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Application of the Global Burden of Animal Diseases methods at country level: the experiences of Ethiopia case study

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Summary

Animals play a central role in the livelihoods and welfare of humans. Animal diseases have a great impact on the benefit derived from animals and can also be a risk to human health. Better control of animal diseases generates wider societal benefits, including reducing the climate change and ecological impact of livestock, and improving animal welfare. To better understand the scale of investment justified for the control and prevention of animal disease, measures of the wide-ranging disease impacts on animal production and health are needed.

The Global Burden of Animal Diseases (GBADs) programme is quantifying animal disease burden, from the local to global levels. The GBADs programme includes country case studies for national and local level analysis. Ethiopia is one of the first case study countries in which GBADs has been applied. The Ethiopia case study consists of three activity areas: 1) stakeholder engagement, 2) livestock disease burden estimation, including data collection, analytics, evidence generation and communication and 3) capacity building in animal health economics. The stakeholder engagement involved different stakeholder communication platforms. It was important to familiarise stakeholders with GBADs and engage their support in various ways, including data access, and through this engagement increase the relevance and utility of the programme tools and outputs to their needs.

Existing data were retrieved from multiple sources and used to estimate disease burden. This involved multiple steps including estimation of biomass and economic value, the animal health loss envelope (farm level disease burden), wider economic impacts, and attribution of the disease burden to different levels of causes. This was carried out for major livestock species (cattle, sheep, goats, and poultry) in Ethiopia. Capacity building on animal health economics was done for GBADs end users to increase competence in utilising animal health economic evidence, including GBADs outputs. This paper documents experiences in the implementation of these activities in the GBADs Ethiopia case study.

Keywords

AHLE – Animal health loss envelope – Attribution – Case study – Disease burden – Ethiopia – GBADs – Global Burden of Animal Diseases – Ruminants – Stakeholder.

Introduction

Animals play a central role in the livelihoods and welfare of humans. More than a billion people worldwide are dependent on livestock for their livelihoods [1]. Animals are a source of nutrient dense foods that are essential to human health and nutrition when appropriately used [2]. Animal source foods are some of the best sources of high-quality protein and micronutrients needed for healthy physical and cognitive development of children [3]. According to the Food and Agriculture Organization of the United Nations (FAO) livestock contribute 40% of the global value of agricultural output and support the livelihoods at least 1.3 billion people worldwide [1].

Animal diseases have a great impact on the benefit derived from animals and can also be a risk to human health. Better control of animal diseases would generate wide societal benefits. To justify the control and prevention of diseases, evidence on the wide range of impacts on animal production and health are needed which unfortunately are not sufficient currently. Therefore, understanding and quantifying the burden of animal diseases related to economic, public health, animal welfare is essential to make sound decisions to mitigate disease impacts. The Global Burden of Animal Diseases (GBADs) programme aims to quantify animal disease burden, from the local to global levels. The programme is organised into different themes and is implemented by a global consortium of institutions, that develop and apply methods for assessing and investigating the global animal disease burden. GBADs includes country case studies for national and local level analysis that produce contextualised estimates of disease burden and related evidence. Ethiopia is the first case study country in which GBADs has been applied. This paper documents the experiences of the application of GBADs methods in the Ethiopian livestock sector.

Ethiopia case study

During the development phase of GBADs, desirable criteria for case study country selection were established which included:

- demonstrated leadership in their region and a willingness to share information and collaborate;
- have livestock systems that are representative of the region;
- possess modern information communication technology resources providing access to data of good quality;
- have institutions and key actors that have an analytical way of working, including recognising the importance of excellent communication and education;
- exploit the GBADs consortium's existing in-country links and other specific in country capacities, such as complementary ongoing programmes.

Ethiopia adequately fulfilled these criteria. Ethiopia is a country in east Africa with a projected human population of 107 million people in 2023 [4]. It is a federal state with 10-member regional states as of 2021 when this analysis was done. It has the largest human and livestock population in east Africa region and the largest livestock population in the African continent [5,6]. Livestock are kept in various production systems and the sector plays a prominent role in Ethiopian economy not only in terms of producing animal source food and fibre but are also means of traction in crop production and transportation [7,8]. National strategic efforts such as the Growth and Transformation Plan II, and the associated Livestock Master Plan, have created a strong political and institutional framework on to which the GBADs programme can be anchored and aligned. Through the leadership of the World Organisation for Animal Health (WOAH) and coordination with the Veterinary Services, GBADs will be an adjunct to the Performance of Veterinary Services and Gap analysis process.

The Ethiopia case study is led by the International Livestock Research Institute (ILRI) in Addis Ababa. The case study team has a team lead, animal health economics analyst, a stakeholder engagement consultant and a PhD student, the latter working on equids.

The Ethiopia case study consists of three activity areas: 1) stakeholder engagement, 2) livestock disease burden and related data collection and analytics, and 3) capacity building on animal health economics for stakeholders.

Stakeholder engagement

GBADs has placed great emphasis on stakeholder engagement. The stakeholder engagement in the Ethiopia case study has been facilitated by a senior consultant who has vast experience within the veterinary service in the country. The strong stakeholder engagement created awareness about GBADs and its importance in Ethiopia. This has multiple objectives: 1) to identify stakeholders' interests and priorities in terms of disease burden analysis within the scope of programme, 2) to create understanding about GBADs analytical tools and outputs and make them usable by end users, and 3) to get support in data access from all sources where GBADs relevant data could exist. Different communication platforms were organised for this purpose. The GBADs case study activities started with consultation of the Chief Veterinary Officer and State Minister for Livestock and Fisheries Development by briefing them with objectives and potential deliverables of the programme. With the support of the State Minister's office, an advisory group representing various stakeholders including the government offices, academic and research institutions, the private sector, and professional bodies was formed. The advisory group had the following roles:

- advise on the case study's direction so the study focus matches national/international stakeholder needs;
- discuss annual plan of the case study and the study updates;
- facilitate stakeholder engagement so outputs are practically used and are not merely academic exercises;
- support stakeholder cooperation to facilitate access to relevant data and guidance for studies;
- facilitate acceptance, from the authorities and other partners, of GBADs activities in Ethiopia and facilitate openness, including in dissemination of findings.

The advisory group meets regularly, receives updates on the progress of the case study and gives direction and support within the scope of the GBADs programme.

Various workshops were held to get feedback from the wider stakeholder groups on relevance and utilities of analytical outputs and solicit more data sources. For this, inception, midterm, and final review workshops were held at various times during the implementation of the case study. In these workshops the participants were presented with the progress of the case study findings, provided with opportunities to comment on the validity and utility of the analytical outputs and provide suggestions on what to include in the future from their offices or organisations perspective.

A core expert group on animal health economics was established within the Ministry of Agriculture as part of the stakeholder engagement. The core group has the main tasks of promoting and facilitating the use of GBADs deliverables and increasing its utility in the country. It has the three major areas of activities: 1) championing and promoting the use of animal health economics including the GBADs approach to support animal health policy and decision making, 2) liaising with, establish and maintain a network with other major stakeholders including regional and national veterinary laboratories, research centres and higher learning institutes to promote the use of animal health economics, and 3) cascading animal health economics capacity to regional veterinary services and creating enhanced understanding of GBADs approach in the regions in close collaboration with the GBADs Ethiopia case study team.

Disease burden and related analytics

National and subnational analysis of disease burden is the core activity of the case study and is conducted following GBADs analytical structure. The analytical structure follows sequential steps in quantifying livestock disease burden (Figure 1). It starts with understanding the livestock population and production system targeted for analysis. This involves classification of production systems and estimation of the biomass and economic values by production systems. This is followed by the analysis of farm level disease burden (animal health loss envelope) by species and production system, then assessing the impact of the farm level burden on the wider economy, and finally attributing this burden to different levels of causes. The burden of animal diseases on public health and its differential impact on gender are other analyses applied in the case study. The different analyses are conducted by the case study team in collaboration with the relevant GBADs global themes including Population and Production System, Production Loss and Expenditure, Animals Health Ontology and Attribution, and Informatics themes. Large varieties and volumes of data are needed to do these analyses and collection and collation of existing data are central activities in the case study. The data collection and analytics done within the case study are presented in detail in section 3.

Capacity building

Capacity building of stakeholders in animal health economics is another activity of the case study. This has two objectives. Firstly, it engages the stakeholders and creates more familiarity for GBADs, and secondly, it creates basic understanding of animal health economics to increase the awareness and competence in the use of animal health economics in decision making for main potential users of GBADs outputs. The course had two parts. Part I was on basic concepts of (animal health) economics and how economic rationalisation can be used in decision making including GBADs approaches of disease burden analysis [9] and part II was on important economic analysis tools that can assist decision making in animals health investment and disease control interventions [10]. The training targeted government employed veterinary and livestock officers including from the field service, research, and academia. A cohort of 13 animal health, production and marketing experts from various offices attended the two parts full course. In addition to this larger group, a small group of three experts from the national veterinary service were further coached on further topics of animal health economics with practical demonstration of the application of the lessons. Economic impact estimation of peste des petits ruminants (PPR) was used for this demonstration.

GBADs data collection and analysis in Ethiopian livestock sector

Data collection and analyses were carried out following the GBADs analytical structure and were done collaboratively between the Ethiopia case study and the relevant GBADs method themes.

Data collection and collation

GBADs data analysis is principally based on existing (secondary) data except where secondary data are relatively scarce. In Ethiopia, for example, a PhD student is working on working equids by collecting primary data. One of the main tasks of Ethiopia case study is the collection and collation of available data from various sources. Being dependent on secondary data, which are collected for other purposes, multiple data sources need to be searched to satisfy the intensive data needs of disease burden analysis. The stakeholders' support was important in accessing relevant existing data sources. Major areas of data needed for GBADs analysis included livestock demography (population number and structure), production system, input use (e.g. feed, labour, veterinary service) production coefficients (e.g. milk yield, parturition interval, draft power output), and production system input and output prices.

Data were searched from databases of government offices, international organisations (e.g. FAO, WOAH, the World Bank, etc.), international nongovernmental organisations data repositories and networks (e.g. CGIAR, LD4D, etc.), private business and cooperatives, and from the literature. While these sources provided valuable data to enable some reasonable analysis, all the necessary data were not available in sufficient quantity and quality. Ideally, data for GBADs analysis (or for any analysis) needs to be complete, unbiased, continuously updatable, and disaggregated demographically and geographically. Limitations were identified in the existing databases with reference to these criteria. Areas for improvement, in the existing data collection systems and when establishing new data capture systems, especially from the private sector, are suggested for improved information generation on disease burden and other livestock sector analysis.

Disease burden and related analyses

While disease burden and related analyses are being undertaken for major livestock species including cattle, small ruminants, poultry, equids and camels, the most progressed currently are cattle and small ruminants and thus only analyses in these latter species are presented in this paper.

Population and production system classification, and biomass and economic value estimation in ruminants

Production system classification, and biomass and economic values estimation was done in collaboration with the GBADs Population and Production System (PPS) theme in CSIRO, Australia.

Ruminant production was classified and mapped into different systems and subsystems to create uniform analytical units. The global livestock production system classification [11] and the commonly used national livestock classification [8] were adapted for classifying the ruminant production systems for GBADs analyses. These systems were: 1) sedentary mixed crop-livestock systems in rainfed temperate and tropical highlands, 2) nomadic pastoral and agropastoral system in the arid and semi-arid grazing lands (pastoral), and 3) intensive and landless specialised ruminant production systems. This classification is roughly like what has been commonly used within the country for various data collection, analysis, and planning purposes. This had the advantage of getting production system level data directly from secondary sources.

In this classification cattle were classified into three major systems including: 1) the crop-livestock mixed (CLM) system, 2) pastoral system, and 3) market-oriented smallholder dairy. This classification did not include the more intensive milk and beef production which are mainly operated in urban and peri urban areas. This was because of the lack of readily available existing data for this sector. The national agricultural census and sample survey series, which are the main sources of the livestock demographic and production data, do not cover the intensive commercial sector. This sector accounts for not more than 2% of the national population in number with a little more contribution to production output [5].

The small ruminants were classified into CLM and pastoral systems. Each of these two major production systems were further classified into subsystems according to the feeding system practiced and herd composition. Accordingly, CLM system was subclassified as those kept mainly at communal grazing land within cereal crop areas, and as those tethered in back yards with feed brought to them in the *enest* (a local root crop) growing areas of the country. The pastoral system was classified as those kept in herds dominated by cattle and as those kept in herds dominated by small ruminants. These subsystems could have different epidemiology of disease and disease impact, but they were not used in most of the GBADs analysis as data at these subsystem levels were not readily available in existing sources.

The biomass of the livestock population was estimated based on average liveweight of each specific sex-age category in each species of animals. For cattle and small ruminants three age categories namely juvenile, sub adult and adult were used for each sex (male and female) group resulting in six sex-age categories. The average liveweight of animals in each sex-age category were multiplied by the number of animals in that age group and these were summed over all sex-age categories to estimate the total biomass.

The total economic values were categorised as the assets value of the animals which is the number of animals in each sex-age category multiplied by its average annual (year 2021) market price, and the production output value was estimated as total annual production offtake (sale, slaughter, draft power milk, manure, skin, etc.) times the average annual (year 2021) market price of these outputs.

The population biomass and economic value of the national ruminant population was estimated using a herd growth model adapted from Lesnoff [12]. The herd model was parameterised by data from various sources principally from the national annual agricultural sample survey and published literature and was simulated for a year. The simulation results were used to calculate annual population number, biomass and economic values (asset value of the stock and the value production outputs) of the livestock in each production system. The estimates of population, biomass and economic value of ruminants for year 2021 is shown in Table I. Detailed results of production system classification, biomass and economic value estimations can be found in papers by Jemberu *et al.* [13] for small ruminants and by Li *et al.* [14] for cattle.

The animal health loss envelope

The animal health loss envelope (AHLE) represents the overall farm level disease burden (see Gilbert's article published in this volume for full description of the AHLE [15]). Estimation of the AHLE is a core component of the GBADs analysis. This analysis was carried out in collaboration with the University of Liverpool who developed the AHLE model. The AHLE can easily be operationalised as the income difference in farm/production system under the current state of animal health and ideal state of animal health (perfect animal health status where morbidity and mortality are absent). Gross margin (income minus variables cost) was used as a measure of income. The annual gross margin was estimated for each state of health (current and ideal) using a herd bioeconomic model parametrised by data from the respective health state.

All data used for calculating the gross margin for the current state of health were derived from secondary data including data collected by livestock related national agencies such as the Ethiopian Central Statical Agency, National Livestock Market Information System, National Veterinary Institute, and Veterinary Drug and Feed Administration and Control Authority, reports, and published literature. The data that were needed for parametrising the herd model for calculating gross margin included: 1) the year's initial population structure in terms of sex and age category, 2) reproduction parameters such as proportion of adult females giving birth and prolificacy rate, 3) mortality for each sex category, 4) production outputs such as net live animal offtake, milk production (daily yield and lactation length), draft power outputs (in case of cattle), manure and skin outputs, 5) production inputs; labour, purchased feed, and animal health care, and 6) price of live animals, production outputs and inputs. When literature was used as data source, it was searched systematically and metanalysis was done to derive model parameter values.

The parameter values of the herd bioeconomic model that change for calculating gross margin under ideal animal health status were those related to mortality and morbidity. The mortality parameter which is directly specified in the herd bioeconomic model was set at zero. Zero morbidity was reflected as improvements in production and reproduction parameters of the herd bioeconomic model such as improved live weight, milk production and reproduction rate. The ideal values for these parameters were derived from structured expert elicitation, carried out in workshops using Cooke's classical method of elicitation, with groups of 8–10 experts per species.

The AHLE in 2021 for major ruminant systems in Ethiopia was estimated to be about 20.8 billion USD, with cattle contributing 17.6 billion and small ruminants 3.2 billion. Burden by the different production systems (pastoral and crop livestock mixed) is presented in Table II.

The AHLE can be disaggregated in different ways. Broadly animal health loss has three components. Burden due to morbidity (production loss), burden to morality (biomass loss) and burden due to cost of prevention and control (animal health expenditure). In all ruminant species, the major burden was due to morbidity which accounted for more than 65% of the economic burden and animal health expenditure accounted for less than 1%. The proportions of the disease burden components are shown in Figure 2.

The AHLE can also be disaggregated by each sex and age category. For example, the AHLE for adult cows can be estimated separately from the AHLE for oxen or calves. The sex-age group AHLE estimates can be found in the GBADs dashboard – https://gbadske.org/dashboards/ahle-casestudy – by using the appropriate selector menu.

The AHLE has also been estimated at a subnational level for cattle. Subnational level (regional state level) analyses were conducted similar to the national level in which the bioeconomic model was used to calculate the gross margin under the current state of health and the ideal state of health, parametrised by subnational specific data. The ideal health parameters used at subnational level were the same as those used at national production level. It would be preferable to generate subnational, region specific, ideal scenario parameters, as regions may have different environmental, genetic, and husbandry situations which could affect the ideal productivity. Nevertheless, the subnational, region-specific estimates generated are considered acceptable given the data scarcity and the subnational AHLE estimates for cattle can be found in GBADs dashboard (https://gbadske.org/dashboards/ahle-casestudy).

Attribution

Once the overall disease burden is estimated, the next step is to determine the causes. Determining what amount of burden is caused by what type of disease is called attribution. Attribution of the overall burden (AHLE) has been started and is mainly undertaken by the Animal Health Ontology and Attribution (AHO) team in Murdoch University, Australia (see Bruce *et al.* article published in this volume for more information about attribution [16]). The AHLE can be attributed to different hierarchical levels of cause groupings. The first and the highest level of cause grouping is classifying the causes as infectious, non-infectious and external causes. The attribution was done independently for different components of the burden i.e. mortality, morbidity, and animal health expenditure. This is because the contribution of causes for different components of the disease burden and different sex-age groups would be different. For example, in terms of component burdens, external forces would cause relatively more mortality, but infectious disease would cause relatively more morbidity and animals health expenditure. Likewise for sex-age groups, infectious causes would cause high burden in juveniles but non-infectious disease (e.g. metabolic disease) would cause high burden in producing adults.

The highest-level attribution was done first by determining the proportional burden of each high-level cause (infectious, non-infectious and external) and then the percentage proportion was multiplied by the overall burden to attribute the USD amount to each cause. It was difficult to determine the proportional burden of the high-level causes based on data. The available literature on disease prevalence and impact is mostly about infectious diseases. Using data from literature for attribution will bias the burden towards infectious diseases that have historically been well researched and documented, hence expert opinion was used to determine the proportional burden of the high-level causes. The attribution of the estimated the AHLE to high level causes is presented in Figure 3. In both cattle and small ruminants, a high proportion of the AHLE was attributed to infectious diseases. The non-infectious and external forces contribute more to the loss burden in small ruminants compared to their contribution to the overall burden in cattle.

The other important level of attribution was at specific disease level such as for foot and mouth disease. Attributing to specific disease has been started for the Ethiopian government priority diseases, including PPR and brucellosis in small ruminants. The specific disease level attribution was carried out using the herd bioeconomic model that was used for estimating the AHLE parametrised by specific disease impact data available in the literature. The model was run at ideal health status and with the presence of the specific disease to which attribution is done. The difference in gross margin between two health status scenarios is what is attributed to that specific disease. The attributed burden for PPR and brucellosis in small ruminants is presented in Figure 4.

Conclusions

The Ethiopia case study successfully proved the application of the GBADs concept of disease burden estimation. It produced overall disease burden and related analytical outputs for the main livestock sectors in Ethiopia. Attribution of the disease burden (AHLE) to different level of causes and assessing its wider economic burden is ongoing and this is believed to generate more usable information for prioritising health problems for investment and intervention. The collaboration and coordination of the different GBADs global themes with the case study was crucial for this success. The strong stakeholder engagement helped for accessing data from various sources, understanding interests of stakeholders and familiarising GBADs tools and outputs for its potential end users. Whereas there were a lot of data from existing sources which enabled reasonable analysis, there were also areas where there was not sufficient data, in which case proxies, expert opinions and assumptions were used. As such, the reported estimates will need to be refined and updated as better data become available. Improving the existing data collection systems and a new data capture system should be instituted for more reliable disease burden estimates. Finally, the Ethiopia case study can give a good experience for other countries of similar socioeconomic status which want to embark on using GBADs analytical approaches.

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Table I

Population, biomass and economic value of ruminants in Ethiopia in 2021

Species	Population (million heads)	Biomass (million tropical livestock units)	Stock value (billion USD)	Output value (billion USD)
Cattle	70	59.08	31.20	12.35
Small ruminants	96	8.88	5.95	1.97

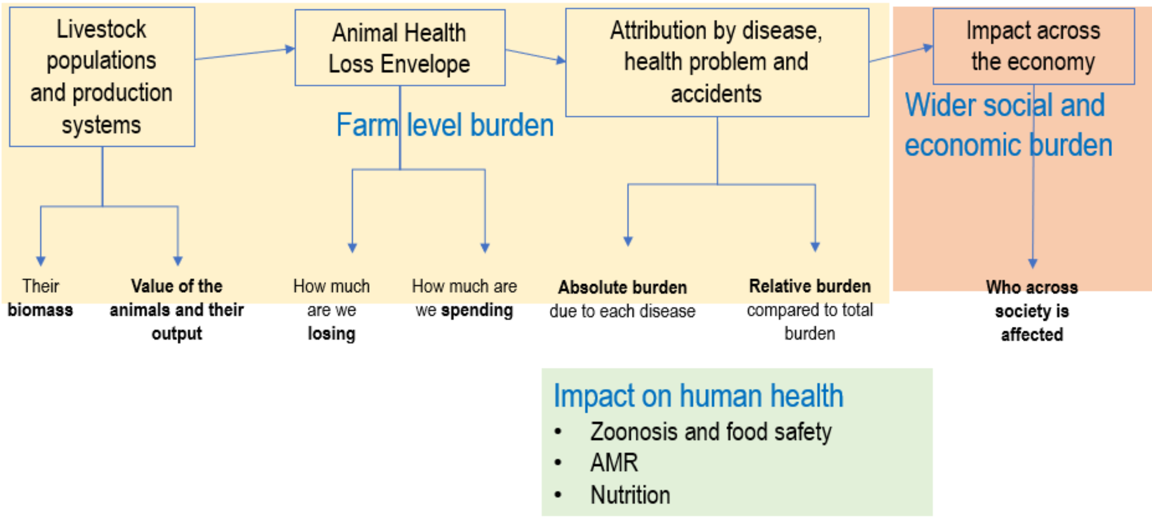
USD: United States dollars

Table II

The Animal Health Loss Envelope (AHLE) in ruminants in Ethiopia in 2021

Production system and species	AHLE (USD)	Population	AHLE/head (USD)
Small holder dairy cattle	1.21E+10	1.80E+06	6.72E+03
CLM – cattle	4.75E+09	5.50E+07	8.64E+01
Pastoral – cattle	6.81E+08	1.35E+07	5.04E+01
CLM – sheep	8.52E+08	2.47E+07	3.45E+01
CLM – goat	9.54E+08	2.22E+07	4.30E+01
Pastoral – sheep	3.18E+08	1.82E+07	1.75E+01
Pastoral – goat	1.13E+09	3.03E+07	3.73E+01
Overall	2.08E+10	1.66E+08	NA

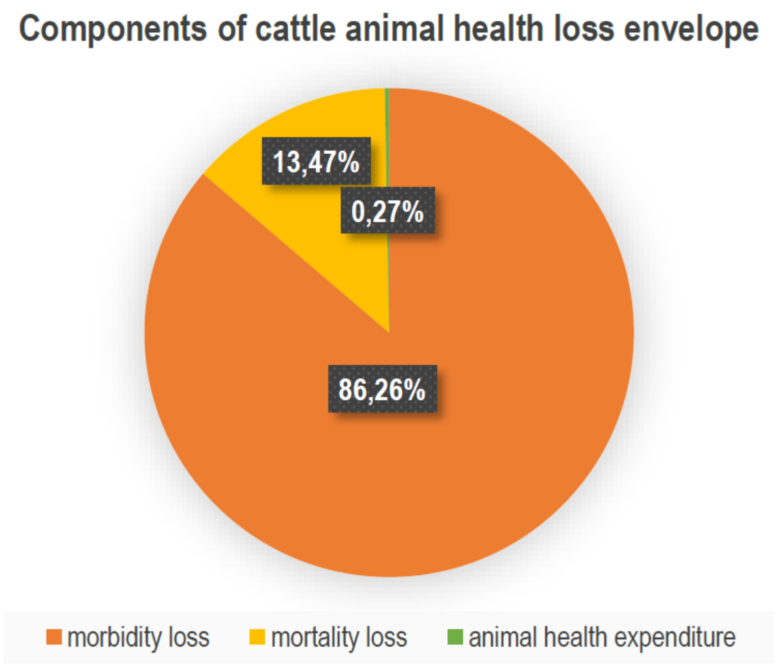
CLM: crop-livestock mixed
NA: not applicable
USD: United States dollars



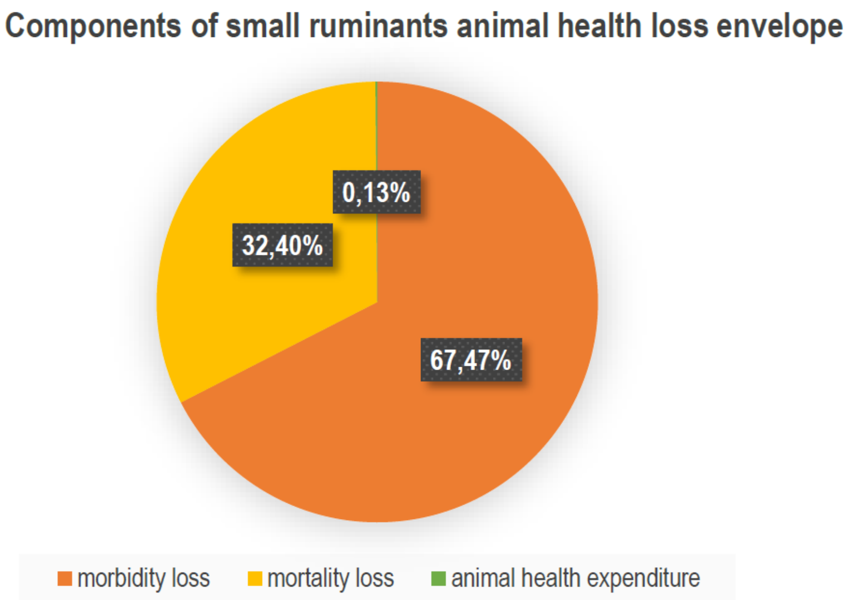
AMR: antimicrobial resistance

Figure 1

Global Burden of Animal Diseases analytical structure



a) cattle



b) small ruminants

Figure 2

Animal health loss envelope components

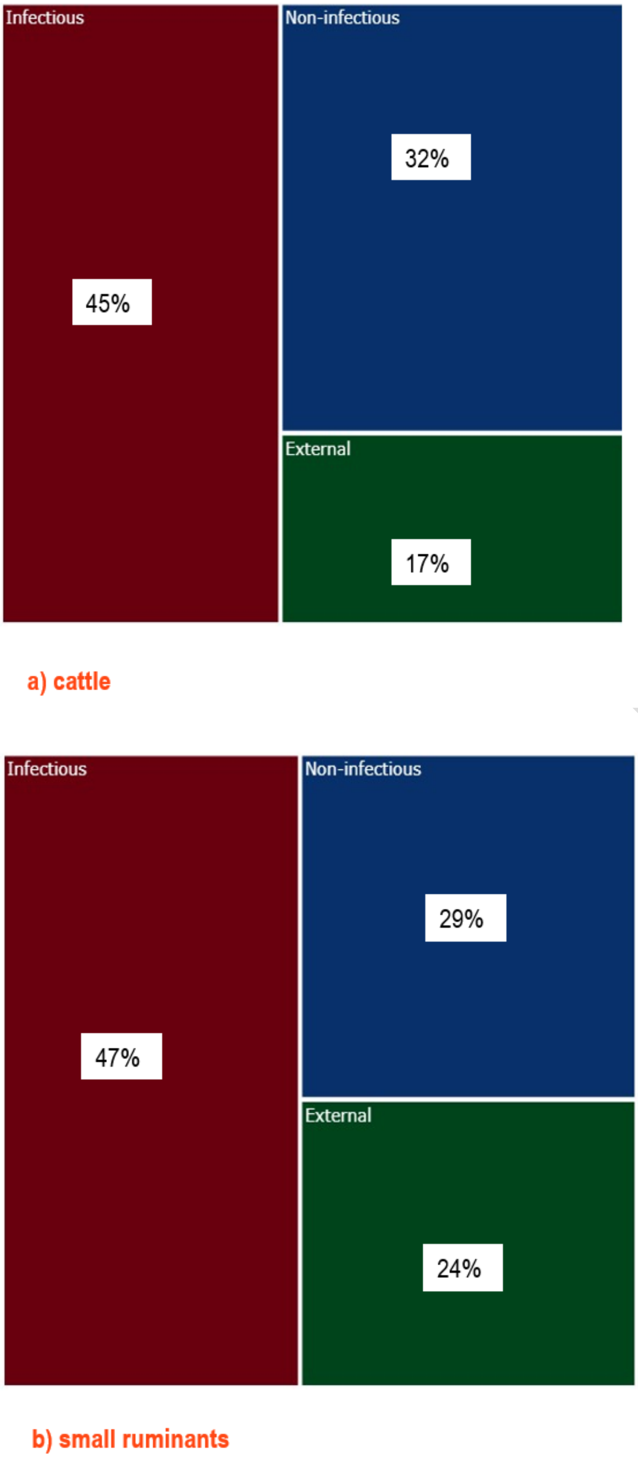
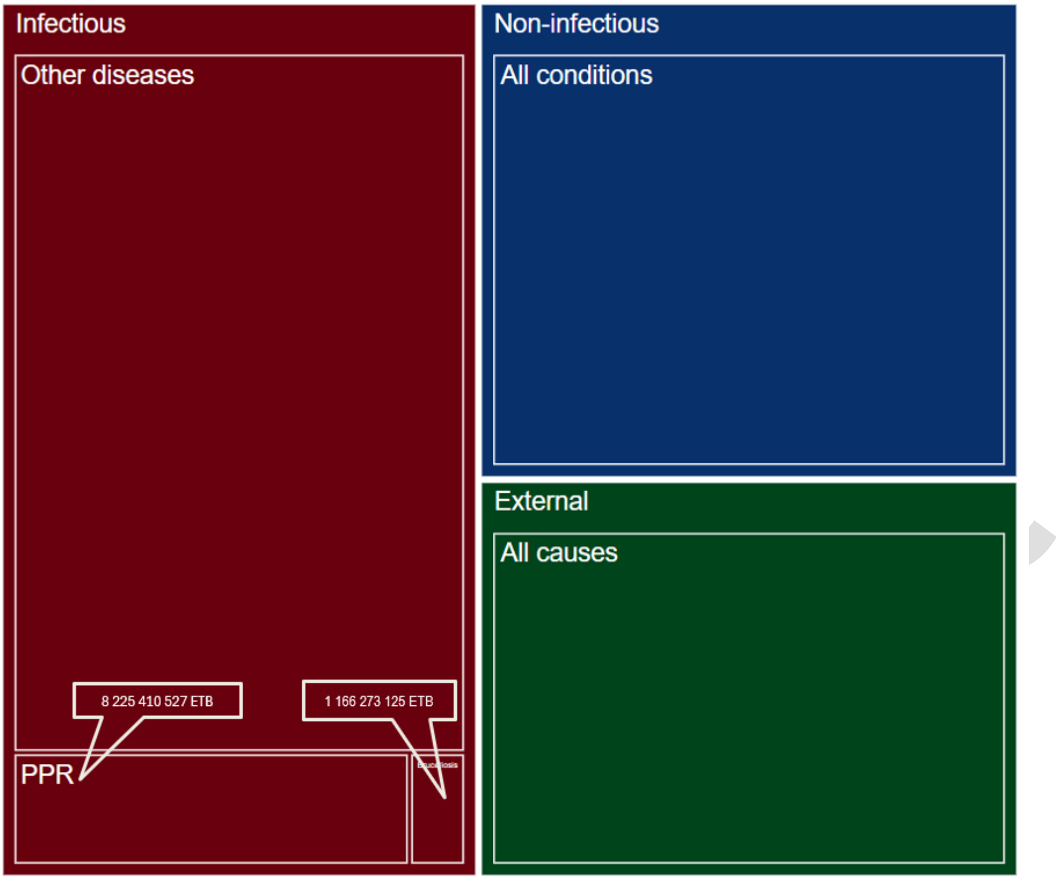


Figure 3

Attribution of the animal health loss envelope to high level causes (infectious, non-infectious and external forces)

Adapted from Global Burden of Animal Diseases dashboard (https://gbadske.org/dashboards/ahle-casestudy)



ETB: Ethiopian birrs
PPR: peste des petits ruminants

Figure 4

The proportional burden of PPR and brucellosis in small ruminants

Note that both PPR and brucellosis are infectious diseases, and they occupy parts only of the infectious disease compartment

Adapted from Global Burden of Animal Diseases dashboard (https://gbadske.org/dashboards/ahle-casestudy)