poverty reduction and food and nutrition security, and suggests continued support to agricultural research for development (European Commission, 2016c).

As mentioned, EU particularly promotes practices and technologies that are environmentally sustainable and that raise rural incomes. Livestock, fisheries, on-farm aquaculture, and commodities receive particular attention. It is concluded that the livestock sector contributes to economic and social development as well as to food

security. Strong positive interrelations with agricultural production make livestock an integral part of farming systems. EU supports an improved structural, organisational and technical framework in order to develop effective sector strategies.

There is a variety of more specific EU aims: strengthening veterinary services' abilities to quickly respond to and manage animal diseases; implementing good practices for animal production in view of enhanced competitiveness; promoting regional and international cooperation and coordination to formulate and implement livestock sector and related policies; improving national capacity to develop livestock production while protecting natural resources and the environment.

Regarding international animal welfare and health initiatives, EU collaborates with FAO and OIE. Coordination on African agriculture, often together with other donors, takes place in the framework of CAADP (see above). The Union is a strong supporter of CAADP and provides financial assistance (European Commission, 2016b).

The United States Agency for International Development (USAID)

USAID appears most conscious of the need to control zoonotic infections and their transmission from domestic and wild animals to humans (USAID, 2016a). The Agency has established an Emerging Pandemic Threats (EPT) programme aiming at strengthening capacities in LICs to prevent, detect and control infectious diseases in animals and people. Emphasis is on early identification and response to dangerous pathogens from animals before they become threats to humans. This includes helping poor countries to monitor e.g. the spread of avian influenza among wild bird populations and domestic poultry. Implementing partners are FAO, WHO and OIE.

USAID will support a variety of measures: monitoring and surveillance, epidemiological studies, prevention and control activities, improving veterinary capacities in Asia, Africa and the Middle East, and promoting links between animal health specialists and the public health sector (USAID, 2016b).

Bill and Melinda Gates Foundation

The Bill and Melinda Gates Foundation has become increasingly involved in sustainable development of agricultural production in LICs. In the livestock sector, the Foundation supports efforts to improve the health and productivity of particularly poultry, goats and dairy cows, by improving animal genetics and veterinary services. To ensure that farmers can benefit from animal health and genetics technologies, it supports systems providing farmers with knowledge and tools to increase their production and to connect to markets (Gates Foundation, 2016).

7 Swedish activities for improved animal health

Unfortunately, it is impossible to obtain detailed and comprehensive information about Swedish funding of activities related to animal health in LICs. Below, we are describing aspects of animal health management where Sweden has been particularly successful in an international perspective, and areas where Swedish expertise has contributed to improving animal health in those countries. It is worth mentioning that one of Sweden's very first contributions of agricultural expertise was made within the veterinary field in India in the 1950s (Bruno, 2016).

7.1 Swedish animal health management

Since the beginning of last century, Sweden has had a tradition of close cooperation between public and private actors within the livestock sector, including management and control of animal diseases (e.g. Cerenius, 2010). Well-organized farmers speaking with a common voice are interacting with well-developed and professional public authorities.

Historically, Sweden has strived to be self-sufficient of food as a preparation for international conflicts. However, this goal was abandoned in the early 1990s. Sweden joined the EU in 1995, and the domestic political attitude shifted towards a more market-oriented economy. This transformed conditions for its traditional public–private partnership. A recent official governmental report questioned

how much the public sector should engage in controls and actions against diseases that are not zoonotic, and thus mainly affect the productivity of livestock (SOU, 2010).

The successful eradication of the devastating zoonotic cattle diseases tuberculosis and brucellosis in the late 1950s are two examples of Swedish partnership. Notably, these diseases are still present in several other high-income countries. More recent interventions, where other high-income countries have failed, are the eradication of Aujeszky's disease in 1996 (Robertsson & Wierup, 2000) and the highly contagious swine disease PRRS (porcine reproductive and respiratory syndrome) in 2007 (Carlsson *et al.*, 2009) .

But the best-known success story for this public-private partnership is the internationally leading Swedish position on livestock rearing – with minimal use of antimicrobials and an exceptionally low occurrence of AMR, while maintaining competitive productivity (ESVAC, 2015; Wierup, 2000). The Swedish experience of replacing routine antimicrobial use with preventive health measures (SOU 1997; Edqvist and Pedersen, 2001), and lobbying efforts, probably contributed to the 2006 EU ban on the use of antibiotics as animal feed additives.

The Swedish University of Agricultural Sciences (SLU) has been an FAO Collaborating Centre for Animal Reproduction, and the National Veterinary Institute and SLU are an OIE Collaborating Centre for Biotechnology-based Diagnosis of Infectious Diseases in Veterinary Medicine. Finally, research and doctoral education has a strong international profile at SLU. At least one third of its PhD students are foreigners, mostly from low-income and middle-income countries.

7.2 Capacity building in LICs

Capacity development of animal health professionals in LICs is one of the main Swedish activities. Training has been performed at SLU through diploma courses in animal reproduction as well as pathology for livestock health and production professionals. The courses have been funded by Sida, but were later phased out for unknown reasons. An international training programme on WTO agreements on sanitary and phytosanitary measures, and the planning of such a programme on

animal health and food safety, are other current initiatives funded by Swedish institutions.

However, most of the animal health capacity development has been performed within MSc and PhD programmes at SLU. Funding has been provided by Sida, the Swedish Foundation for International Co-operation in Research and Higher Education (STINT), the Swedish Institute and by the governments of students (e.g. Thailand).

A vast majority of the PhD and MSc graduates trained in Sweden are nowadays professionally active in their respective countries rather than contributing to the academic diaspora. Quite a few have taken on leading positions – as heads of department, deans or vice chancellors, and even ministers in national governments – thus promoting a long-term domestic capacity building in animal health.

Research on international animal health issues is frequent at SLU. It is often combined with PhD training of students from LICs and from Sweden. Funding has until recently come from the Sida research council (U-forsk). Today it is handled by the Swedish Research Council (Vetenskapsrådet), and is sometimes co-funded by the Swedish research council Formas and the Swedish Civil Contingencies Agency (MSB). This funding mechanism has helped build a Swedish resource base for solid research and training competence on animal health issues in LICs.

The fact that SLU is leading the animal health part of the upcoming international CGIAR research programme "Livestock agri-food systems" (2017) could be viewed as a recognition of its capacity (CGIAR, 2016).

Swedish-funded programmes, run by Swedish expertise, on reforming national veterinary services in Central Asia and Caucasus is another initiative. In Tajikistan, a major effort was initiated with considerable institutional support from SLU, the National Veterinary Institute and the Swedish Board of Agriculture. However, the programme was terminated after only two years as the cooperation with Tajikistan was phased out in 2007 (UD, 2008). The Republic of Georgia has an ongoing reform programme aiming to modernize the veterinary services, led by the Swedish Board of Agriculture (SJV, 2016).

One major Swedish effort in LICs was the contribution – with more than SEK 100 million – to FAO's battle against the highly

pathogenic avian influenza more than a decade ago (FAO, 2010). Sida handled the support, and created a group of Swedish experts who followed FAO's work closely. They also participated in programme evaluations and gave advice to Sida. The arrangement gave Swedish animal health experts a natural opportunity to get acquainted with FAO's *modus operandi* and to establish professional links with international colleagues.

8 Conclusions and recommendations

8.1 Conclusions

LICs need comprehensive investments in sustainable animal health enabling them to achieve a number of the Sustainable Development Goals. This is true particularly for the goals related to poverty reduction and economic growth, food security and nutrition, and to human health and gender equity.

Animal diseases have dire consequences for the livelihood of 750 million poor livestock keepers around the world. Setting up adequate health systems in low-income regions is thus a major intervention benefiting the poor.

We have reached a number of conclusions:

1. Livestock are doubly important in rural areas: they generate income and they are stores of investment. For urban populations they are high-quality sources of micronutrients. Thus, livestock constitute a critical component for development.
2. Healthy animals are underpinning livestock improvement and reliable livestock food systems.
3. Many livestock systems are managed and owned by women and ethnic groups that are not always fully integrated in society. Effective animal health services demand cultural awareness and gender sensitivity.
4. Two-thirds of human infectious diseases originate from animals. People in low-income settings are most at risk for

contracting zoonotic infections as they are living in close contact with their animals. Zoonoses are most effectively managed at the source, often in a low-income country.

5. Reliable global data are urgently needed on the use of antimicrobials and on the distribution of antimicrobial resistance in livestock. Reducing resistance must be an integrated part of sustainable animal health systems. We know that cost-efficient health management and biosecurity measures are reducing non-rational use of antimicrobials. These measures must be made available to LICs.

6. Inclusion of more nutrient-rich animal source foods is a highly effective way to prevent micronutrient deficiency and provide more dietary diversity. In LICs, deficiency is most widespread among fertile women and small children. A decent productivity in the livestock sector – through healthy animals – is crucial for securing access to animal source food and a more balanced human nutrition.

7. There is a potential for increased exports of livestock and livestock products from LICs – but only if they manage to eradicate and control diseases. It requires strengthened animal health services and institutions (including functional border control), which are typical public goods.

8. Climate change represents a serious challenge to livestock production and health – not least in LICs where livestock farming and other forms of agriculture are key economic elements. Strengthened economic and institutional support to this sector will require a considerable mobilization of national resources.

9. Public sector interventions for animal health must be capable of correcting for market failures and of securing the provision of public goods. The most effective systems involve a public-private coordination and investment.

10. Building health services in LICs requires infrastructure and human capacity investments. Effective foreign aid may be helpful in this respect. Nevertheless, few international donor organizations are expressly including animal health in their strategies,

11. Swedish aid should contribute to making agriculture more productive in LICs. The Government also underlines the importance of continuous research and development, and training and capacity building for food security.
12. The African Union is a key partner in Swedish development cooperation. The Union has a strong belief in the key role of agriculture, including livestock farming, as a vehicle of development. Access to dependable animal health services and reliable advisory institutions is a main challenge. The AU obviously welcomes persistent investments in sustainable animal health systems.

8.2 Recommendations

Animal health investments – aiming at better disease management in the medium and long term – form the basis for a productive and resilient livestock sector in LICs. Enhanced animal health will directly improve the livelihood and welfare of 750 million poor livestock keepers in the world – many of whom are women. It also provides growing urban populations with affordable livestock products.

Creating effective and sustainable animal health systems in LICs remains a challenge. So how should Sweden's unique experience of these closely linked issues be put to good use? Data are still weak on the economic and societal impact of animal health in these countries. Expertise is needed to design data collection and analysis processes that prepare the ground for practical measures.

Bearing these aspects in mind, we recommend three areas for Swedish assistance and increased investment in animal health systems:

I. **Assessment of efficiency.** There is a great need for data collection and analysis processes to determine the burdens of animal disease and costs of disease management. The aim is to create tools for analysing how efficient health interventions are. Sweden has an outstanding position in surveillance, prevention and control of livestock diseases. These skills

should be used in cooperation with institutions related to the UN, CGIAR, and OIE.

II. **Systems based on efficient delivery and public-private partnerships.** Prevention is better than cure – this is a good basic principle when it comes to health issues. Sweden could be seen as a role model, since it combines a uniquely low use of antimicrobials in the livestock sector with high productivity and good animal welfare. On the international arena, Swedish professionals should strengthen their support to organisations like FAO, OIE and CGIAR promoting more sustainable animal health systems. A positive Swedish political environment is needed to make this happen.

III. **Building human capacity.** Sweden has over the years developed an advanced educational and training capacity in animal health and production. Efforts are directed towards both practitioners and academics, often coming from LICs in Africa and Asia. Support to training and research institutions in those countries has enduring and often self-sustaining effects.

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