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SECTOR ENVIRONMENTAL GUIDELINE: LIVESTOCK PRODUCTION

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PREFACE: ABOUT THIS DOCUMENT AND THE SECTOR ENVIRONMENTAL GUIDELINES

This document presents one sector of the *Sector Environmental Guideline*s (SEGs) prepared for the United States Agency for International Development (USAID) under the Agency's Environmental Compliance Support (ECOS) contract. *Sector Environmental Guidelines* for all sectors are accessible at https://www.usaid.gov/environmental-procedures/sectoral-environmental-social-best-practices/sector-environmental-guidelines-resources.

Purpose: The purpose of this document and the *Sector Environmental Guidelines* overall is to support environmentally sound design and management (ESDM) of USAID development activities by providing concise, plain-language information about:

- The potential for beneficial impacts from well-managed livestock systems;
- The typical adverse environmental impacts of activities in the sector;
- How to prevent or otherwise mitigate adverse impacts, both in the form of general activity design guidance and specific design, construction, and operating measures;
- How to minimize vulnerability of activities to climate change; and
- More detailed resources for further exploration of these issues.

Audience: This SEG is mainly for USAID Agreement and Contracting Officers' Representatives (A/CORs), USAID Mission, Regional and Bureau Environmental Officers and Advisors (MEO/REA/BEOs), Agricultural Officers, Project Design Teams, and implementing partner (IP) staff engaged in implementation of livestock production activities. However, this SEG, like the entire SEG series, is not specific to USAID's environmental procedures. SEGs are written generally and are intended to support ESDM of livestock production by all actors.

Environmental Compliance Applications. USAID's mandatory life-of-project environmental procedures require that the potential adverse impacts of USAID-funded and managed activities be assessed prior to implementation via the Initial Environmental Examination process defined by 22 CFR 216 (Reg. 216).

They also require that the environmental management/mitigation measures ("conditions") identified by this process be written into award documents, implemented over life of project, and monitored for compliance and sufficiency.

The procedures are USAID's principal mechanism to assure ESDM of USAID-funded and managed activities—and thus to protect environmental resources, ecosystems, and the health and livelihoods of beneficiaries and other groups. They strengthen development outcomes and help safeguard the reputation of USAID.

The Sector Environmental Guidelines directly support environmental compliance by providing information essential to assessing the potential impacts of activities, and to the identification and detailed design of appropriate mitigation and monitoring measures.

*However, the Sector Environmental Guidelines are **not** specific to USAID's environmental procedures. They are generally written and are intended to support ESDM of these activities by all actors, regardless of the specific environmental requirements, regulations, or processes that apply, if any.*

Guidelines Superseded

This updated *Livestock Sector Environmental Guideline* replaces the previous *Livestock Sector Environmental Guideline* (2003, and 2015) and the following region-specific guidance: (1) *Environmental Guidelines for Small Scale Activities in Africa*; (2) *Environmental Guidelines for Development Activities in Latin America and the Caribbean*; and (3) *Asia/Middle East: Sectoral Environmental Guidelines.* Apart from some more recent Africa sectors, all regional documents were developed over the period 1999–2004.

Development Process and Limitations. In developing this document, agro-pastoralism-specific content in predecessor guidelines has been retained when applicable. Content related to other livestock production systems has been added. In addition, a more global perspective on livestock production, consideration of social and economic impacts of sector activities, and a more substantial assessment of climate change adaptation and mitigation considerations for the sector have been included. Furthermore, statistics have been updated, references verified, and new references added.

Please note that, the *Sector Environmental Guidelines* are not a substitute for detailed sources of technical information or design manuals. Users are expected to refer to the accompanying list of references for additional information.

Comments and Corrections. Sectors are constantly evolving, and therefore, these guidelines are a reflection of the sector at their time of development. Comments, corrections, and suggested additions are welcome. Please provide feedback via email at: [To be provided.]

How to Use the Document

The SEG introduces practices and information that can be used to address management of environmental and social impacts from livestock activities.

The impacts and mitigation measures described in the Livestock SEG are intended to be used as a reference when completing 22 CFR 216 requirements. Specifically, the impacts described can be used as reference when completing USAID's Environmental Impact Assessment (EIA) Process, described below in Figure 1, or IEE for USAID Livestock Activities. After impacts have been assessed through the EIA Process, the mitigation measures described for each impact in the SEG can be used as a resource in developing Environmental Mitigation and Monitoring Plans (EMMPs) for USAID Livestock Activities.

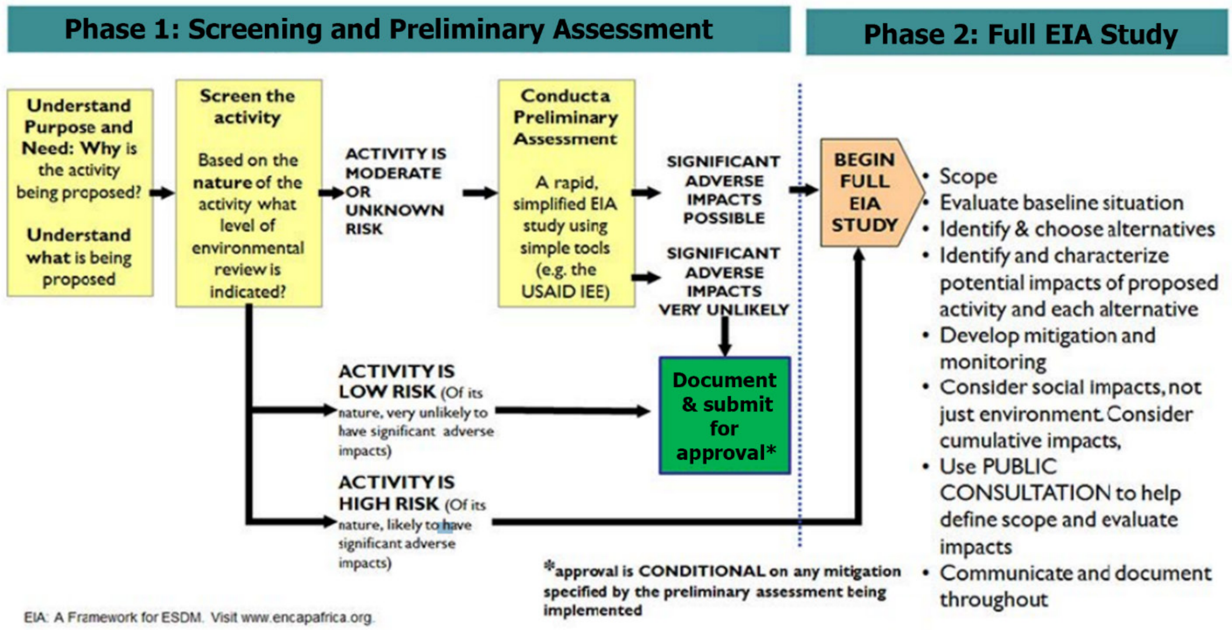

Figure 1. EIA Process *(USAID 2019a).*

The structure of the document is as follows:

Chapter One: How to Use the Document provides a brief introduction to the purpose of the document and the topics to be covered.

Chapter Two: Sector Description briefly describes the different livestock production sectors.

Chapter Three: Environmental Impacts summarizes the environmental impacts and mitigation measures that are associated with livestock production.

Chapter Four: Climate Change and Mitigation describes the potential impacts of livestock to climate change and the impacts that climate change has on livestock production along with adaptation and mitigation practices.

Chapter Five: Health Risks associated with livestock including human health, wildlife health, and the health of livestock animals are discussed.

Chapter Six: Social Impacts that should be considered when conducing livestock practices are explained.

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1 HOW TO USE THIS DOCUMENT

1.1 GOALS AND OBJECTIVES OF THE DOCUMENT

Livestock rearing is a critical livelihood strategy for many people across the world. In developing countries, livestock are associated with supporting a growing population and millions of farmers. Rural populations and local cultures rely on livestock to provide highly nutritious food, materials, income, wealth, transportation, and mechanical power for pulling carts, drawing water, and/or plowing fields (Feed the Future 2017). Investments in livestock production and animal-source foods (ASF) market systems support the following three Global Food Security Strategy (GFSS) goals, as described in Feed the Future (2017):

1. Inclusive and sustainable agriculture-led economic growth
2. Strengthened resilience among people and systems
3. A well-nourished population, especially women and children

Properly managed livestock production can enhance land and water quality, economic stability, and biodiversity. Livestock manure can serve as fertilizer to sustain crops and vegetation and promote biodiversity by dispersing seeds, controlling shrub growth, breaking soil crusts, stimulating grass growth, and improving seed germination. Livestock can also serve as a form of currency and savings. However, livestock production has the potential to increase environmental harm as well as economic and social harm when improperly managed. For example, manure stored improperly can leach into water sources, threatening human health and degrading ecosystems.

The goal of the Livestock Sector Environmental Guideline, a part of the USAID Sectoral Environmental Guidelines series, is to provide information essential to assessing the potential impacts of livestock activities, and to identify appropriate mitigation and monitoring measures. However, this SEG is not specific only to USAID's environmental procedures. It is written to support broad environmentally and socially sustainable approaches to the livestock sector. Site specific context should be taken into consideration when using the Livestock SEG. Additional or modified impacts and mitigation measures may be required.

This document presents considerations for developing economically, socially, and environmentally sustainable livestock systems. Each section describes considerations of environmental impacts of livestock systems and provides mitigation measures to avoid, minimize, and reduce any adverse impacts of livestock production. Adherence to mitigation measures described herein will enhance the sustainability of livestock activities. Concurrent analysis of all impacts discussed in subsequent sections of this document while designing activities will lead to more sustainable outcomes.

The SEG can assist USAID stakeholders in developing compliance documentation, project development questions and environmental impacts assessments, further described in Section 1.4.

1.2 ACTIVITY DESIGN GUIDANCE FOR SUSTAINABLE LIVESTOCK SYSTEMS

Activity design guidance sections for livestock are included at the beginning of each chapter throughout the document and are intended to provide important overarching factors for consideration in designing livestock activities. The factors should be assessed with respect to the objectives and context of the activity prior to decision making in the activity design process. For example, livestock production systems (i.e., rangeland, mixed-crop livestock, urban/peri-urban, or intensive) should be selected by considering the potential beneficial and adverse impacts in the local community and the feasibility of implementing best practices in the community of interest. Considerations specific to climate change, the environment, human health, and social impacts are included in their respective chapters throughout the document and should be referenced throughout the activity design process.

Project design should include local stakeholders as appropriate to ensure locally led development and site-pertinent sustainable implementation. "If we truly want to make aid inclusive, local voices need to be at the center of everything we do," said USAID Administrator Samantha Power on November 4, 2021, at Georgetown University in Washington, DC.

In addition to the activity design guidance provided in each chapter, the Global Food Security Strategy (GFSS) Technical Guidance for Investing in Livestock Production and Animal Food Market Systems [1] provides guidance on considerations for activity design (Feed the Future 2017).

1.3 INDICATORS FOR MEASURING IMPACTS

Discussions of indicators for measuring livestock impacts are also included as possible throughout the chapters of this SEG. Choosing metrics for measuring environmental impacts is important for adaptive management—that is, to assess effectiveness or impacts during the life of the project and make changes to ensure that programmatic and environmental goals are achieved. Existing resources and conditions should be assessed prior to project implementation to establish a baseline and select relevant indicators to monitor throughout the project lifecycle.

The Food and Agriculture Organization of the United Nations (FAO) Livestock Environmental Assessment and Performance (LEAP) Partnership has published numerous guidelines [2] for assessing impacts from livestock activities, the majority of which consider lifecycle

BOX 1. THE DAIRY SUSTAINABILITY FRAMEWORK

The Dairy Sustainability Framework was developed to establish sustainability goals and align global sustainability efforts across the dairy sector. The framework takes a holistic, global approach to monitoring and addressing negative environmental impacts of the dairy sector, and it was established through combining efforts of existing sustainability initiatives. The framework establishes global, high-level indicators for sustainability within the eleven criteria listed below.

1. Greenhouse Gas Emissions
2. Soil Nutrients
3. Soil Quality and Retention
4. Water Availability and Quality
5. Biodiversity
6. Working Conditions
7. Animal Care
8. Waste
9. Market Development

1 The GFSS Technical Guidance for Investing in Livestock Production and Animal Food Market Systems is available publicly online at GFSS_TechnicalGuidance_IncreasedSustainableAgProductivity.pdf (amazonaws.com)

2 FAO LEAP Guidelines are available publicly online at: https://www.fao.org/partnerships/leap/resources/guidelines/en/

assessments and include the environmental impacts of all stages of a project. These frameworks can provide a comprehensive way to complete impact assessments and measure the effectiveness of a project; however, in many cases, collecting data to fulfill the requirements of the assessments can be expensive, time-consuming, and require technological capabilities that may not be accessible for many projects.

Additionally, Box 1 above describes a global approach to establishing indicators for measuring environmental impacts of the dairy sector. The Dairy Sustainability Framework was created to align global sustainability efforts and establish sector-wide sustainability goals.

For determining the appropriate metric or assessment framework for measuring environmental impacts, the following should be considered. Please note that environmental impacts are multi-dimensional in nature, and a holistic approach to measuring and addressing all environmental impacts should be prioritized in USAID activities.

- Determine the resources (i.e., time and funding) available to develop an evaluation program.
- Determine the length of time that the evaluation program should be implemented in relation to the proposed project.
- Determine the focal environmental resource concern(s) to be measured (e.g., water productivity, water quality, rangeland condition).
- Develop a framework for measuring the impact to the resource:
    - What will be measured?
    - What is the spatial scale of the assessment?
    - Who will conduct the assessment?
    - How will the assessment be prepared?
- Determine how the outcome of the assessment will be used during project implementation.

2 SECTOR DESCRIPTION

Chapter 2 introduces the importance of the livestock sector to the livelihoods, culture, and resilience of communities and the categories of livestock production systems of focus in this document. Each of these broadly defined livestock production systems has distinct characteristics that in turn result in potentially beneficial and adverse climate change, environmental, and health impacts that are assessed in later chapters. These impacts, their mitigation measures, and activity-specific context (i.e., geographic appropriateness) should be considered when selecting these specific production systems for use in USAID activities. The four livestock production systems described in this chapter include the following:

- Rangelands and extensive grasslands
- Mixed crop-livestock
- Urban/peri-urban
- Intensive

Please note that there is considerable heterogeneity within these four categories, and the unique characteristics of any given livestock production system should be carefully considered when evaluating impacts and mitigation measures, as described further in Section 2.2.

2.1 LIVESTOCK SECTOR IMPORTANCE

The use of livestock such as cattle, sheep, goats, pigs, and poultry offer many benefits to the growing global population and millions of farmers in the developing world. These animals are integral to rural livelihoods and local cultures and strengthen resilience. Benefits of livestock systems and products include: [3]

- Providing nutrient-dense ASFs within diversified diets (i.e., meat, eggs, and dairy products);
- Generating income through markets for animals, ASF, and other animal products (i.e., hides, skins, manure, and fibers) and services (i.e., traction);
- Offering financial and risk-management services such as liquid capital assets to address urgent cash needs; provide insurance (i.e., against crop failure); offer financing for diversification of productive livelihoods that spread risks; promote savings; and secure informal credit;
- Supporting cultural identity and social cohesion;
- Enhancing crop production through animal traction, threshing, expanding cropping area, and improving soil fertility nutrient cycling via manure;
- Providing transportation of water, people, and goods, thereby expanding market access and reducing labor inputs; and
- Building social capital and informal safety nets to strengthen formal and informal networks.

Note: Livestock products benefit food security.

Animal-source foods offer important protein, energy, and micronutrient nutrition, promoting growth, cognitive function, physical activity, and health, particularly in children and women (Neumann, et al. 2003).

[3] (Source: Feed the Future 2017 Technical Guidance)

2.2 GLOBAL LIVESTOCK SYSTEMS

Note to the reader: The purpose of this section is to broadly categorize the wide range of livestock production systems that are implemented around the world; however, these systems are, in reality, arranged along a continuum and may not fit neatly into one of the four categories presented below. The use of these broad categories is intended to provide a first step to structuring production systems for a high-level review of the potential benefits and impacts of livestock projects and for project planning. Many factors are involved in the classification of livestock production systems, and they should not be considered rigid. Figure 2 below presents a generalized approach to differentiating between the four types of production systems presented in this SEG. These production systems are described below (Figure 2).

USAID recognizes that the diversity of livestock production systems and programming is a strength of this sector, and further, that on-the-ground planning and programming are most successful when livestock production systems are considered based on the characteristics of the system/sub-system of interest and in local context.

2.2.1 RANGELANDS AND EXTENSIVE GRASSLANDS

Rangeland and extensive grassland systems include pastoral, transhumant, agro-pastoral, and sylvo-pastoral production systems. These systems are characterized by livestock and livestock-crop systems with low stocking rates (typically less than 10 tropical livestock units [TLUs] [4] per hectare). In smallholder rangeland systems, this number can drop below 1 TLU (FAO 2011). There is a high degree of herd mobility in the grazing system beyond the farm for at least part of the production cycle, which supports livestock nutrition and provides environmental benefits, such as soil health and vegetation composition.

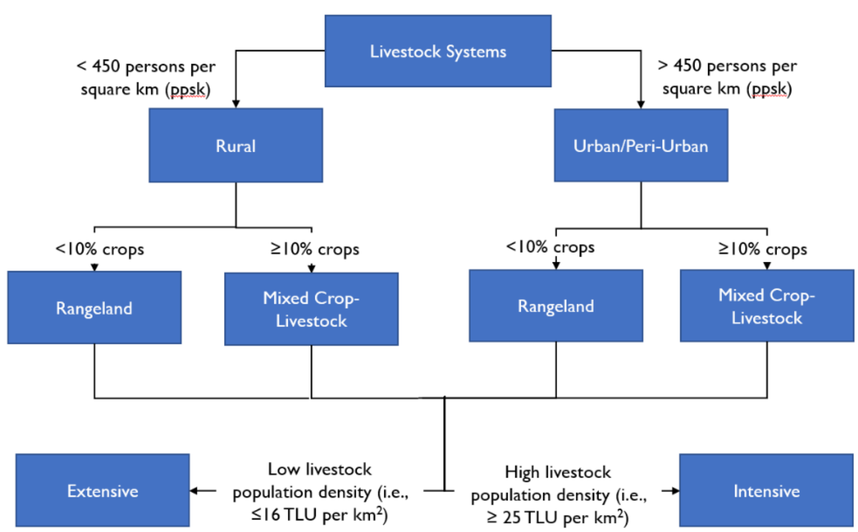

Figure 1 Livestock System Decision Tree *(FAO 2011).*

[4] TLU is a measurement for providing an equivalent estimate of livestock biomass. One TLU is equivalent to 250 kg, where one bovine is equivalent to 1 TLU, and a sheep or a goat is equivalent to 0.1 TLU (FAO 2011).

Rangelands and extensive grassland systems are usually in arid and semi-arid zones, with rainfall-dependent growing seasons less than 180 days per year. The predominant livestock species in these systems are large and small ruminants, including cattle, sheep, and goats, but also camelids and yaks.

Impacts and mitigation measures specific to rangelands and extensive grassland systems will be described in chapters 3, 4, 5, and 6 of the SEG.

2.2.2 MIXED CROP-LIVESTOCK

Mixed crop-livestock systems are those that closely integrate crop and livestock production, where crop and livestock systems depend on one another for inputs and are rurally located, typically on a small holding or farmstead. Livestock in these systems are generally kept for production of nutrient rich ASFs to be consumed in the home but may also generate income through market linkages. Livestock density in crop-livestock systems is variable.

The balance of crop to livestock may vary considerably in these systems, but both crop and livestock components contribute at least 10 percent of the total farm production—either 10 percent of the dry matter fed to animals comes from crop-byproducts or stubble, or more than 10 percent of the total value of production comes from non-livestock farming activities.

Mixed crop-livestock systems occur in a range of tropical and temperate agro-ecologies and are typically rain-fed but may also include irrigated land. These livestock systems include ruminants, pigs and poultry, small stock (i.e., rabbits, guinea pigs), and animals kept for traction (i.e., oxen, buffalo, and equids).

Impacts and mitigation measures specific to mixed-crop livestock systems will be described in chapters 3, 4, 5, and 6 of the SEG.

2.2.2.1 REGIONAL PERSPECTIVE

Mixed crop-livestock systems are the predominate method of agriculture for smallholders in developing countries in tropical regions. These systems produce approximately 80 percent of the world's supply of meat from ruminants and 90 percent of the world's supply of milk. Mixed crop-livestock systems are most commonly rain-fed in sub-Saharan Africa (SSA) and are primarily irrigated in Asia (Thornton, Rosenstock, et al. 2017). Figure 3 below depicts the distribution of mixed-crop livestock systems in tropical regions.

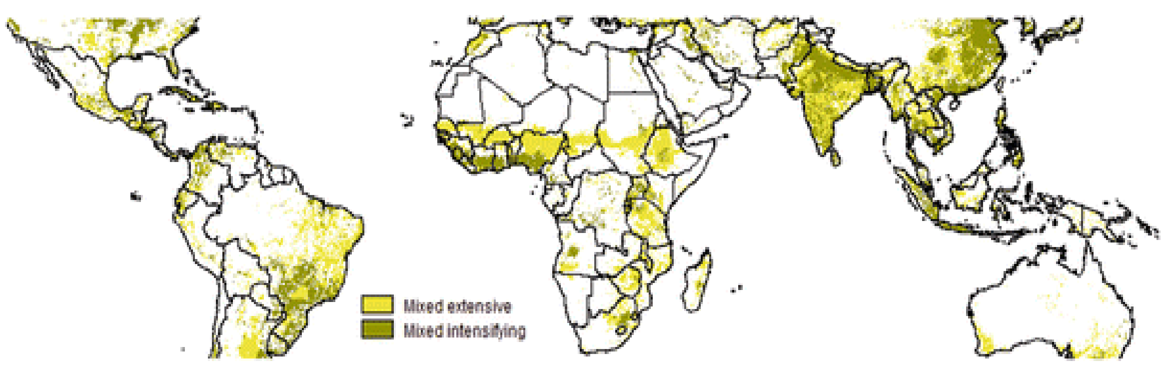

Figure 2. Mixed-Crop Livestock Systems in the Tropics and Subtropics *(Thornton, Rosenstock, et al. 2017).*

In many areas in Asia, mixed crop-livestock systems combine rice production, livestock (poultry, ducks, geese, and pigs), aquaculture, fruits and vegetables, and cash crops. Typically, these systems are smallholder farms, maintained by families, and are found in regions with high water availability (World Bank and FAO 2021).

Mixed extensive systems generally have a length of growing period (LGP) of less than 180 days per year, and mixed intensifying systems generally have an LGP of greater than 180 days per year and have improved market access of less than eight-hour travel time to urban areas with greater than 250,000 people (Thornton, Rosenstock, et al. 2017).

2.2.3 INTENSIVE

Intensive livestock systems are those that operate at a considerable scale and are highly commercialized, involving significant financial investments and technical inputs in housing, feeding, animal health, and marketing. Livestock in intensive systems are typically housed and fed formulated rations. Because these rations are typically commercially sourced, intensive livestock systems are not as dependent on local natural resources as smallholder systems. Intensive systems are generally driven by demand and are the result of growing demand for ASFs from rapidly urbanizing populations.

This system is distinguished from urban and peri-urban systems (see Section 2.2.4) in the scale of operations and level of technical inputs and degree of capital investment required for production.

Intensive livestock systems typically include pig and poultry production units and may also include ruminant fattening in large-scale feedlots that represent intermediate markets for mixed crop-livestock or rangeland systems. Globally, there has been a major increase in intensive systems, notably toward monogastric (pigs and poultry) farms in parts of Asia.

Intensive systems account for 17 percent of beef, veal, sheep, and goat production and 7 percent of global dairy production. Intensive landless systems often include a single species fed on grain and industrial by products such as beef, cattle, pigs, or poultry. These account for 72 percent of global poultry production and 55 percent of global pork production (Haan, Gerber, and Opio 2010).

Impacts and mitigation measures specific to intensive livestock systems will be described in chapters 3, 4, 5, and 6 of the SEG.

2.2.3.1 REGIONAL PERSPECTIVE

Intensive livestock production systems are often found in areas with cost advantages, frequently close to ports or cities. Manure management is a common challenge for intensive livestock systems in these areas, as they often lack adequate land area to store manure (Gerber, et al. 2013).

Intensive grazing systems in Europe and North and South America consist generally of beef or dairy farms and are typically found in temperate climate zones near high-quality grassland or fodder production and are usually individually owned or owned by a corporation. In East and Southeast Asia and Latin America, intensive landless systems can be found close to urban centers near feed-producing areas or ports, and consist of beef cattle, pigs, and poultry. Intensive livestock production systems are largely expanding, most prominently in East and Southeast Asia and Latin America (Haan, Gerber, and Opio 2010).

2.2.4 SMALL-SCALE/HOUSEHOLD AND URBAN PRODUCTION SYSTEMS

In urban/peri-urban livestock systems, livestock are kept in close proximity to human population centers. Criteria established by FAO indicates that livestock systems in areas where there are greater than 450 people per square kilometer (ppkm) are considered urban or peri-urban (FAO 2011).

Figure 3. Household Livestock Production.

Source: Serhii Ivashchuk, Aït Benhaddou, Morroco

These systems are typically small- to medium-scale, with variable levels of intensification (i.e., from a single animal to mid-sized enterprises such as small dairies or fattening operations). Land holdings are typically small or include confined, caged, and landless production systems.

Production in these systems may target home consumption, local markets, or both. Animal feedstuff includes crop residues or by-products that are obtained from on- or off-farm sources. These systems often drive feed and forage supply industries that assure value-addition for crop straws and stovers and food-processing waste as well as offer employment. These livestock systems include poultry, small-scale dairy, pigs, micro-stock, and fattening operations.

Impacts and mitigation measures specific to urban/peri-urban livestock systems will be described in chapters 3, 4, 5, and 6 of the SEG.

2.2.4.1 REGIONAL PERSPECTIVE

Peri-urban areas in India have experienced rapid growth in recent years, contributing to an increase in demand for food. As of 2020, the livestock sector in India was growing at an annual rate of 4.6 percent, and more than 80 percent of the livestock sector consists of smallholders. Due to this, peri-urban livestock systems have become increasingly common in India (Aggarwal, et al. 2020).

In West African cities, urban and peri-urban systems are also becoming more prevalent. Most commonly, these are small-scale systems comprised of poultry, pigs, and micro stock such as rabbits (Roessler, et al. 2016). Additionally, peri-urban dairy and sheep/goat fattening production are becoming more prominent (Wilson 2018). In these systems, livestock have relatively little space and rely on food waste from the household, restaurants, communal institutions, and industrial processes (Roessler, et al. 2016).

2.3 RESOURCES

- FAO Global Livestock Production Systems: https://www.fao.org/3/i2414e/i2414e00.htm
- Global Rangeland Production Systems and Livelihoods at Threat Under Climate Change and Variability: https://iopscience.iop.org/article/10.1088/1748-9326/ab7395
- A Qualitative Evaluation of CSA Options in Mixed Crop-Livestock Systems in Developing Countries: https://link.springer.com/chapter/10.1007/978-3-319-61194-5_17

- Animal Health Complete Guidance for Mixed Crop-Livestock, Humid (Monogastrics): https://www.sustainablelivestockguide.org/sites/isl/files/2021-02/Animal percent20Health percent20Context percent20Five_Jan percent202021.pdf
- Livestock in a Changing Landscape, Volume 1: https://islandpress.org/books/livestock-changing-landscape-volume-1
- Tackling Climate Change Through Livestock: https://www.fao.org/3/i3437e/i3437e.pdf
- Overview of Zoonotic Diseases in Peri-Urban Areas and Introduction to the Special Issue: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7232981/

Figure 4. Maasai Woman with Her Dairy Cows.

Source: Kevin Ouma, TechnoServe

3 ENVIRONMENTAL IMPACTS

Livestock production systems pose significant beneficial and adverse impacts to the environment such as impacts to water quality, biodiversity, and more. Conversely, the environment can also significantly impact livestock production systems, with adverse impacts from the environment causing detriment to the performance of livestock production systems and ultimately their productivity. This chapter describes such impacts in detail and offers mitigation measures to address them. Also introduced are activity design considerations to assess anticipated environmental impacts specific to proposed livestock activities.

3.1 ACTIVITY DESIGN GUIDANCE FOR ENVIRONMENTAL IMPACTS

Included below in Box 2 are potential environmental considerations for livestock activity design. These factors should be assessed at the inception of the activity and utilized in the decision-making process to address potential context-specific environmental risks to the activity. Please note that these considerations are not comprehensive and are meant to provide examples of important project-specific design context. A holistic review of project context should be conducted to assess all potential environmental impacts.

3.2 GENERAL IMPACTS AND MITIGATION MEASURES

This section presents an overview of general adverse and beneficial environmental impacts common to all livestock system types. Individual impact mechanisms may differ slightly at the project level; however, the sections provide high-level considerations for analyzing impacts and regional examples applicable to livestock systems.

BOX 2. SAMPLE ENVIRONMENTAL CONSIDERATIONS FOR ACTIVITY DESIGN

Decreased Water Quality and Supply

- Location of water resources in the project area and potential for contamination and land degradation depending on use patterns
- Amount of manure to be produced and manure management strategies

Land Degradation

- Vulnerability of the project area terrain to livestock grazing and grazing management practices in place
- Presence of ecologically sensitive areas in the project area
- Opportunities to improve soil health through improved manure management and improved grazing practices

Damaged Habitat and Reduced Biodiversity

- Potential impacts of the project on local wildlife or native vegetation and their habitats
- Potential impacts of nearby wildlife on the project and local attitudes towards wildlife that may endanger livestock
- Impacts of changes in climate variability that may change environmental risks

General

- Social infrastructure available to support mitigation strategies
- Options available for packages of technologies that will synergistically mitigate environmental impacts
- Impacts that may arise at each step of the animal production process (i.e., soil health in feed production, manure produced in animal husbandry) and related mitigation measures

3.2.1 BENEFICIAL IMPACTS

Described below are general potential beneficial impacts of the livestock sector on the environment. These impacts include the following:

- Invasive species control
- Beneficial impacts to biodiversity
- Beneficial use of marginal lands

3.2.1.1 INVASIVE SPECIES CONTROL

In some situations, livestock may provide benefits in the form of removal of unwanted or invasive plant species. This may be achieved directly, through the direct grazing/browsing of undesirable plant species by livestock. For example, goats can be an effective way to control invasive species in extensive grassland systems or in mixed production systems where they will feed on invasive forbs or woody shoots of invasive shrubs and trees. This may be used in particular in crop systems, where goats can control invasive species on crop field borders to keep weed infestation from spreading. In South Africa, constant browsing by goats on invasive *Acacia karroo* sprouts will prevent regrowth of the species and reduce its spread in semi-arid grasslands (Ravhuhali, et al. 2021). In disturbance-adapted ecosystems (i.e., Subhumid grasslands), livestock grazing may indirectly control invasive species through maintenance of conditions favorable to native plants, such as soil structure and natural disturbance levels.

Livestock used as a means to control invasive species should be analyzed in context with the ecological system in which the livestock system will be present. In some cases, mismanagement of livestock (i.e., overstocking, removal of livestock, or failure to consider inadvertent introduction of invasive species) may result in the proliferation of invasive species.

3.2.1.2 BENEFICIAL IMPACTS TO BIODIVERSITY

Biodiversity is marked by the number and diversity of genes, species, populations, and ecosystems and is recognized as essential to human well-being (Steinfeld, et al. 2010). Biodiversity is declining at unprecedented rates around the world, however, livestock systems have the potential to positively impact biodiversity either directly or indirectly. Biodiversity may be positively affected by intermediate levels of disturbance opening up new niches (i.e., a variety of conditions and resources) for a greater diversity of species to become established. Extensive livestock grazing may be essential in maintaining semi-natural habitats (i.e., those that support a livestock system, wild species, and provide key ecosystem services) in semi-arid, tropical, and temperate grassland ecosystems (Steinfeld, et al. 2010). Water sources developed for livestock may also provide greater availability and access to water for wildlife that occur in the vicinity, especially during times of drought. For example, in the Chaco ecosystem of South America, wildlife are often sighted drinking water from dams or pools built for livestock production (Zavala 2022).

Livestock biodiversity is a component of global biodiversity, especially when considered in a cultural landscape system. This aspect of livestock biodiversity is discussed further in Section 6 — Social Impacts. Improved access to livestock products can decrease hunting pressure on indigenous wildlife. Further, the diversity of livestock breeds and genetics also provides ecosystem services that benefit natural communities and the human communities that depend on them (Hall 2019).

3.2.1.3 USE OF MARGINAL LANDS

In some areas, livestock may be grazed or kept on lands for which there is little other use or utility — which may include abandoned crop lands or areas insufficient for building housing for people. These lands are otherwise not capable of producing food resources for people without enormous amounts of resource input (i.e., water or fertilizer). Livestock species may be better suited to these areas and be a more efficient and effective use of marginal lands than other land uses. Extensive grazing systems, in particular, are best suited for using land areas of low production and also have the opportunity to revitalize degraded lands.

3.2.2 ADVERSE IMPACTS

Described below are general potential adverse impacts of the livestock sector on the environment. These impacts include the following:

- Decreased water quality and supply
- Land degradation
- Damaged habitat and reduced biodiversity

3.2.2.1 DECREASED WATER QUALITY AND SUPPLY

UNSUSTAINABLE WATER USE AND WATER QUALITY

Where water is scarce, either chronically or seasonally, the diversion of water to sustain livestock potentially limits its availability for other purposes. This is of particular concern in arid and semi-arid regions, where the construction of boreholes to support livestock can lead to unsustainable withdrawal rates and depletion of aquifer reserves. Rules or norms for limiting use of the water resources tend to be much less common for groundwater than for surface water. As a result, groundwater resources are often overused, and aquifers become depleted over time. The same aquifers that supply water for animals and agriculture often also provide water for human consumption, so water shortages that result from over-pumping for livestock can have negative consequences on drinking water supply and crop irrigation. These impacts may be exacerbated in areas made drier or hotter by climate change. On the other hand, good grazing management encourages water infiltration. See (Döbert, et al. 2021).

CONTAMINATION FROM LIVESTOCK WASTE

Livestock manure can contaminate bodies of water, causing adverse effects including eutrophication, oxygen depletion, sedimentation, contamination with enteric bacteria and possibly other pathogenic organisms, toxic pollution from pesticides, and contamination of groundwater and aquifers with both nitrates and pesticides. High concentrations of nitrate in potable water supplies represent a potential health hazard, especially for children (refer to chapter 5). Pesticides used for livestock may adversely impact non-target organisms, such as pollinators, in ecosystems.

WELLS AND BOREHOLES

Wells and boreholes are traditional practices to provide water resources for livestock and human consumption. The development and subsequent concentration of water resources in one area may also present environmental impacts associated with concentration of livestock animals and competition for resources. Wells and boreholes may provide water for all four livestock systems. In particular, wells and boreholes are useful for concentrated livestock operations for intensive production systems as well as small-scale/household urban systems, where water may also be needed for household uses or irrigation. However, wells and boreholes may result in adverse impacts to environmental resources beyond water quality and availability. For extensive grazing systems, wells and boreholes concentrate livestock near water locations, which increases the grazing pressure in the immediate area. In turn, this can cause degradation of soils, overgrazing of vegetation, and erosion near these water resources.

MITIGATION MEASURES

USAID invests considerable programming in developing safe, accessible, and clean drinking water for people; therefore, it is important to consider mitigation strategies that prioritize access to clean water for people when developing water resources for livestock.

- Water supplies for people and livestock should be separated physically where technically and financially feasible;
- Well-designed multi-use water systems are preferred;
- Separate access points should be available for livestock and people, with sufficient separation of the livestock access point (trough, spigot, etc.) from the water source and the access point for household consumption to mitigate contamination by livestock waste and runoff;
- When developing new sources of water for livestock, consideration should be given to also developing a clean and accessible source of water for people in the vicinity; and
- Monitoring of water quality at potable water supplies and livestock sources would signal changes to water quality or quantity such that adaptive management measures may be implemented.

Proper manure management will reduce the risk of adverse impacts to aquatic environments from contamination. Manure should be disposed of in areas not adjacent to water sources. A discussion of best practices for manure management is included in chapter 5.

Any USAID-funded and supported activities require the preparation of 216 regulation documentation such as a PERSUAP or EA for use of pesticides or chemicals. This documentation will consider how the proposed pesticide/chemical may impact non-target organisms. Examples of best management practices that may be implemented for pesticide use related to environmental impacts include but are not limited to the following:

- Insecticides that are recommended should have no effect on non-targeted flora and fauna;
- In cases where non-selective herbicides are used; these should be used in such a way that spray and spray drift does not reach non target flora, fauna, or any protected areas or organic farms;
- Correct pesticide application rates must be used, and pesticides must not be applied while it is raining or about to rain so that there is no runoff or leaching into water systems;
- Use of pesticides that are prone to leaching must be minimized and considered as a main factor for pesticide selection; and
- Physical environmental conditions should be considered when selecting pesticides. For example, lower pesticide rates are usually used on sandy soils compared with loams and clay soils.

Potential impacts from environmental contamination are discussed in more detail in chapter 5.

Projects involving the creation of new water sources or changes in use of existing water sources should consider their impacts to the landscape, including whether the new source would be located in a sensitive ecosystem that may be particularly impacted by concentrations of livestock. In addition, a thorough accounting of the uses for existing water supplies should be conducted in order to ensure that existing uses (especially those for human consumption) are accounted for and maintained and any possible losses at existing sources are mitigated (i.e., creation of a separate water access for human use to allow for livestock use at existing source).

Water quality and quantity should also be monitored at pre-determined intervals to detect any changes and provide timely intervention opportunities.

3.2.2.2 LAND DEGRADATION

USE OF MARGINAL LANDS

Growing populations require increased livestock production for food security and increased nutrition, which can result in the use of marginal lands, or those not suitable for high-yield agricultural production, cultural, or industrial value, for grazing and fodder production. In particular, poorer farmers raising livestock for subsistence in grazing or small-scale/household systems may be forced to use increasingly marginal lands to continue to survive. Additionally, resources (i.e., vegetation production, soil productivity, and water) depleted on marginal lands used for livestock production often do not regenerate in a timescale amenable to continued subsistence livestock production systems. Therefore, livestock farmers may move livestock into increasingly marginal areas for resources or migrate to other areas that may be overburdened from concentrated population pressures and use.

Marginal lands may be less resilient to surface disturbance or grazing pressure from livestock. Soil nutrients and forage values may decline over time and also due to increased use. Livestock systems on marginal lands may require increasingly more land in order to support the same number of livestock or off-farm inputs of animal feed. Livestock production may also decline due to decreasing available resources.

MITIGATION MEASURES

Projects that may be located on marginal lands should carefully consider what livestock species or breeds are being proposed for use and determine how their grazing/browsing habits may further degrade marginal lands.

- Priority should be given to livestock species or breeds that are local or are known to be compatible with use on marginal lands; and
- Proper grazing management, such as rotational grazing or avoiding grazing during wet seasons, can also prevent further degradation of marginal lands.

Projects may employ techniques to minimize erosion on marginal lands, which may include fencing particularly sensitive areas to prevent livestock from access. Other techniques may include terracing or planting soil-stabilizing species in risk-prone areas.

SOIL EROSION

Improper livestock management can have adverse impacts on soil erosion, typically arising from the overpopulation of animals in any production system. One of the most common examples of unsustainable livestock production or agriculture is overgrazing on sloping lands, which leads to soil erosion and uncontrolled rainfall run-off following removal of vegetation that previously maintained soil structure. These consequences can be far-reaching, leading to both minor and major environmental impacts, including landslides, earth slumps, gully formation, siltation and sedimentation of water courses, and downstream flooding with significant loss of life and property. Slope, topsoil depth, and soil type all affect the potential for erosion and dictate the appropriate conservation measures essential for controlling it.

Soil erosion may result in sedimentation in waterways downstream of impacted areas, causing degradation to water quality following rainfall events. Over the long-term, the loss of soils through erosion may prevent re-establishment of vegetation in overgrazed areas and therefore lead to land degradation.

In some areas, ranchers or farmers may use wildfire to clear vegetation or increase new, nutrient-rich grasses for livestock forage. Intense wildfires may contribute to soil degradation through loss of soil nutrients, establishment of invasive species, and erosion.

MITIGATION MEASURES

Areas around sensitive soil areas, including steep slopes, riparian areas, or gullied lands should be noted and avoided through well-developed grazing plans, which may include education and training for livestock managers to better understand potential environmental impacts and to learn ways to avoid these areas. Another option is to place fencing around the sensitive soil areas to prevent livestock from accessing them, if funding is available and maintenance of fencing is possible. Determining the carrying capacity of a particular rangeland or farm and implementing quota systems may also reduce the impacts of livestock in a particular area and may avoid concentration of animals in sensitive soils areas.

For mixed crop-livestock production systems or small/scale household urban production systems, farmers may construct landscape systems that help reduce soil erosion, including:

- Ditches or diversion structures — separating crops, pastures, and other land uses in consideration of the potential for soil erosion
- Terraces — on extremely sloping lands, construction of graded terraces that create flat sections for agricultural or livestock use
- Living barriers — construction of vegetated barriers on terraces or near areas of high soil erosion potential that would retain soils and prevent run-off

3.2.2.3 DAMAGED HABITAT AND REDUCED BIODIVERSITY

Adverse impacts to biodiversity may result from habitat conversion or degradation, direct removal of wildlife, nutrient pollution, introduction of new diseases to wildlife populations, and secondary habitat loss. Most impacts to biodiversity as a result of livestock production are considered indirect (i.e., loss of habitat, pollution) rather than direct (i.e., direct mortality due to trampling/grazing) (Reid, et al. 2009).

Improper grazing management in all systems may result in overgrazing, potentially causing soil degradation and reducing plant diversity and productivity. Following the removal of livestock or inadequately managed grazing practices, secondary loss of biodiversity may result from increased dominance of a few colonizing species or shrub encroachment (FAO 2020).

LOSS AND DEGRADATION OF HABITAT

Habitat conversion is one of the largest adverse impacts to biodiversity resulting from global livestock production. Approximately 54 percent of the global terrestrial surface is considered rangelands for livestock (International Livestock Research Institute 2021). Impacts to biodiversity resulting from the loss or degradation of habitat may be direct (direct habitat conversion or degradation to graze animals or to produce livestock feed) or indirect (removal of habitat). Improper grazing management may lead to overgrazing, potentially resulting in habitat degradation through soil degradation and reduction of plant diversity and reduction in productivity. In addition to overgrazing, inadequate or no grazing can lead to habitat degradation and biodiversity loss following encroachment of unwanted species (i.e., shrub dominance or invasive species). Land conversion, particularly at edges of intact ecosystems or landscapes, may result in the loss or alteration of ecosystem services. For example, conversion of the edge of forests may result in rapid declines in soil health, soil erosion, and disruptions in water and mineral cycles, in addition to the decline of biodiversity.

MITIGATION MEASURES

Sustainable grazing management techniques are essential to avoid adverse impacts to habitat and vegetation and may be applied to extensive systems, mixed crop/livestock systems, and small-scale urban household systems. Some of these methods include:

- Development of a management plan tailored to the ecological conditions of the rangeland or pasture.
- Rotational grazing management — moving animals between pastures.
- Seasonal exclusions
- Rehabilitation of degraded areas (reseeding, tillage)
- Restoration of native or introduced vegetation. Introduced vegetation should be carefully selected to weight the cost/benefit and to ensure that species are not invasive.

In addition to sustainable livestock management practices, conservation of biodiverse areas, including wetlands, tropical forests, and riparian corridors, among others, within projects is desirable. If feasible, these biodiverse areas should be left free from livestock grazing if the land use is incompatible, or from vegetation removal for grazing or cropping. Other conservation approaches may include developing a mosaic approach to crop areas and leaving some areas of native vegetation in farmed landscapes.

TRANSMISSION OF LIVESTOCK AND WILDLIFE DISEASES

Transmission of livestock and wildlife diseases may have adverse impacts to biodiversity and livestock health. Pathogens found in wildlife populations and spillover to livestock populations presents potential risk to human disease emergence. Adverse impacts to livestock and subsequent potential human transmission is discussed in further detail in chapter 5. Adverse impacts resulting from transmission between livestock and wildlife pathogen reservoirs may include the reduction in biodiversity of wildlife, and loss of livestock and productivity. Prominent diseases in the wildlife-livestock interface include avian influenza, which impacts wild birds and poultry farms; bovine tuberculosis, brucellosis, and foot and mouth disease, which impacts cattle and wild ungulates; and rabies, leptospirosis and salmonellosis, diseases which generally impact cattle and wild carnivores (Wietholeter et al. 2015). Other transmission pathways, such as tick-borne diseases, present risk to both livestock and wildlife populations, particularly in cattle and buffalo that are farmed near areas with wild ungulates (Grootenhuis and Olubayo 1993)

MITIGATION MEASURES

Application of preventative veterinary care for livestock may prevent or reduce the spread of diseases between livestock and wildlife reservoirs. Chapter 5 discusses mitigation measures for livestock for prevention of diseases in production systems. The application of these measures will also ameliorate the risk of spread to wildlife reservoirs. Proper housing of livestock that creates space and prevents contact between wildlife and livestock may be addressed during the design process of projects. For example, for poultry or pig production systems, consideration of where livestock may come into contact with wildlife would be a starting point. Mitigation or design features may include secure livestock enclosures or barns in high-risk areas and best management practices for decontamination of equipment or clothing used for livestock practices.

SPREAD OF INVASIVE SPECIES

Livestock systems, if managed improperly, can support the introduction and proliferation of invasive species. Mixed crop and livestock systems may attract non-native and potentially harmful species of plants, insects, or small mammals that could cause ecological damage (Steinfeld et al. 2010). Invasive species can establish and spread in areas that have been disturbed by grazing livestock in all systems because these species are typically highly adaptable and out-compete native plants. Microbes and other parasites problematic or alien to livestock species may become established in systems where livestock are concentrated, such as in intensive systems, mixed-crop and livestock systems, or in peri-urban settings (Pimental 2005). Livestock themselves may also be considered invasive species in some contexts. Impacts of livestock grazing such as replacement of native species, proliferation, and overpopulation of individuals, and ability to outcompete native species are similar detrimental environmental impacts that are observed from the introduction of other invasive species. In addition, livestock may incidentally introduce other invasive species through seeds in manure or stuck in animal hides (Steinfeld, et al. 2010).

MITGATION MEASURES

Preventing the spread of invasive species through project design and planning is easier than developing eradication techniques following establishment and proliferation. Understanding the ecology and climate of a particular area will help in predicting the potential for invasive species as a result of livestock introduction. Project planners can determine the appropriate livestock species or breeds that would be best suited for the project area. During project initiation, any livestock, livestock products, feed, and equipment being used should be cleaned, inspected, and quarantined as necessary to avoid the introduction of novel species into the project area.

Project planners should also establish a monitoring program based on considerations of the ecology, climate, and available resources in the area. Components of the monitoring program should include timing and protocols, identification of potential non-native species that might occur, and identification of funding and organizations that would be available for conducting monitoring. The monitoring program can also identify potential fast-response protocols for eradication of any invasive species that are observed, tailored to taxa and species as needed.

In the event that an invasive species becomes established in a project, early detection and eradication will be important to prevent additional ecological, agricultural, and social damages. Eradication of plant species may include mechanical removal (i.e., pulling, disking, prescribed fire) or chemical (i.e., herbicide). Note that any use of herbicides will need to follow all USAID considerations for use of chemicals, including the development of a PERSUAP or EA to disclose impacts of its use on the natural environment and to develop best management practices to be implemented for their safe use. Eradication of livestock pests may require application of pesticide and would follow the considerations enclosed in chapter 5.

REMOVAL OF WILDLIFE

Impacts to biodiversity may also include the direct removal of wildlife, including wild ungulates, which may compete with livestock for available forage, and predators that may prey on livestock resources. Additionally, wildlife farming may increase pressure on wildlife, as described in Box 3. Livestock management practices such as the construction of fences and land clearing may additionally lead to disruption of wildlife and subsequent removal from livestock production areas.

BOX 3. WILDLIFE FARMING SYSTEMS

Wildlife farming involves the commercial breeding and legal sale of wildlife species for consumption. Adverse impacts resulting from wildlife farming systems may include animal welfare concerns, waste management, land degradation, increased poaching pressure, and genetic bottlenecks. In Cambodia, wildlife farms of long-tailed macaques and Siamese crocodiles may illegally sell wild-caught individuals of these species, thereby increasing poaching pressure and creating markets for wild-caught species rather than farmed animals. Wildlife farms are often reservoirs for zoonotic diseases and increase overall acceptability of the practice while lowering the stigma of wildlife consumption. Bans against wildlife products, however, can forward conservation benefits by decreasing the social approval of wildlife consumption and lessening animal welfare consequences.

Removal of or alteration to wild ungulate populations can lead to loss of biodiversity through the direct removal of wildlife; but may also result in loss of biodiversity through the alteration of ecosystem processes that maintain biodiversity at the landscape scale. For example, in SSA, an increase in livestock grazing may contribute to the suppression of fire, which maintains grassland composition and structure in mesic areas. The replacement of fire with livestock as the primary consumer of grassland biomass may in turn contribute to the alteration of ecosystem infrastructure and the introduction and proliferation of undesirable woody vegetation in grasslands (Hempson, Archibald and Bond 2017). Additionally, conversion of wildlife habitats to croplands or rangelands may result in a mosaic of land uses that would prevent the movement of wildlife through landscapes. This is particularly applicable to portions of East Africa where communal grazing areas are shifting to private landownership and different land uses (Reid et al 2010).

Some livestock producers may perceive local ungulate species as direct competition to their livestock for forage, water resources, and space, or threat via wildlife diseases, and will directly remove ungulate wildlife by shooting or poisoning (Gordon 2018).

Large carnivores, such as cheetahs, African lions, and tiger species, may prey upon livestock, which in turn, may devastate the livelihoods of livestock producers, potentially resulting in increased food insecurity (Karanth, Gupta and Vanamamalai 2020). Global declines in large carnivore populations have been attributed to killing by humans driven by concern of livestock depredation (Dickman, Marchini and Manfredo 2013).

In addition to mammalian predators, large predatory birds (raptors) and scavengers (i.e., vultures or condors) have historically been regarded as threats to livestock. Raptors have been shot, trapped, or poisoned through secondary means via ingestion of contaminated prey resources (typically via rodenticide) as a result. Nests, eggs, and young also may be destroyed by livestock producers. Alteration of foraging habitat to rangeland systems may result in the loss of habitat for raptor prey species, and therefore, the functional loss of habitat for raptors or avian scavengers who may depend on it. Scavenging birds in Asia and Africa have experienced population declines resulting from poisoning from eating anti-inflammatory drugs used in livestock production that are toxic to birds. In some cases, declines of vultures exceeded 90 percent.

MITIGATION MEASURES

Specific mitigation strategies for wildlife and livestock conflict issues may fall into two categories: prevention and compensatory mitigation. Activities that are identified to have potential for wildlife conflict issues should consider an education or outreach component that covers wildlife issues, dispels myths regarding wildlife conflict, and provides clear and simple strategies to protect livestock from wildlife. These strategies may include the following:

1. In areas where this is possible, livestock should be corralled or kept in structures overnight when animals may be vulnerable to predation from large mammalian predators. Corralling or keeping livestock in barns during parturition may also protect young from predators. Corrals and structures should be built close to where livestock herders or carers can be nearby, if possible and safe for people, such that predators may be discouraged from coming around livestock or can be scared away. Corrals or structures should be built to ensure that they are sound to both keep livestock in, and to keep wildlife out.

2. For some livestock species, the use of guard animals has proven to be effective at deterring predators from herds. For example, in Namibia, livestock dogs have been placed with pastoral ranchers and have resulted in reduction of livestock loss and a positive economic benefit to livestock producers (Potgieter et al. 2016). Other guard animals may include larger ungulates or camelids that may be more aggressive towards predators than livestock, such as donkeys or llamas. Using guard animals such as this may be particularly effective in systems where livestock are kept in smaller enclosures, such as mixed-crop livestock or small-scale/household urban livestock production systems (Andelt 2004). Guard animals would require some up-front monetary investment and potential on-going feed and maintenance, which may present a barrier for some livestock producers and require cost to benefit consideration to determine if the risk of livestock losses is significant enough to warrant a larger up-front investment in protection strategies.

Compensatory mitigation programs may be effective at ensuring livelihoods for livestock producers in the event of a wildlife depredation event. Programs that offer compensatory mitigation can be problematic, resulting in difficulties maintaining funding sources to provide for losses, preventing adoption of other strategies to avoid depredation of livestock, and confusion regarding criteria for eligibility for compensatory mitigation. As such, Nyhus et. al (2003) present the following criteria for developing an effective livestock compensation program:

1. Timely and accurate verification of damage and loss;
2. Prompt and fair payment for livestock losses;
3. Sufficient and sustainable funds;
4. Site specificity and identification of who, what, and where is considered part of the compensatory mitigation program. Shared management between locals and institutions for compensatory programs may reduce internal conflict;
5. Clear rules and guidelines – compensation should be linked to clear guidance; and
6. Developing measures of success – is the program meeting intended targets (e.g. fewer livestock losses, fewer wildlife casualties).

To prevent poisoning of scavenging or predatory birds feeding on livestock carcasses treated with veterinary pharmaceuticals, the least toxic anti-inflammatories for livestock should be used during production.

EXTINCTION OF LOCAL LIVESTOCK BREEDS

Growth and diversification of livestock production systems may result in the loss of diversity of livestock breeds. This phenomenon may be particularly applicable to extensive grazing systems and intensive livestock production systems; however, wherever selective breeding of livestock occurs, there may be a loss of genetic diversity of livestock species. Livestock breeds that may be genetically valuable, but less productive may be replaced by breeds that are robust and profitable.

In addition, livestock breeds that have not been developed in concert with ecosystems in the project area may also cause environmental degradation from grazing/browsing strategies that may denude or destroy vegetation or soil compaction and erosion. For example, in some communities in the Andes, cattle farming has replaced traditional camelid (i.e., alpaca or llama) farming. However, cattle are less suited to steep or sensitive environments, especially at higher elevations, and may cause increased soil disturbance. Cattle farmers may also clear and manage more land for more grass fodder than for traditional breeds of livestock.

MITIGATION MEASURES

Project planners should consider local breeds or species of livestock when developing livestock systems and evaluate the potential risks and rewards of using a potentially less-productive breed or species that may be more well-suited to the environment. New species or breeds of livestock should be thoroughly researched, including grazing/browsing preferences, impacts on physical environmental conditions, and any indications of potential for disease transmission to indigenous wildlife or traditional livestock in the project.

3.3 LIVESTOCK PRODUCTION SYSTEM-SPECIFIC IMPACTS AND MITIGATION MEASURES

This section includes a discussion of environmental impacts and mitigation measures specific to the four livestock production system categories of focus for this SEG, listed below. Environmental impacts vary between these systems, and it is important to consider these differences in impacts when selecting a livestock production system for use in USAID activities.

- Rangelands and extensive grassland production systems;
- Mixed crop-livestock production systems;
- Intensive production systems; and
- Urban/peri-urban production systems.

3.3.1 RANGELANDS AND EXTENSIVE GRAZING PRODUCTION SYSTEMS

Aspects of rangelands and extensive grazing production systems have the potential to either degrade landscapes or improve landscapes depending on how they are applied in context. Grazing practices described in this section may include a variety of livestock management systems applied during project implementation. Box 4 includes a glossary of potential grazing management systems and a brief description for consideration while planning projects in rangelands and extensive grazing production systems.

BOX 4. GRAZING PRACTICES

The following presents potential grazing systems that may be implemented to mitigate adverse impacts from livestock grazing systems.

Grazing Planning – A grazing plan is useful to implement adaptive grazing. Planning allows for goal setting, identification of existing conditions, and strategies for long-term successes.

Rotational Grazing – A grazing strategy where grazing areas may be subdivided and grazed sequentially to allow areas to "rest" from grazing.

Intensive/Mob Grazing – A strategy involving moving animals daily between smaller grazing areas

Holistic Land and Livestock Management – Holistic management practices consider livestock production in the context of broader ecosystem processes, and includes planning, monitoring, and identification of production systems appropriate for the ecological context.

3.3.1.1 BENEFICIAL IMPACTS

BENEFICIAL IMPACTS TO BIODIVERSITY

Extensive livestock grazing systems may play a key role in maintaining biodiversity in semi-natural habitats in certain ecosystems. Grasslands in semi-arid, tropical, and temperate regions may benefit from grazing through maintenance of semi-natural habitats supporting wildlife and ecosystem services, especially in ecosystems where native herbivory is an integral part of maintaining ecological structure and function (Buisson et. al 2018). In forested areas where vegetation has been cleared for pasture, extensive grazing systems may have adverse impacts to biodiversity (Nepstad et al. 2008). For some plant species that have co-evolved with herbivores, grazing may have beneficial impacts, including more production following being grazed, seed dispersal, or seed germination in livestock-grazed areas (Steinfeld, et al. 2010).

BENEFICIAL IMPACTS TO LANDSCAPES

In keeping lands under appropriate levels of grazing, extensive grazing systems may contribute to a reduction in more destructive land use pressures such as land clearing for urbanization or agriculture, and from disturbance regimes such as fires. Given that pastoral systems are dependent

BOX 5. CASE STUDY: SILVOPASTORAL SYSTEMS

In silvopastoral livestock systems, animal forage or fodder is not just herbaceous. Shrubs or small trees palatable to livestock are planted. Fruits from small trees may also be consumed. Suitable shrubs include species from the genus *Leucaena,* which is native to Mexico. In addition to being excellent food for livestock, this species fixates nitrogen, grows rapidly in tropical areas, and is tolerant of drought. Intensive silvopastoral systems in Colombia have employed *Leucaena* species successfully. In most silvopastoral systems, it is necessary to graze animals rotationally to avoid damage to shrubs and trees. In Colombia and Mexico, cattle are moved every couple of days or separated using electric fences. (Source: Broom et al. 2013.)

upon the productivity of rangelands, farmers are incentivized to ensure that rangelands remain as productive as possible. See Box 5 on silvopastoral systems, a type of rangeland.

IMPROVING SOIL CONDITIONS

For extensive grazing systems, moderate grazing can have positive impacts on grassland ecosystems by breaking up crusted soils to improve conditions for seed establishment. The addition of manure from livestock can sustain soil fertility and help to recycle nutrients in the ecosystem. Hoof action at the soil's surface can reduce capping and can integrate manure and urine to allow for increased soil fertility and better seed germination.

3.3.1.2 ADVERSE IMPACTS

LAND DEGRADATION

In some regions, changes in land use or land tenure have led to rangeland fragmentation and subsequent reduction in livestock mobility. Grazing animals may become concentrated in one place. As the rangelands are fragmented, more pressures are placed on individual grazing areas, which may lead to stocking rates that exceed the carrying capacity of the pasture.

OVERGRAZING AND LOSS OF RANGELAND PRODUCTION AND FERTILITY

Overgrazing is the result of the concentration of livestock in areas and the resulting overuse and depletion of rangeland resources. This leads to soil erosion, loss of soil fertility, reduction in rangeland production, and nutrient loss. Overgrazing in sensitive or unsuitable ecosystems may result in more adverse impacts. Overgrazing may be the result of improper grazing management — for example, stocking improper livestock species or breeds for the rangeland, stocking too many livestock, or not employing sustainable grazing management practices like rotational grazing.

MITIGATION MEASURES

The application of sustainable grazing practices can prevent or mitigate impacts from overgrazing. Projects should consider the carrying capacity of rangelands to determine stocking rates to avoid overgrazing. If possible, livestock should be rotated on lands susceptible to degradation. Projects could include seasonal grazing to avoid grazing sensitive areas during wet seasons or particularly dry seasons to reduce likelihood of overgrazing impacts. Farmers and programs should carefully consider the livestock species and breeds and their compatibility with the rangeland. Climate is a strong driver for how land responds to various grazing management strategies and should be reflected in choice of livestock management plans.

3.3.2 MIXED CROP-LIVESTOCK PRODUCTION SYSTEM IMPACTS

3.3.2.1 BENEFICIAL IMPACTS

SOIL HEALTH

Mixed crop-livestock systems may allow for greater opportunities for crop and pastureland rotations that can benefit vegetation and soil health. In areas where rotational projects are possible, soils may rest following crop-growth and grazing, which will prevent nutrient depletion, allow for the redevelopment of soil nutrients, and reduce soil erosion.

HABITAT HETEROGENEITY

Mixed systems may also provide a mosaic of habitats at the farm-scale based on the need for rotational operations or grazing to allow for the maintenance of soil health. These habitat mosaics may provide resources for indigenous wildlife or pollinating insects. Habitats may be built into project design that can benefit wildlife and pollinators. In areas where burning crop residue is a problem and environmental concern, small ruminants may be allowed to graze, which will help maintain soil nutrients and mitigate the negative impact on the environment caused from burning.

3.3.2.2 ADVERSE IMPACTS

Adverse impacts resulting from mixed crop-livestock systems are covered above in General Impacts, Section 3.2.2. Ecological and local context for adverse impacts may be tailored to individual projects as they are developed.

3.3.3 SMALL-SCALE/HOUSEHOLD AND URBAN PRODUCTION SYSTEMS

3.3.3.1 BENEFICIAL IMPACTS

Peri-urban livestock systems may provide beneficial impacts that may alleviate some environmental degradation and pollution control in urban or increasingly urbanized areas. Wastewater that is generated from households can be used for irrigation of peri-urban crops or feedstocks, thereby reducing the potential for contaminated water to enter water-ways. Conversion of marginal land or open space in peri-urban areas to crop/feedstock and livestock areas may result in changes to previous land uses that may have included environmentally adverse practices, such as dumping of trash or other household wastes.

3.3.3.2 ADVERSE IMPACTS

Increasing urban and peri-urban livestock systems can create negative environmental impacts resulting from increasing numbers of livestock in areas of human habitation. Concentrations of animals, even without reaching thresholds for intensive systems, may result in undesirable conditions such as noise, smells, and contamination of waterways. Livestock raised in peri-urban settings may additionally be exposed to contamination from heavy metals, fecal pathogens, and other parasites from proximity to untreated raw sewage. Peri-urban systems may result in concentration of animals in areas with little to no agricultural land, resulting in more pronounced environmental impacts in peri-urban areas than would be observed in agricultural or pastoral settings (FAO 2006). For example, higher concentrations of livestock can produce nutrient overloads that can have major downstream effects in peri-urban systems, such as the eutrophication of surface water, leaching of nitrates from manure storage facilities, and imbalance of soil fertility due to application of concentrated animal waste (FAO 2006). This may result in decreased water availability and quality.

MITIGATION MEASURES

In designing peri-urban systems, carefully considering the location of projects and construction of proper animal housing may ameliorate impacts from increased noise and smells in the neighborhood of implemented projects. Using plots of land that are otherwise degraded or located away from housing centers should be considered first when designing projects. For household systems, effective waste management, such as recycling or having the means to sell livestock waste products off site in a timely manner may improve smells. For example, chicken manure may be a valuable fertilizer for agriculture production. Additional ways to convert waste to prevent smells and contamination in smallholder peri-urban systems include developing a compost program or system, which would require some direct knowledge of composting and well as business assistance for creating a market for the product.

3.3.4 INTENSIVE LIVESTOCK PRODUCTION SYSTEM IMPACTS

3.3.4.1 BENEFICIAL IMPACTS

INCREASE IN EFFICIENCY OF NATURAL RESOURCES

Intensive livestock systems are designed to more efficiently use natural resources to produce livestock products. With this increase in efficiency, the need to clear large areas of land for pasture or feed crops would be reduced. An intensive system may have a smaller footprint to produce the same amount of meat or dairy than an extensive grazing or mixed crop-livestock system, therefore reducing the amount of habitat that may need to be cleared to efficiently produce animal-based nutrition products. For intensive livestock production systems, it will be necessary to measure the specific benefit of the system in relation to the potential impacts it may have to evaluate if increasing intensity corresponds to an increase in the number of livestock or livestock products produced per measure of natural resource used (Reid et al. 2010).

3.3.4.2 ADVERSE IMPACTS

Adverse environmental impacts from intensive agricultural systems mostly stem from the concentration of animal waste and the resulting need for disposal, the clearing of land for construction of intensive systems and feed production, its location in relation to population centers (i.e. air particulates and water quality near large concentrated residential areas), and the loss or reduction of livestock diversity.

LOSS AND DEGRADATION OF HABITAT

For intensive and peri-urban systems, most livestock feed is produced off-farm on large areas of farmland with simplified landscapes, leading to loss of habitat and biodiversity. Off-farm production areas may be located far from the animal production area and may require the use of roads, resulting in the potential for new roads or increased use of existing roads. Since the majority of intensive livestock systems occur near urban areas, these systems may contribute to urban sprawl, habitat fragmentation, increased GHG emissions, and increased urban/wildland interface issues (i.e., wildlife encounters). The footprint for intensive systems where livestock are raised may allow for smaller areas to be used to produce similar output compared to other livestock systems; however, this may not take into account that large amounts of land may need to be converted in order to support the necessary feedstocks or waste management of intensive systems.

MITIGATION MEASURES

Intensive livestock systems should be carefully sited to consider potential impacts to waterways, human water sources, and sensitive ecosystems. Because intensive systems involve the input of off-farm resources, these systems may be cited on lands that are otherwise marginal or not suitable for other purposes when possible.

For off-farm production areas that may be under direct control of the farmer or project, mitigation strategies include careful siting of new crop areas to avoid the loss of sensitive ecosystems, such as wetlands, riparian areas, or important wildlife habitat. If possible, areas that are currently in-production should be used. If off-farm production areas are not under direct control, project planners should assess the origin of off-farm fodder to ensure that production of resources for intensive systems does not result in the loss of habitat.

3.4 SUMMARY OF MITIGATION STRATEGIES

Mitigation and monitoring methods will be dependent on both impacts and indicators selected for each livestock system. Table 1 below summarizes the common environmental impacts for livestock production systems and associated mitigation measures described above.

TABLE 1. SUMMARY OF ADVERSE ENVIRONMENTAL IMPACTS AND MITIGATION STRATEGIES

IMPACT MECHANISM/DRIVER	LIVESTOCK SYSTEM OF CONCERN	POTENTIAL ADVERSE IMPACT	MITIGATION STRATEGY
WATER QUALITY AND SUPPLY			
Contamination from Livestock Waste	All	Waste can contaminate surface and ground water resources.	• Mitigation strategies that prioritize access to clean water for people are imperative. • Water supplies for people and livestock should be separated. • Water quality monitoring should be conducted to signal any changes in quantity or quality for human consumption • Manure management. More details for management strategies can be found in chapter 5. • USAID-funded activities require 216 regulation documentation for any pesticide or chemical use.
Wells and Boreholes	All	Concentration of livestock and wells and boreholes may lead to degradation of soils and vegetation in the immediate vicinity. Overuse of bore holes may cause reduction in available water or lowering of water table in vicinity.	• Grazing or livestock management plans should be developed to avoid pressures at livestock water sources. Management plans should include water budget strategies to avoid water scarcity and adaptive management strategies to address the potential for reduction in water quantity at water supplies.
LAND DEGRADATION			
Use of marginal lands	All	Livestock production may be concentrated in areas where lands are marginal based on soil, water, or vegetation resources. These areas are generally less resilient and susceptible to increased degradation over the long-term and may not regenerate in an economically feasible time frame.	• Consider livestock species that are more suitable to marginal lands or those that may be local. • Use physical barriers such as fencing or terracing to manage access to sensitive areas • Develop grazing management plans and educational opportunities about marginal lands and ways to avoid adverse impacts over the long-term

IMPACT MECHANISM/DRIVER	LIVESTOCK SYSTEM OF CONCERN	POTENTIAL ADVERSE IMPACT	MITIGATION STRATEGY
Soil Erosion	All	Overpopulation of animals in any production system may result in the erosion of soils, uncontrolled run-off following vegetation removal, and loss of soil nutrients.	• Develop grazing management plans incorporating education and training for project partners to understand impacts and ways to avoid sensitive resources. • Consider carrying capacity of lands to stock appropriate numbers of animals in order to avoid overpopulation and degradation of resources. • If funding is available, consider fencing or physical barriers for sensitive soil areas.
Loss of Rangeland Production and Fertility	Rangelands and Extensive Grazing Systems	Overgrazing of rangelands resulting from overpopulation of livestock may result in overuse and depletion of rangeland resources, including soil fertility, biomass, and nutrient loss. In sensitive ecosystems, this may result in greater adverse impacts.	• Application of sustainable grazing practices and education for project partners to understand impacts and mitigate overgrazing effects. • Projects should consider carrying capacity of rangelands to determine livestock numbers and types suitable to the grazing area. • Seasonal grazing in sensitive areas or seasons should be employed to reduce or mitigate impacts.
DAMAGE TO HABITAT AND REDUCED BIODIVERSITY			
Loss and Degradation of Habitat	All	Habitat conversion resulting from land use changes in livestock systems may result in direct (direct conversion to feedstock production or pastures) or indirect (removal of habitat from loss of forage, introduction of invasive species, etc.) impacts.	• Development of a management plan tailored to the ecological conditions of the rangeland or pasture. • Rotational grazing management — moving animals between pastures. • Seasonal exclusions • Rehabilitation of degraded areas (reseeding, tillage) • Restoration of native or introduced vegetation. Introduced vegetation should be carefully selected to weigh the cost/benefit and to ensure that species are not invasive. • Conserve biodiverse areas in project areas, such as wetlands or tropical forests.

IMPACT MECHANISM/DRIVER	LIVESTOCK SYSTEM OF CONCERN	POTENTIAL ADVERSE IMPACT	MITIGATION STRATEGY
Spread of Invasive Species	All	Improperly managed livestock systems may support the introduction and proliferation of undesirable, non-native species. Disturbance associated with grazing or tillage may provide ecological opportunities for invasive species to establish. Concentrations of livestock may result in the introduction and proliferation of microbes and parasites. Livestock themselves may be considered an invasive species if not managed properly.	• Develop an invasive species/noxious weed management strategy that includes prevention of establishment of invasive species during the design phase and strategies for detection and mitigation of invasive species. • Understanding of ecology and context is important while projects develop. • During project initiation and implementation, livestock, livestock products, feed, and equipment should be cleaned, inspected and quarantined. • Develop monitoring programs based on considerations of ecology, climate, and available resources. • Develop management plans for early detection and eradication of invasive species to prevent social, ecological, and economic damage.
Removal of Wildlife	All	Direct removal of wildlife may result in the loss of biodiversity — including wild ungulates that compete with livestock for available forage and wildlife predators that may prey on livestock resources. Livestock management practices such as fencing, or land clearing may lead to disruption of natural wildlife behaviors.	• Projects should be planned such that livestock species chosen for activities will not outcompete or require the removal of wildlife species in the general vicinity. • Mitigation strategies for wildlife impacts typically fall into two categories: prevention and compensatory mitigation. • Corrals or small enclosures may prevent predation. • Guard animals may be effective in deterring predators. • Compensatory mitigation programs may be employed to offset losses due to predation.
Extinction of Local Livestock Breeds	All	Growth and diversification of livestock production systems may result in the loss of diversity of livestock breeds, including the loss of genetics and phenotypes as well as the loss of culturally important livestock species.	• Activities should consider local breeds or species of livestock when developing projects. • Evaluation of the risks and rewards of using livestock breeds should be conducted at the project-initiation phase. • New species or breeds of livestock that may be novel to an area should be thoroughly researched. • Identify opportunities to preserve indigenous/heritage genetics such as nuclear/pure herds. • Education for participants in community-based breeding schemes.

3.5 RESOURCES FOR ENVIRONMENTAL IMPACTS

- *The State of Food and Agriculture. Part 1: Livestock in the Balance*. FAO. 2009. http://www.fao.org/docrep/012/i0680e/i0680e00.htm
- *Biodiversity and the Livestock Sector – Guidelines for Quantitative Assessment.* FAO 2020. https://www.fao.org/documents/card/en/c/ca9295en
- *Defining Outcomes & Indicators for Monitoring, Evaluation, and Learning in USAID Biodiversity Planning.* USAID 2016. https://pdf.usaid.gov/pdf_docs/PA00M8MX.pdf
- *Water Use of Livestock Production Systems and Supply Chains*. FAO 2020. https://www.fao.org/3/I9692EN/i9692en.pdf
- *Accounting for Livestock Water Productivity*: How and Why? FAO 2021. https://www.fao.org/documents/card/en/c/ca7565en.
- *Environmental Performance of Feed Additives in Livestock Supply Chains. Guidelines for Assessment.* FAO 2020. https://www.fao.org/documents/card/en/c/ca9744en
- *The Savory Institute Resource Library* – providing resources regarding Holistic Grazing Management. https://savory.global/resource-library/
- *Livestock's Long Shadow: Environmental Issues and Options.* FAO 2006. https://www.fao.org/3/a0701e/a0701e00.htm

4 CLIMATE CHANGE MITIGATION AND ADAPTATION

Livestock production relates to climate change both in terms of the risks that climate change impacts can pose to livestock activities as well as in terms of the greenhouse gas (GHG) emissions livestock production generates that contribute to climate change.

Figure 5. Livestock Farmer Grazing Goats

Source: Yuichi Mori, Hadramaut, Yemen

With regard to climate risks, climate change can have direct and indirect impacts on livestock and has the potential to significantly disrupt livestock production activities. For example, increased temperatures caused by climate change may cause heat stress within livestock, which can decrease livestock reproductivity and increase livestock mortality, negatively impacting the performance of livestock production systems (Rojas-Downing, et al. 2017). At the same time, livestock production systems are a significant source of GHG emissions.

This chapter explores these climate change impacts in detail and proposes mitigation and adaptation measures to address them. Climate change impacts fall under the spectrum of environmental impacts and should thus be considered a sub-section of Chapter 3. While they are also environmental, climate change impacts are extensive in their own regard and are integral to consider in livestock activities in a respective chapter. Also included are considerations for addressing project-specific climate change impacts in the activity design and indicators for monitoring impacts throughout the activity lifecycle. A discussion of climate change is included to provide relevant context of the importance of incorporating climate change considerations in USAID activity design.

Note: USAID Activities must assess, address, and adaptively manage climate risks through a Climate Risk Management (CRM) process (USAID 2017).

To align with the Agency's climate goals and reduce the impacts associated with climate change, both mitigation and adaptation strategies are required. Mitigation refers to actions that reduce, avoid, or sequester carbon dioxide (CO_2) and other greenhouse gases, identified as the main cause of anthropogenic climate change (USAID 2022a). Preventing dangerous anthropogenic interference with the global climate system requires mitigation efforts by both developing and developed countries (USAID 2017). Climate adaptation comprises actions taken to assess, address, and adaptively manage the risks associated with climate change impacts to reduce vulnerability and/or avoid harm (USAID 2022b). Adaptation is both a response to experienced climate changes and the preparation for projected future climate impacts.

Although the precise magnitude of climate change impacts is unknown, there is research available to confirm the effects of climate change to livestock and livestock production. Furthermore, livestock production also contributes to GHG emissions and can cause and exacerbate climate change effects. In this section, both the climate impacts to and from livestock are described.

4.1 ACTIVITY DESIGN GUIDANCE FOR CLIMATE RISK AND GHG EMISSIONS

Included below in Box 6 are climate change considerations for livestock activity design. These factors should be assessed at the inception of the activity design and utilized in the decision-making process to address potential context-specific climate change risks to the activity. Please note that these factors are not exhaustive, and all project-specific context should be considered in assessing climate change impacts.

BOX 6. SAMPLE CLIMATE CHANGE CONSIDERATIONS FOR ACTIVITY DESIGN

Impacts of Future Climate Trends on Livestock Production

- Compatibility of proposed livestock production system with future climate change trends (e.g., higher temperatures, increased drought or flood risk, extreme heat, more frequent and intense extreme weather events, etc.)
- Anticipated impacts of temperature changes caused by climate change on local fodder crops and grazing areas

GHG Emissions from Livestock Production

- Potential emissions based on proposed herd size and animal weight

4.2 GENERAL IMPACTS AND MITIGATION MEASURES

Section 4 describes the adverse climate change impacts listed below and potential emissions mitigation adaptation measures. As possible, regional climate change impacts are included to highlight differences in global climate change impacts between locations and the importance of location in assessing climate change impacts. It should be noted that these impacts are common throughout the livestock sector and are not specific to the four livestock production systems of focus in this SEG. For livestock production system-specific climate change impacts, please reference Section 4.3.

- Climate Change Risks to Livestock Production
- GHG Emissions from Livestock Production

4.2.1 CLIMATE CHANGE RISKS TO LIVESTOCK PRODUCTION

Climate variability and change is a multi-faceted issue that can undermine development progress and increase risk, especially in developing countries. Climate change affects the frequency, duration, and intensity of extreme weather conditions, alters precipitation patterns, disrupts ecological systems, and is leading to temperature increases and rising sea levels worldwide (USAID 2022a). These changes can result in shocks (i.e., short-term events like storms) and longer-term stresses (i.e., reduced rainfall, altered rainfall patterns, and droughts) (USAID 2018a). Climate change risks result from the interaction of climate-related hazards (i.e., shocks and stressors) with the underlying vulnerability of societies and systems exposed to climate change (ADS 201mal).

Temperature increases may also affect the animals themselves: most livestock species perform best at temperatures between 10°C and 30°C and at temperatures above 30°C, livestock experience heat stress, which reduces their feed intake, water intake, and milk production and can disrupt reproductivity (i.e., decreased conception rates) and increase mortality (Rojas-Downing, et al. 2017). Water availability presents an issue as temperature increases and precipitation decreases, which may decrease animal water consumption or availability of reliable water sources (FAO 2021). Extreme weather events lead to direct impacts to livestock health including temperature-related illness, changes in metabolic functions, and morbidity (Ali, Carlie and Giasuddin 2020).

Table 2 below includes a summary of direct and indirect impacts of climate change on livestock production systems.

TABLE 2. DIRECT AND INDIRECT IMPACTS OF CLIMATE CHANGE ON LIVESTOCK PRODUCTION SYSTEMS

DIRECT IMPACTS	INDIRECT IMPACTS
• Temperature increases • Changes in water availability • Increased variability of climatic conditions • Alterations to animal nutritional feed quality and quantity • Increased frequency of extreme weather events • Sea-level rise and coastal inundation	• Increases in disease transmission • Supply chain disruption • Zoonotic disease spread • Increases in resource prices • Crop yield reductions leading to the low availability of reliable feed for livestock

Sources: FAO 2021 and Rojas-Downing, et al. 2017

4.2.1.1 REGIONAL PERSPECTIVE

Each region will be subject to different climate stressors and risks based on their geographic location and climate. This section provides a summary of likely regional stressors that may affect livestock USAID activities.

The East Africa region is subject to climate variability and extremes including droughts and floods. Climate models predict that the region will likely experience both near-term alterations in climate such as warmer temperatures, changes in frequency and intensity of extreme climate events, as well as decreased precipitation and sea-level rise. Projected climate impacts will increase the vulnerability of communities that depend upon natural resources, in this case, livestock production systems will experience both direct and indirect impacts from climate change (USAID 2020a).

Climate extremes are a major impediment to resilience in **Southern Africa**. Floods likely linked to climate change have brought intense floods to the region, leading to loss in crops, livestock, and infrastructure as well as outbreaks of diseases in livestock (USAID 2016a).

West Africa is one of the world's most vulnerable regions to climate variability and change. Increasing temperatures and shifting rainfall patterns are already affecting livelihoods, food security, and economic and governance stability. Since the 1970s, climate vulnerability has resulted in significant agricultural losses, water scarcity, extreme flooding, and environmental degradation. There are increased crop/livestock losses from drought, floods, pests, and disease, and coastal erosion and inundation (USAID 2018b).

A large portion of **Central Asia** is covered by rangelands and grasslands. Climate stressors expected to impact the region are increases in temperature and extreme weather events. Such stressors will impact pastures, crop lands, and livestock. Reduced livestock reproductivity, storm damage to crops and livestock, and increased spread of infectious disease among livestock are all impacts from climate change in this region (USAID 2018c).

The **Pacific Islands** region is experiencing significant impacts from the changing climate. The region is vulnerable to sea-level rise, tropical storms, drought, and extreme rainfall events. The region's low elevation puts it more at risk for impacts from climate change. Climate planning and adaptation is crucial for a viable future with the changing climate (USAID 2018d).

The **Amazon Basin in South America** has a wealth of ecosystem services and biodiversity. Climate change has decreased rainfall, increased temperatures, and drought. In the agricultural sector, climate change has decreased crop productivity. As a result, there is increased competition for land use (USAID 2018e).

4.2.1.2 CLIMATE CHANGE RISK MITIGATION

Climate Risk Management (CRM) Analysis is detailed in the ADS 201 Mat and Mal guidance as "the process of assessing, addressing, and adaptively managing climate risks". CRM is mandated by USAID internal policy and is required for all new country/regional strategies (USAID 2021a). The CRM Analysis tasks the project designers to consider how the changing climate may impact the USAID activity during and after project life, focusing on the local conditions of the implementation site. However, CRM is only one part of the process of adaptively managing climate change impacts in projects. Risk ratings and severity of climate change impacts for each region will vary depending on the context of stressors and geographical factors.

Table 3 summarizes common climate risk management and mitigation practices for livestock production activities.

TABLE 3. COMMON MITIGATION MEASURES FOR CLIMATE RISKS

CLIMATE CHANGE STRESSORS	CLIMATE RISKS	RISK MITIGATION STRATEGIES	OPPORTUNITIES TO STRENGTHEN CLIMATE RESILIENCE
Rising temperatures	Heat stress in livestock, leading to reduced reproduction rates, growth rates and milk production	Introduce and improve access to insurance	Drought early warning systems (with DRR or S&T programs). Conflict prevention with DG programs as water becomes scarcer. Leverage the government's increasing focus on climate change adaptation and agricultural extension. Disaster preparedness plans Drought-resistant crop production Raise more heat-tolerant livestock breeds
Increased frequency & intensity of heavy rainfall	Increased incidence of pests and diseases for crops and livestock Crop damage and degraded crop and pastureland	Improve vaccination cover for herds Improve crop management Improve fodder storage/banking strategies	Adopt certain plant varieties, planting techniques, and management practices
Rising temperatures and evaporation rate	Increased water scarcity and variability for irrigation Decreased availability and quality of reliable feed and fodder, increased prices for feed	Improve fodder storage/banking strategies	Adopt certain plant varieties, planting techniques, and management practices Improve capacity of farmers and pastoralists to manage crop planting; micro-insurance to support price sensitivity

4.2.2 LIVESTOCK PRODUCTION CONTRIBUTIONS TO GLOBAL CLIMATE CHANGE

4.2.2.1 GHG EMISSIONS SOURCES

Livestock production is a significant source of GHG emissions, mainly methane, which has a global warming potential (GWP) 28 times higher than carbon dioxide, and nitrous oxide, which has a GWP 265 times higher than carbon dioxide. Feed production and processing contribute about 45 percent of emissions, enteric fermentation produces about 39 percent, and manure storage accounts for 10 percent of the total emissions for the entire livestock sector. The remaining 6 percent is attributable to the processing and transportation of animal products (Gerber, et al. 2013). In the agricultural and waste sectors, livestock production produces the most emissions (IPCC 2021).

Methane is primarily produced from enteric fermentation and manure storage. Enteric methane production is naturally occurring methane that is directly impacted by the level of intake, the type and quality of feed, the amount of energy consumed, animal size, growth rate, level of production, and environmental pressure. During enteric fermentation, microbes decompose and ferment plant materials in the animal's digestive tract or rumen (Grossi, et al. 2019). Enteric methane is a by-product of this process and is expelled by the animal through burping (FAO n.d.).

Nitrous oxide arises from manure storage. When manure is handled as a solid or spread on pastures, nitrous oxide production increases. It is produced through nitrification and denitrification processes of the nitrogen contained in manure.

Feed production is also a source of GHG emissions, contributing to emissions of both carbon dioxide and nitrous oxide (Grossi, et al. 2019). Soil carbon dioxide emissions are mainly due to soil carbon dynamics, the manufacturing of synthetic fertilizers and pesticides, and from fossil fuel use in on-farm agricultural operations. Nitrous oxide is emitted when organic and inorganic fertilizers are applied to the soil.

4.2.2.2 GHG EMISSIONS MITIGATION

There is potential to reduce GHG emissions from the livestock sector through different practices and technologies. Reversing deforestation, targeting for higher-yielding crops with climate change adapted varieties, and improving land-use and water management can support carbon capture. [5]

Methane emissions from enteric fermentation can be reduced through practices such as improvement of animal nutrition and genetics. That can include increasing dietary fat content, providing higher-quality forage, increasing protein content, providing supplements, and the use of antimethanogens (vaccines to suppress methane emissions). [6] Effectiveness on absolute reduction of emissions is estimated to be low to medium, but some of these options can achieve

BOX 7. CASE STUDY: RENEWABLE NATURAL GAS

Livestock farms can use anaerobic digestion to convert livestock manure into biogas that can ultimately be converted to renewable natural gas (RNG). RNG can be used for heating, electricity, and vehicle fuel. Replacing traditional vehicle fuel with RNG vehicle fuel can reduce pollutant emissions, increase fuel diversity, and reduce GHG emissions. RNG use can yield GHG reductions up to 75 percent (EPA 2020). Two thirds of bioenergy is generated in developing countries. RNG is starting to emerge as a potential fuel source to export globally.

[5] The process of storing carbon in a carbon pool (IPCC 2021)
[6] Directly related to pharmaceutical use

substantially lower emission intensity by improving feed efficiency and animal productivity. Reducing methane emissions from manure storage includes shortening storage duration, improving timing and application of manure, use of anaerobic digestors, covering the storage, using a solids separator, and changing the animal diets (Rojas-Downing, et al. 2017). Box 7 describes renewable natural gas, a form of energy produced from livestock manure.

For feed production, mitigation measures such as increasing nitrogen use efficiency, plant breeding and genetic modifications, using technologically advanced fertilizers, and combining legumes with grasses in pasture may decrease GHG emissions in feed production (Rojas-Downing, et al. 2017).

Managing herd size is also a mechanism to reduce emissions. Herd size and animal weight drive emissions: the larger and heavier the herd is, the higher the emissions. Increased off-take rate and decreased herd age at slaughter can reduce livestock herd size and ultimately decrease emissions as the quantity of cattle influences the amount of methane, carbon dioxide, and nitrous oxide (Rojas-Downing, et al. 2017).

TABLE 4. SUMMARY OF KEY EMISSIONS SOURCES AND MITIGATION MEASURES IN CONNECTION WITH LIVESTOCK PRODUCTION

ACTIVITY	EMISSIONS SOURCES	MITIGATION OPTIONS
Range and Grassland Production	• Rangeland animals • Land conversion towards rangelands	• Better land and soil management • Afforestation • Improved forest management
Mixed Crop-Livestock Production	• Enteric fermentation	• Nutrient management
Intensive Livestock Production	• Enteric fermentation • Increased production of livestock	• Manure management • Conversion of methane to biogas • Managing herd size

4.2.2.3 CLIMATE CHANGE ADAPTATION AND RESILIENCE OPTIONS

Adaptation opportunities for livestock production systems include a variety of measures involving production and management system modifications, shifting breeding strategies, institutional and policy changes, adopting new technologies, and building understanding of climate risk.

Diversification of livestock and crop varieties can increase tolerance to drought and heat waves and may increase livestock production when animals are exposed to temperature and precipitation stresses. In addition, increasing diversity of livestock species and/or breeds is effective in preventing the occurrence and distribution of livestock diseases increased by climate change.

Climate change will also affect the prevalence of pests and diseases. For example, increased rainfall exacerbated by climate change can increase reproduction of pests and transmission of disease on livestock. Farmers can adapt by improving vaccination cover to reduce losses (USAID 2012).

Improving feeding practices as an adaptation measure could improve the efficiency of livestock production. Some of the feeding practices include modification of diet composition, altering feeding times and frequency, and training farmers in production and conservation of feed for different agro-ecological zones. These practices can lower the risks associated with climate change by promoting increased intake, reducing excessive heat load, decreasing feed insecurity during dry seasons, and reducing animal malnutrition and mortality. Diversification of livestock varieties including replacement of animal breeds with new varieties intended for higher heat tolerance, is recommended to increase productivity in the face of temperature increases (World Bank 2003). Box 8 details a method of diversification of livestock species.

BOX 8. CASE STUDY: AFRICAN CATTLE BREEDING

Producers can target support to more heat-tolerant livestock breeds such as Turkana and Azaouak cattle, indigenous to Africa, that can survive on scarce water versus the Kuri cattle that are intolerant to heat and sunlight (Mwai, et al. 2015).

Due to climate change, seasonal rainfall patterns have diverged from historic patterns globally. There is a sharp increase in flooding, prolonged droughts, and water scarcity during dry seasons. Livestock production is adversely affected, as these water-security issues negatively impact livestock reproduction, growth rates, and milk production. Pests are also more prominent because of changes in evaporation rates. Changing precipitation patterns have also expanded the risk areas for disease vectors (Mweya, Moboera and Kimera 2017).

Producers can adapt by improving early warning systems to include access to data on climate hazards, helping institutions and governments proactively address risk, and take early action to reduce exposure and vulnerability. This is an ongoing, community process that aims to address the need to avoid harm due to climate hazards (Kelman and Glantz 2014). Another option is livestock insurance provided by governments and programs such as Feed the Future. For countries that do not receive livestock insurance from programs like Feed the Future, USAID has supported producers through the environment program. USAID/Cambodia has assisted farmers in accessing markets/buyers for a reasonable price as well as training them to treat animal diseases (Mukadas 2022).

Improving forage species; supplementing with feed blocks; producing silage from maize; and improving pasture on rangelands can all have an impact on the availability and quality of feed. Producing improved forage would be suitable for intensive and semi-intensive dairy farms and mixed systems. Feed blocks (food supplements) could be suitable for extensive drylands and produce similar mitigation results to improving forage quality (USAID 2018f). Market patterns should be taken into consideration, such as transportation costs and local feed production to address potential feed deficits.

4.3 ADDRESSING CLIMATE IN SPECIFIC LIVESTOCK PRODUCTION SYSTEMS

This section includes a discussion of climate change impacts, mitigation, and adaptation measures specific to the four livestock production system categories of focus for this SEG, listed below. Climate change impacts vary between these systems, and it is important to consider these differences in impacts when selecting a livestock production system for use in USAID activities.

- Rangelands and Extensive Grassland Production Systems
- Mixed Crop-livestock Production Systems

- Intensive Production Systems
- Small-scale/Household Urban Production Systems (focus on small-scale/household urban)

4.3.1 RANGELANDS AND EXTENSIVE GRASSLANDS PRODUCTION SYSTEMS

4.3.1.1 GHG EMISSIONS SOURCES CLIMATE CHANGE IMPACTS

Rangelands play a significant role in climate change processes. Range animals emit GHGs, and the demand for rangelands can shift landscape vegetation over time. A contributing factor toward the impact of rangelands to climate change is the increased use of rangeland production systems. According to the IPCC, grazing lands contribute more than one-third of total nitrous oxide emissions – more than 50 percent of total agricultural emissions (IPCC 2019a). Conversions of tropical forests into grazing lands and cropland to rangeland is accelerating due to an increase in demand for meat for human consumption and is resulting in soil degradation and/or depletion of irrigation water supply from aquifers and drying rivers (Holecheck, et al. 2020). In addition, land clearing directly causes deforestation and land conversion that results in significant additional GHG emissions. For example, Box 9 provides a case study of land conversion in Brazil.

> **BOX 9. CASE STUDY: LAND USE CHANGE IN BRAZIL**
>
> A problem worth mentioning is the conversion of forestry to pasture for grazing cattle. The livestock sector in Brazil is a significant source of income for the population there and poverty-stricken families rely on it. Parts of major tropical forests, including the Amazon rainforest have been reduced due to cattle ranchers converting them into pasture. The converted pasture is often used for a short-term then the land become unsuitable for grazing.

4.3.1.2 GHG EMISSIONS MITIGATION OPTIONS

There are a number of land management options, such as improved management of cropland and grazing lands, sustainable forest management, and increased soil organic content that do not require land-use conversion or land-use change (IPCC 2019b). Preserving and restoring natural ecosystems with high carbon sequestration potential such as peatland and forests can reduce the climate change impacts of land use conversion. Also, policies preventing land use conversion for livestock grazing can aid in the decrease in land-use conversion.

Afforestation is also a significant GHG mitigation measure. There are also opportunities to mitigate GHG emissions through rangeland management. Better management of soils can offset 5–20 percent of current GHG emissions. Sustainable land management can involve enhanced forest protection, improved forest and agricultural management, and afforestation on previously degraded lands (Olsson, et al. 2019).

4.3.1.3 CLIMATE RISKS AND ADAPTATION MEASURES

Rangeland systems differ widely, so no single adaptation strategy is applicable to all rangelands. Adaptation strategies for livestock production involve changes in grazing management, rainwater harvesting, adapted livestock breeds or species, pest management, enterprise structure, and the geographic relocation of livestock production systems to contend with the impacts of climate change.

4.3.1.4 REGIONAL PERSPECTIVE

Approximately half of the earth's terrestrial surface is considered rangeland, including extensive grassland. Of the global rangeland area, half is anticipated to experience a decrease in mean biomass and a significant increase in inter-annual variability due to climate change, which can have harmful impacts on livestock production. This negative impact on livestock production is expected to be the most prevalent in the Sahel, Australia, Mongolia, China, Uzbekistan, and Turkmenistan, regions that support 376 million people and 174 million ruminant TLUs (Godde, et al. 2020).

4.3.2 MIXED CROP-LIVESTOCK PRODUCTION SYSTEMS

4.3.2.1 GHG EMISSIONS SOURCES AND MITIGATION OPTIONS

An increase in temperatures due to climate change will accelerate the growth of plants in some areas. However, increases in maximum temperature may lead to severe crop yield reductions and reproductive failure. For livestock, most species have a comfort zone between 10 and 30 °C. Increased temperatures that exceed their comfort zone will reduce their feed intake by 3–5 percent per additional degree of temperature. In addition, increased rainfall variability has direct impacts on productivity for crops and livestock (Thornton and Herrero 2014).

Indirect impacts of climate change on mixed crop-livestock systems include degraded quality of grains and fodder as well as decreases in quantity. Furthermore, increased disease epidemics among crops and livestock, increased resource price, and increased cost of animal housing (e.g., cooling systems) (Thornton and Herrero 2014).

4.3.2.2 GHG EMISSIONS MITIGATION

Some adaptation measures in mixed crop-livestock production systems can provide mitigation co-benefits. Nutrient management, crop residue management, soil management, manure management, and improved feeding all have the potential for providing mitigation co-benefits to adaptation (Thornton and Herrero 2014).

4.3.2.3 CLIMATE RISK AND ADAPTATION MEASURES

Mixed crop-livestock production systems may face risks associated with climate change globally, based on projected changes to crop-growing days, available water, and crop failure threshold breaches. These challenges are expected to be particularly pronounced in places like Sub-Saharan Africa, where areas of mixed systems are projected to be doubly impacted by climate change risks by the 2050s (Thornton and Herrero 2015).

Mixed crop-livestock farmers can adapt to climate change impacts by increasing the resilience of their systems. There are several ways to enhance the overall efficiency and resilience of crop and livestock production systems in the face of climate change. For example, soil and nutrient management through composting manure and crop residues and reducing the need for synthetic fertilizers (with the co-benefit of reducing greenhouse gas emissions associated with their use). In situations with decreasing rainfall and increasing rainfall variability, improving water harvesting through the use of pools, dams, and pits is effective in retaining water.

Heat stress also impacts mixed crop-livestock systems. It can lead to increased cost of animal housing. For example, implementing cooling systems may present additional costs for producers. Insurance and aid from governments can assist farmers with this problem. The United States has options to ensure domestic farmers and the program has been effective in protecting them when unexpected costs are present (Edwards 2021).

4.3.2.4 REGIONAL PERSPECTIVE

Mixed crop-livestock systems are the backbone of African agriculture, providing food security and livelihood options for millions of people. Adaptation measures include increasing reliance through soil and nutrient management as well as adapting to rainfall variability. In addition, use of weather forecasts can increase preparation for rainfall variability. This information helped in cases of above-normal rainfall in West Africa and led to increased preparedness and ultimately saved lives (Rivera-Ferre and Lopez-i-Gelats 2012).

4.3.3 INTENSIVE LIVESTOCK PRODUCTION SYSTEMS

4.3.3.1 GHG EMISSIONS SOURCES AND MITIGATION OPTIONS

Intensive livestock production contributes to and is affected by climate change. The impacts to climate change from intensive livestock production are partly due to the considerable pressure on livestock production to deliver, under changing environmental conditions, an ever-increasing demand for protein in human diets. Although intensive livestock is more present in developed countries, developing countries also have intensive livestock systems that impact the climate.

Intensive livestock production systems are projected to increase. They may become the favored choice as these systems uses less land. For example, in Brazil, there are reports that the number of beef cattle has more than doubled since 2012 (Junior, et al. 2012). The IPCC estimates that there is a 1.4-fold increase in numbers for cattle, buffalo, sheep, and goats, and a 1.6- and 3.7-fold increase for pigs and poultry, respectively, has taken place since the 1970s (Smith, et al. 2014). Generally, the increases are due to population growth and the increased demand for higher protein in human diets.

4.3.3.2 GHG EMISSIONS MITIGATION

Increases in confined animal productions have significantly increased methane emissions from both animals and manure. In addition to the previously stated mitigation measures, there are other measures specifically suited for reducing emissions from intensive livestock systems. For example, better manure management could yield high beneficial results in reducing emissions. There's also the option for anaerobic digestion, which produces biogas that can be converted into renewable natural gas used for heating and lighting. Some forecasts estimate that biogas production could result in a 50 percent reduction in emissions in cooler climates and a 75 percent reduction in warmer climates (Casuto 2010). In addition, advanced grazing management as a replacement for concentrated animal feeding operations (CAFOs) is a recommendation for reducing greenhouse gas emissions that are produced from livestock operations (National Sustainable Agriculture Coalition 2019).

4.3.3.3 CLIMATE RISK AND ADAPTATION MEASURES

To adapt to relevant climate impacts to intensive livestock production systems, producers will need to be educated and trained to learn how to effectively manage their livestock production systems. While some climate change impacts may become apparent over a relatively long–time frame, producers should start taking proactive steps to adapt soon to prevent the most adverse of consequences and promote sustainable practices in the future. Education, efficient water management, coordination between producers, government aid, and sustainable crop management practices will all improve the adverse impacts from climate change on livestock production systems.

Diet manipulation as an adaptation measure could improve the efficiency of livestock production. Altering feeding times and changing diet composition can lower the risks associated with climate change. This includes reducing excessive heat load and reducing animal malnutrition and mortality.

Intensive livestock production is expected to move closer to urban areas, and livestock housing systems will change with self-sufficient energy supply, recycling of water, and sophisticated cooling systems. It is anticipated that manure management of intensive livestock systems will become an industrial process, with decreased environmental impact over time (Rust 2019).

4.3.3.4 REGIONAL PERSPECTIVE

Although extensive or pasture-based farming methods are the norm in Africa and some parts of Asia, Latin America and Asia increasingly favor intensive production systems over more sustainable options. Most of the emissions in Latin America come from livestock. A highly effective option for reducing emissions from livestock production in these regions is switching from intensive livestock production systems to pasture-based systems. It should be noted that there may be trade-offs in climate change impacts between intensive and pasture-based systems; however, it is difficult to evaluate these on a broad scale. Climate change impacts should be evaluated for each production system at the project level.

4.3.4 SMALL SCALE/HOUSEHOLD URBAN PRODUCTION SYSTEMS

4.3.4.1 GHG EMISSIONS SOURCES AND MITIGATION MEAURES

Urban livestock production systems produce higher methane emissions than rangeland and mixed-livestock production systems due to emissions from enteric fermentation and poor manure management (Berhe, Bariagabre and Balehegn 2020). Carbon dioxide emissions are also higher in urban production systems due to feed production and energy use (Berhe, Bariagabre and Balehegn 2020).

4.3.4.2 GHG EMISSIONS MITIGATION

Land-use practices on feed producing crops can offer mitigation options. Reducing soil disturbance and ensuring deeper-rooted vegetation and greater plant litter retention leads to larger volumes of carbon retained by the soil. Improved grazing management can also enhance carbon sequestration. Improving feed by replacing roughages with maize grain improved digestibility of feed and reduces manure production and enteric fermentation. Manure management should also be improved to reduce the amount of methane and nitrous oxide emissions (Berhe, Bariagabre and Balehegn 2020). Producers can also change the type of livestock raised, shifting from grazers such as cattle and sheep to browsers such as camels and goats as well as shifting toward raising short-cycle animals like poultry, dairy cows, and pigs as these livestock provide daily revenues and food security (Zhang, McCarl and Jones 2017).

4.3.4.3 CLIMATE CHANGE ADAPTATION

Producers can adapt by guaranteeing more stable feeding conditions is the adoption of fodder crops and pasture enclosures. Other adaptation strategies include land-use management, altering stocking rates, altering breeding and species mix, and production relocation (Zhang, McCarl and Jones 2017).

4.3.4.4 REGIONAL PERSPECTIVE

Small-scale farmers in Africa can have an impact on climate change by stopping the clearing of plantations. Livestock diversification, grazing management, and the practice of agriculture along rivers has helped in countries such as Kenya where climate change has been having an impact on livestock production.

4.4 RESOURCES FOR CLIMATE CHANGE IMPACTS

- "Climate Change in USAID Country/Regional Strategies: A Mandatory Reference for ADS Chapter 201." www.usaid.gov/sites/default/files/documents/.
- "Climate Risk Management for USAID Projects and Activities: A Mandatory Reference for ADS Chapter 201." https://www.usaid.gov/sites/default/files/documents/201mal.pdf.
- "Climate Strategy: 2022-2030." https://www.usaid.gov/policy/climate-strategy.
- USAID Climate Links: Regional and Country Risk Profiles and GHG Emissions Fact Sheets. Regional & Country Risk Profiles and GHG Emissions Fact Sheets | Global Climate Change (climatelinks.org)

5 HEALTH RISKS

Figure 6. Animal Health Worker Training in Quang Tri Province, Vietnam

Source: Richard Nyberg, USAID

When managed properly, livestock production systems offer benefits to human and animal health, including serving as a source of livelihood and nutrition to humans and reducing disease spread among animals; however, mismanagement of livestock systems can pose severe risks to human, livestock, and wildlife health. Best management practices for human and livestock health should be considered and incorporated into the design of livestock production systems, to prevent and mitigate risks to human, livestock, and wildlife health.

This chapter includes a detailed discussion of beneficial and adverse livestock health impacts and their mitigation measures, as well as potential factors to consider when assessing project-specific health impacts. These factors include activity design considerations and health indicators that can be used to evaluate and address health impacts to livestock production systems throughout the project lifecycle. Additional resources for health risks can be found at the end of the chapter.

5.1 ACTIVITY DESIGN GUIDANCE FOR HEALTH RISKS

This section includes potential health considerations for livestock activity design in Box 10 below. These factors should be assessed at the inception of the activity and utilized in the decision-making process to address potential context-specific health risks to the activity. Please note that these considerations are not comprehensive and are meant to provide examples of important, project-specific design context. A holistic review of project-specific health risks should be conducted prior to decision making for the activity design.

BOX 10. SAMPLE HEALTH CONSIDERATIONS FOR ACTIVITY DESIGN

Human Health

- Exposure to toxins in the production environment and impacts on health
- Environmental fecal pathogen exposure and impacts on health and nutrition
- Exposure to zoonotic diseases of livestock due to the production environment
- Exposure to and amplification of emerging infectious diseases through expansion of livestock production into forest edges and other undisturbed ecosystems
- The role of ASFs in tackling acute and persistent malnutrition and tradeoffs in production system environments

Animal Health

- Transboundary animal diseases and environmental determinants
- Environmental determinants of diseases of production
- Endemic diseases and environment

Wildlife Health

- Disease transmission between livestock and wildlife and vice versa
- Degraded environments and impacts on wildlife health and well being
- Antibiotics and antimicrobial resistance

5.2 INDICATORS FOR MEASURING HEALTH RISKS

USAID aligns with the World Organisation for Animal Health (WOAH), which establishes international guidance and standards for animal heath, including metrics for monitoring health risks within its Terrestrial Animal Health Code and Aquatic Animal Health Code. Additional indicators for human health can be found in the Feed the Future Indicator Handbook. Indicators will be project-specific and should be defined during the project design stage. Some examples of indicators include the following (WOAH 2021a, WOAH 2021b, USAID 2019b):

USAID aligns with the World Organisation for Animal Health (WOAH) which establishes international guidance and standards for animal heath, including metrics for monitoring health risks within its Terrestrial Animal Health Code and Aquatic Animal Health Code. Additional indicators for human health can be found in the Feed the Future Indicator Handbook. Indicators will be project-specific and should be defined during the project design stage. Some examples of indicators include the following (WOAH 2021a, WOAH 2021b, USAID 2019b):

Animal Health Indicators

- Increases in morbidity or mortality rates in livestock
- Prevalence of zoonotic disease in local human populations

Human Health Indicators

- Prevalence of moderate and severe food insecurity based on the Food Insecurity Experience Scale (FIES) [ZOI-level]
- Yield of livestock production systems

5.3 GENERAL IMPACTS AND MITIGATION MEASURES

Livestock production systems can have both beneficial and adverse impacts to human and livestock health. Health impacts are often cross-cutting between humans and livestock (i.e., an outbreak of zoonotic disease between livestock may lead to human infection), and a holistic approach should be taken to mitigate them. These impacts and their mitigation measures are described in Sections 5.3.1 and 5.3.2 and are summarized in Section 5.3.3 below.

5.3.1 BENEFICIAL IMPACTS

When managed properly, livestock production systems play a beneficial role in health. This section describes these health benefits and highlights their importance. Specifically, the following health impacts are discussed:

- Benefits to human health
- Benefits to livestock health

5.3.1.1 BENEFITS TO HUMAN HEALTH

Approximately one billion people globally have an income of less than two dollars a day and depend on livestock as a source of both livelihood and nutrition. Keeping livestock can improve human health through increased access to nutritious ASFs in households, which provide high-quality protein and essential structured fats. ASFs also are a bioavailable source of essential micronutrients such as vitamin A, vitamin B-12, calcium, iron, and zinc, which are linked with the growth, health, and cognitive ability of children and increased resistance to and recovery from infections. Additionally, livestock are associated with higher household cash incomes that can increase household ability to pay for healthcare and to purchase ASFs and food crops (Thumbi, et al. 2015).

5.3.1.2 BENEFITS TO LIVESTOCK HEALTH

In recent years, many advancements have been made with respect to livestock health. In developed countries, new technologies and strategies to mitigate disease in livestock such as pesticides and vaccines have contributed to a significant decline in infectious disease in livestock and a shift to noncommunicable disease in livestock (i.e., noncontagious chronic conditions that do not result from an acute infectious process) (Perry, Grace and Sones 2013, CDC n.d.). While this trend is not as evident in developing countries, some progress has been made. For example, Rinderpest, also known as the cattle plague, was globally eradicated in 2011, as described in Box 11. Additionally,

BOX 11. CASE STUDY: RINDERPEST

Rinderpest is a highly contagious and deadly livestock disease, primarily affecting cattle, which has been known since the start of livestock domestication. Historically, Rinderpest is the deadliest cattle disease, with up to a 100 percent death rate in some herds within ten to fifteen days of infection. Livestock losses caused by Rinderpest have created economic disruption and famines, particularly in Africa and Asia (WOAH n.d.). Additionally, the introduction of rinderpest to Africa in 1908 significantly impacted wild ungulate populations, killing many. Rinderpest has also been linked to the decline of the European bison (Morens, et al. 2011).

Despite the transmissibility and severity of the diseases, global efforts to eradicate the disease have succeeded, with the last case reported in 2001 and the disease declared eradicated in 2011. Rinderpest is the first animal disease to have been eradicated and the second disease overall to have been eradicated, with smallpox for humans being the first (WOAH n.d.).

some livestock farmers in developing countries have also adopted the use of veterinary drugs (Perry, Grace and Sones 2013).

5.3.2 ADVERSE IMPACTS

Livestock production systems may have various adverse impacts to health. These health impacts can be detrimental to livestock activities, causing potential severe harm to livestock producers and, in some cases, global health. Therefore, adverse health impacts from livestock are of significant importance to consider when designing livestock systems. These impacts and their mitigation measures are described in the sections below and include the following:

- Harm to human health
  - Spread of zoonotic disease
  - Increased parasitic infections and food-borne illnesses
- Harm to Livestock Health
  - Increased pressure and disease burden
  - Potential spread of disease between livestock and wildlife
  - Impacts of parasitic infections
- Health impacts from improper waste management
  - Decreased water quality
  - Impacts from improper carcass management

5.3.2.1 HARM TO HUMAN HEALTH

SPREAD OF ZOONOTIC DISEASE

Livestock farming can increase the risk of transmission of zoonotic pathogens from animals to humans (Thumbi, et al. 2015). Currently, more than 70 percent of emerging diseases are zoonotic, and there are as many as 850,000 undiscovered viruses present in mammals and birds that can infect humans (USAID 2021b). As human populations grow and expand into new geographic areas, more people are living near livestock, creating greater opportunities for zoonoses to infect humans. Pathogens commonly transmitted from animals include *salmonella* infection, anthrax, leptospirosis, trypanosomiasis, and rabies (Thumbi, et al. 2015).

INCREASED PARASITIC INFECTIONS AND FOOD-BORNE ILLNESSES

Consumption of ASFs can also increase the risk of contracting parasitic infections or other food-borne illnesses such as cysticercosis, taeniasis, cryptosporidiosis, and brucellosis in humans. Additionally, ASFs are energy-dense and contain high levels of saturated fats which can contribute to cardiovascular disease, cancers, and diabetes. Livestock are also associated with antimicrobial resistance in humans, as described in Section 5.4.3.2 (Thumbi, et al. 2015). Furthermore, the disturbance of wildlife habitats for livestock farming can increase human exposure to wildlife pathogens and create greater risks to human health, as described in Section 5.3.2.1 (Tomley and Shirley 2009).

MITIGATION MEASURES

Several steps can be taken to reduce zoonotic disease transmission, including wearing proper protective equipment when handling livestock, practicing adequate personal hygiene, keeping physicians informed of animal related activities, maintaining clean, well-organized animal housing areas, monitoring animal health status , and maintaining food safety (Illinois Office of the Vice Chancellor for Research and Innovation n.d.).

One Health

On a global scale, a One Health approach is being endorsed by national and international agencies to limit human health impacts from the human-animal-environment interface. One Health is a global collaborative, multisectoral, and transdisciplinary approach which aims to improve health outcomes by recognizing the interconnection between people, animals, plants, and their environment. The One Health approach to mitigating health issues aims to monitor and control public health threats and learn about how diseases spread by involving experts in human, animal, environmental health, and other disciplines (CDC 2018).

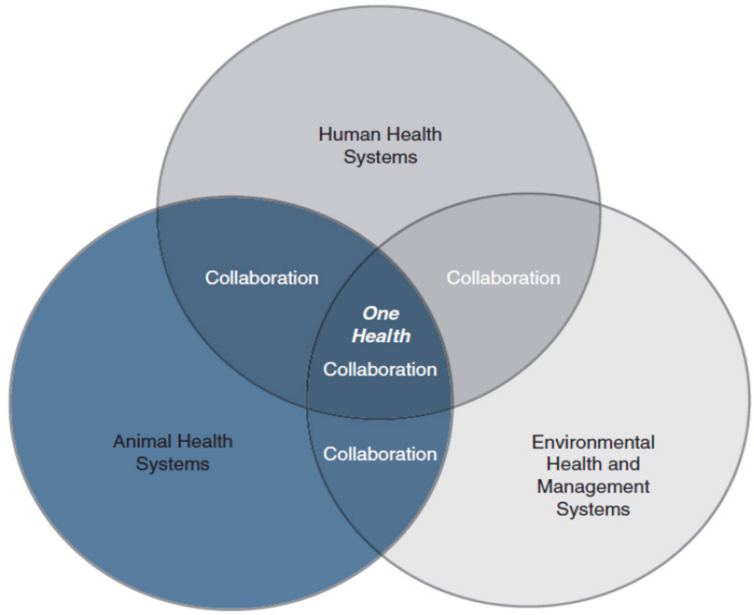

Figure 7. One Health Approach *(World Bank 2021).*

USAID is collaborating with the international community to take a One Health approach, working at local, regional, national, and global levels to understand and address connections between biodiversity, food production, and human health. For example, Box 12 describes how USAID is taking a One Health approach to addressing Nipah virus (USAID 2021b).

Building on successes like these, USAID recently launched a new cross-sectoral program called HEARTH: Health, Ecosystems, and Agriculture for Resilient, Thriving Societies (USAID 2021b). The HEARTH program includes 15 activities in 10 countries and works to advance conservation of threatened landscapes and the well-being of communities that depend on them. HEARTH does this by collaborating

BOX 12. CASE STUDY: NIPAH VIRUS

Studies suggest that Nipah virus crossed the species barrier from bats to pigs in 1997, when infected fruit bats were searching for food in orchards adjacent to a pig farm. When the infected pigs were sold to other commercial pig farms, an outbreak of Nipah virus resulted (1998-1999) (UNEP 2020).

USAID is taking a One Health approach to addressing the spread of Nipah Virus. USAID partnered with Thailand's Chulalongkorn University and the Department of Livestock Development to study Nipah virus in the country's pig farms. The partnership developed an app called E-Smart Plus based on their research, which allows farmers to reduce the risk of Nipah virus dependent on inputs on their farms and related risk factors (USAID 2021b).

with private sector partners whose business objectives align with USAID's development objectives. These projects are collaboratively designed to benefit livelihoods, human well-being, biodiversity conservation, and good governance. Working with the private sector through HEARTH allows USAID to put One Health principles into practice, generating sustainable benefits for people and the planet (USAID 2021b).

5.3.2.2 HARM TO LIVESTOCK HEALTH

INCREASED PRESSURE AND DISEASE BURDEN

Two factors that may affect the outcome and impact of livestock projects worldwide, particularly in SSA, Asia, and the Near East, are human population growth and fatal or debilitating epidemic diseases. Population growth increases pressure on herds and may lead to conflict over grazing lands, reduction of the size of individual farms or rangelands so that they cannot sustain livestock, severe immobility of the herd, and environmental degradation. Fatal or debilitating epidemic human diseases may also limit capacity to implement proper livestock management techniques (USAID 2015).

By 2050, the global population is anticipated to exceed 9 billion. Population growth is typically accompanied by increased urbanization. As human populations relocate to cities, livestock are also relocated. In urban areas in developing countries, livestock are often kept in small, unsanitary spaces, close to people. This increases the risk of disease transmission, both between livestock and between livestock and humans. Additionally, population increases and economic growth in developing countries are driving an increase in demand for ASFs such as eggs, poultry meat, and pork. Demand for these products has most significantly increased in Asia and Latin America and has been accompanied by a trend toward intensification of livestock systems. While some endemic and epidemic diseases become less difficult to control in intensive systems, this trend also increases the risk of an increase of diseases associated with animal crowding and environmental degradation. Poorly regulated intensive livestock systems also increase the prevalence of food-borne illnesses if facilities are not sanitary. In an increasingly globalized society, diseases are also transmitted much more easily and can increase the disease burden on livestock (Perry, Grace and Sones 2013). The increase in global livestock trade and global trade of ASFs, due to increased demand for ASFs, has also widely increased the spread of disease (Jost, et al. 2021).

POTENTIAL SPREAD OF DISEASE BETWEEN LIVESTOCK AND WILDLIFE

Wildlife-livestock interfaces are bidirectional and transmit pathogens freely within and between livestock and wildlife species. This occurs because wildlife and livestock come into indirect contact through a use of shared resources (i.e., pasture, water) and through vectors. For example, as described in 12, studies suggest that Nipah virus crossed the species barrier from wild bats to domestic pigs, resulting in an outbreak of Nipah virus on pig farms (UNEP 2020).

Globalization and ecological disruption have and will continue to facilitate disease emergence and reemergence (Perry, Grace and Sones 2013). Land use change can disrupt wildlife ecosystems and increase contact between species that would typically have little or no prior interaction, creating opportunities for pathogens to cross the species barrier (WOAH 2021c). Deforestation and other forms of land-use change have also contributed to an increase in transmission of vector-borne disease. There are several hypotheses proposed to explain this. A first theory suggests that disturbed habitats favor opportunistic species that tend to be reservoirs for viruses. A second theory is that reduced biodiversity and ecosystem disruption can increase virus transmission through a lack of the "dilution effect." The dilution effect reduces opportunities for disease transmission in biodiverse communities because there are more animal species that viruses can interact with, not all of which are susceptible to infection. Therefore, species that are susceptible to infection certain viruses are exposed to the viruses in lower rates in biodiverse communities. In single-species communities, disease can spread much more rapidly. A third theory suggests that as humans disrupt ecosystems, forest fragments force wildlife that host pathogens to undergo rapid change, increasing modifications in the pathogens and the likelihood that these pathogens become able to infect humans (UNEP 2020).

Traditionally, human bias toward the importance of livestock has overemphasized the impact of wildlife on transmission of pathogens to livestock. This has contributed to livestock farmers taking action to prevent livestock contact with wildlife, including slaughtering wildlife. One study observed that 77 percent of livestock pathogens are capable of infecting multiple host species, including wildlife (Wiethoelter, et al. 2015). Diseases that are transmitted between wildlife and livestock can also spill over into humans (UNEP 2020).

MITIGATION MEASURES

Due to the severe impacts of epidemic diseases and challenges controlling them once established, prevention of epidemic diseases should be of the utmost priority. Preparedness is also of high importance for epidemics that cannot be prevented. It should be noted that approaches to disease prevention and preparedness that are used in high-income countries may not be appropriate in lower-middle-income-countries. These countries may have limited resources to improve processes, poor infrastructure, and actors may have limited technical knowledge. Epidemic risks are most produced in lower-middle-income-countries, so it is important to ensure that effective prevention and preparedness approaches are developed (Jost, et al. 2021).

Improved animal husbandry, including biosecurity, and trends toward extensive livestock production can be important strategies for preventing outbreaks of epidemic disease (Jost, et al. 2021). Additionally, maintaining biodiversity can aid in mitigating disease transmission between livestock and wildlife and can also reduce disease transmission between livestock in the same community through the dilution effect, as described in Section 5.3.2.2. Additionally, the maintenance of wildlife ecosystem health and connections to wildlife habitats can help reduce disease transmission between livestock and wildlife because wildlife in abundant natural ecosystems are less likely to encounter livestock (UNEP 2020).

Disease surveillance should also be widely used to ensure that disease outbreaks are detected early-on and improve emergency preparedness. In some lower-middle-income countries, recently improved digital surveillance has enhanced disease surveillance and preparedness by expanding the network of disease surveillance to include animal health providers, livestock owners, actors involved in wildlife trading, and consumers (Jost, et al. 2021).

Transboundary cooperation is also essential for effective disease prevention and preparedness, due to the increasingly global nature of disease outbreaks. A collaborative, transboundary approach allows areas affected by resource scarcity to gain access to global networks, share information, and mobilize expertise (Jost, et al. 2021).

Vaccinations

Livestock vaccination may contribute to improved animal and human health, due to reduced transmission of zoonoses or disease transmission between wildlife and livestock. Additionally, vaccination may improve animal welfare, agricultural sustainability, and reduce the need for antimicrobial agents, such as pesticides, in livestock. Vaccination has proved its capacity as an effective alternative to stamping-out policy, which requires killing animals that are suspected of being affected by a disease outbreak (WOAH 2021d). By reducing the need for this practice, economic losses due to livestock deaths may be reduced.

Vaccinations, however, may not be 100 percent effective at preventing infection, and some vaccines may only prevent clinical signs or reduce multiplication and transmission of certain pathogens. Additionally, vaccination may hinder animal health surveillance by masking underlying infections and have implications for the movement of vaccinated animals and their products (WOAH 2021d).

Vaccinations are considered USAID restricted goods and meet USAID regulations under ADS Chapter 312 for use in USAID activities, as described in 13.

Antibiotics

Antibiotics are commonly provided to animals to improve their growth rates and prevent infections, and the administration of antibiotics to livestock is anticipated to continue increasing significantly over the next 15 years. As of 2015, of all antibiotics sold in the United States, approximately 80 percent were sold for use in treating livestock. However, overuse of antibiotics significantly contributes to antibiotic resistance both in humans and in livestock, as described below (Martin, Thottathil and Newman 2015).

Antimicrobial Resistance

In 2015, 70 percent of the antibiotics sold in the United States for use in agriculture were deemed to be "medically important," meaning they are from classes important to human medicine. The widespread practice of providing nontherapeutic antibiotics to animals has contributed to increased antibiotic resistance in humans. Humans can be exposed to antibiotic resistant bacteria through consumption of undercooked meat, contact with uncooked meat or surfaces contaminated by uncooked meat, exposure to animal manure, and through other direct contact with animals. To mitigate antibacterial resistance, livestock should not be provided antibiotics in feed to promote growth (Martin, Thottathil and Newman 2015).

Antibiotics are considered USAID restricted goods and must meet USAID regulations under ADS Chapter 312: Eligibility of Commodities for use in USAID activities, as described in Box 13 below.

IMPACTS OF PARASITIC INFECTIONS

Parasitic infections in livestock have adverse impacts on both animal health and on the economic success of livestock production (Sharma, Singh and Shyma 2015). Physically, effects of parasitism can fall under two categories: subclinical and clinical. Subclinical effects include losses in animal productivity, such as milk production, weight gain, altered carcass composition, conception rate, and more. Clinical effects, on the other hand, include visibly noticeable disease-like symptoms, including roughness of coat, anemia, edema, and diarrhea. Subclinical effects have greater impacts on the economic success of the livestock producer than clinical effects (Gadberry and Powell n.d.). Parasitic infections can be categorized as internal or external, and these types of infections can impact livestock differently. Internal parasites are those that live within the body of the animal, and external parasites feed on external tissues such as skin, blood, and hair.

INTERNAL PARASITES

In cattle, internal parasitic infections can have varying degrees of impact on the animal, depending on the age and stress level of the animal. Younger cattle and animals under greater stress are most likely to exhibit symptoms associated with parasitism. Additionally, immunity is suppressed in pregnant cows near parturition, leaving them particularly vulnerable to adverse impacts from parasitic infections (Gadberry and Powell n.d.).

Common parasites, including tapeworms, flukes, lungworms, protozoans, and roundworms, can infect livestock through several methods and have varying impacts on livestock production. For example, fluke and lungworm lifecycles depend on snails, and therefore most commonly flourish in areas with large snail populations, including stagnant pools of water and poorly drained pastures. On the other hand, roundworm eggs, which have the most severe impacts on the economic performance of livestock production, are commonly found on wet vegetation (Gadberry and Powell n.d., Villarroel 2013).

EXTERNAL PARASITES

External parasites can include lice, flies, ticks, cattle grubs, and mites, and have the potential to negatively impact all species of livestock. These arthropod pests can cause irritation and discomfort for the host animal. More seriously, blood-sucking, external parasites are vectors, capable of transmitting vector borne disease from one animal to another. Additionally, external parasites may slow or reduce livestock weight gain, cause losses in milk and meat production, create weakness in the animal, cause mange and dermatitis, and create sites for secondary parasite infection. External parasites are most prevalent in the warm spring and summer months; however, in warmer climates, they may live year-round (Kaufman, Koehler and Butler 2020).

BOX 13. VETERINARY PHARMACEUTICAL USE IN USAID ACTIVITIES

Veterinary pharmaceuticals include, but are not limited to, pharmaceuticals containing pesticides, vaccines, and antibiotics and are considered USAID-restricted goods, regulated under ADS Chapter 312. Use of veterinary pharmaceuticals in USAID activities must be evaluated and approved per ADS Chapter 312 guidance. (USAID 2020c).

Bureau specific guidance for veterinary pharmaceuticals may be available. For example, the Bureau for Humanitarian Assistance (BHA) has developed a list of Veterinary Essential Medicines (Vet EML) containing recommended veterinary pharmaceuticals. The Vet EML is purposefully limited to those pharmaceuticals considered essential for animal health activities in a humanitarian context. While these veterinary pharmaceuticals are recommended by BHA, their use must still be evaluated and approved in accordance with ADS Chapter 312 (USAID 2020c).

For any activity that intends to support pesticide use, detailed safety and mitigation procedures that meet the requirements of the Pesticide Procedures Section of the USAID environmental compliance regulations (22 CFR 216.3(b)) must be provided, and at a minimum, a Pesticide Evaluation Report and Safer Use Action Plan (PERSUAP) that addresses all relevant points including the 12-factor analysis listed in 22 CFR 216.3(b) must be prepared (USAID 2020c).

MITIGATION MEASURES

Pesticide Use

Pesticides are commonly used to mitigate parasitic infections in livestock. They can significantly improve profitability of livestock operations, livestock health, and limit transmission of vector-borne diseases, both between livestock and between livestock and other animals, such as humans (Villarroel 2013).

However, improper use of pesticides use can cause adverse impacts both to human and livestock health through overexposure to hazardous chemicals as well as contribute to antimicrobial resistance (Villarroel 2013). Pesticide runoff can also cause environmental pollution, as described in the impacts of improper waste management section (Section 5.2.2.3) below.

Pesticides are considered USAID-restricted goods and meet USAID environmental compliance regulations for use in USAID activities, as described in Box 13.

Anthelmintics

Anthelmintics are also commonly used to treat intestinal worm infections in livestock. These include several classes of drugs such as avermectins and benzimidazoles. While some classes of anthelmintics are considered safe for use, others such as benzimidazoles are toxic to human health. Anthelmintics can be transformed in the bodies of livestock, and these transformation products can be detected in ASFs, increasing potential for adverse human health impacts (Romero-Gonzalez, Frenich and Vidal 2014).

Anthelmintic resistance has been observed for all classes of anthelmintic drugs and poses a significant threat to the production of grazing animals and economic productivity of livestock farming (Shalaby 2013). Additionally, anthelmintic resistance poses a threat to human health, as human parasitic infections are also commonly treated with anthelmintics (Vercruysse, et al. 2011).

Refugia, or maintaining a population of parasites not exposed to anti-parasitic drugs, is proposed as critical strategy to mitigating anthelmintic resistance. Additionally, animals treated with anthelmintics should be strictly quarantined and should be treated using a combination drug strategy. The use of parasite-resistant livestock breeds, maintenance of livestock nutrition, pasture management, nematode-trapping fungi, antiparasitic vaccines, and botanical dewormers can also be used to reduce the increase in anthelmintic resistance (Shalaby 2013).

5.3.2.3 HEALTH IMPACTS FROM IMPROPER WASTE MANAGEMENT

DECREASED WATER QUALITY

Improper management of livestock manure, carcasses, and runoff from livestock farms can all contribute to decreased water quality. This can limit access to water, sanitation, and hygiene (WASH), which has large human health and social impacts, particularly for women and girls. Insufficient access to WASH services has contributed to the deaths of more than 297,000 children annually, who die from diarrheal diseases each year. Unsafe water also contributes to child malnutrition and physical and mental underdevelopment (UN Water 2021).

Livestock manure contains relatively high concentrations of nutrients, solids, enteric bacteria and other microorganisms, and organic material (USAID 2015). Mismanagement of manure can lead to pollution and eutrophication of surface waters, groundwater, and coastal marine ecosystems (Menzi, et al. 2010).This commonly occurs when livestock farmers release manure wastes into lakes or streams because they cannot economically transport it to crop fields for use as fertilizer (USAID 2015).

Livestock carcass decomposition can also contribute to groundwater contamination. As carcasses decompose, bodily fluids (leachate) have the potential to reach sources of groundwater and can cause nitrate contamination. Nitrate contamination can cause methemoglobinemia, which is potentially fatal to infants (Miller and Flory 2018).

Additionally, over-grazing on sloping lands commonly contributes to soil erosion and rainfall run-off from farms, leading to contamination of water sources by enteric microorganisms, toxic pesticides, and nitrates. Pesticides or other vector-control treatments used on livestock represent threats to the health of livestock managers, their families, and others exposed directly or through water use. These substances may be toxic to both humans and the environment, cause birth defects, alter children's proper development, promote cancer, or slowly poison one or more organ systems (USAID 2015).

MITIGATION MEASURES

Proper manure management is not often apparently advantageous to livestock farmers, due to the cost and effort required. Manure should be transported to crop farms to be used as a source of organic matter and nutrients, composted, or treated to remove health risks. Composting manure offers the benefits of reducing manure odor, limiting the spread of fly populations, and reducing the volume and weight of manure, making it easier to transport and distribute (NDSU 2022). Use of manure in crop fields can promote plant growth and create added benefits to crop farmers. Discharge of manure into the environment is generally prohibited in OECD countries (Menzi, et al. 2010).Overgrazing of farmland should also be limited to prevent runoff into local water sources. Where possible, livestock farms should not be located where manure can leach into water sources, such as lakes and rivers, and should not be located on sloping lands. Additionally, proper carcass management should be practiced to limit carcass leaching into sources of groundwater, as described in the following section.

IMPACTS FROM IMPROPER CARCASS MANAGEMENT

Poor management of livestock carcasses can create serious health risks, including exposure to bacteria, prions, chemical contaminants, and airborne particles. This can create human health risks and disease spread among livestock, especially during animal disease outbreaks (i.e., pathogenic avian influenza, foot and mouth disease, African Swine Fever, or Lumpy Skin Disease) (Miller and Flory 2018).

MITIGATION MEASURES

There are four common types of livestock carcass management for small to medium-sized farms, each of which pose varying degrees of risk to human and livestock health. Of these, composting poses the lowest risk to public health, biosecurity, and is the most successful at pathogen inactivation (Miller and Flory 2018).

Composting

Composting involves constructing a porous base layer of carbon-based material (i.e., wood chips), layering carcasses with additional carbon-based material in the core, and covering the mixture with carbon-based material to increase temperatures and promote decomposition. Composting is safe and successful at pathogen inactivation, sustainable, and easy to implement. However, it is slow and expensive, and requires a knowledgeable and experience operator to ensure the process is carried out correctly (Miller and Flory 2018).

Deep Burial

Deep burial involves burying livestock three to four meters below the ground's surface, allowing the carcasses to undergo anaerobic decomposition. The decomposition process may take decades and may generate body fluids (leachate), which have the potential to contaminate groundwater. Anaerobic decomposition of carcasses also generates methane, which can travel through soil and enter enclosed spaces such as sheds and houses and become an asphyxiation hazard or accumulate in explosive concentrations. Pathogens may also survive deep burial. This method, however, may be suitable for low quantities of animals in appropriate soils. It is simple and quick to implement and has a low cost (Miller and Flory 2018).

Above-ground Burial

In above-ground burial, livestock carcasses are buried in a 60 centimeter (cm) deep trench lined with 30 cm of carbonaceous material (i.e., straw or wood chips). A plant species that is readily available and appropriate for the local and seasonal climate is selected to be used as the vegetative cap and is planted on the soil covering the carcass. The decomposition process may take nine to twelve months, after which the disposal site can be leveled and used for other purposes. Above-ground burial reduces the risks of water supply contamination and methane hazards posed by deep burial and is safer for public health. Above-ground burial is also low-cost and efficient. However, pathogens may survive above-ground burial, and there is potential for scavengers to uncover the burial site (Miller and Flory 2018).

Open Burning

Open burning involves placing livestock carcasses on a bed of combustible materials (i.e., wooden timbers), covering the carcasses with additional combustible materials, and igniting the fire. Inputs and outputs to this process are difficult to be monitored or regulated. This has the potential to lead to incomplete, smoke-filled, and low-temperature combustion. Low-temperature combustion may allow some pathogens to survive. Additionally, the air movement caused by combustion has the potential to spread active pathogens by air. Open burning is also slow, expensive, and is a risk to fire safety, and produces emissions. For these reasons, some governments explicitly prohibit open burning for these reasons (Miller and Flory 2018).

5.3.3 SUMMARY OF MITIGATION MEASURES AND IMPACTS

Table 5 below summarizes adverse health impacts of livestock production systems and mitigation measures, highlighting mitigation measures that are cross-cutting between impacts. This table should be used as a checklist to ensure that best practices are followed when mitigating adverse health impacts in livestock production systems.

TABLE 5. SUMMARY OF MITIGATION MEASURES FOR HEALTH RISKS

IMPACT	MITIGATION MEASURE							
	One Health Approach	Practices for Purchases of Livestock	Maintenance of Biodiversity	Pest Management	Vaccinations	Appropriate Antibiotic Use	Proper Manure Management	Proper Carcass Management
Spread of Disease between Livestock and Wildlife	☐	☐	☐	☐	☐	☐	☐	☐
Spread of Zoonotic Disease	☐	☐	☐	☐	☐	☐	☐	☐
Increased Human Parasitic Infections and Food-borne Illnesses	☐	☐	☐	☐	☐	☐	☐	☐
Increased Pressure and Disease Burden on Livestock	☐	☐	☐	☐	☐	☐	☐	☐
Impacts of Parasitic Infections on Livestock	☐	☐	☐	☐	☐	☐	☐	☐
Decreased Water Quality	☐	☐	☐	☐	☐	☐	☐	☐
Impacts from Improper Carcass Management	☐	☐	☐	☐	☐	☐	☐	☐

5.4 LIVESTOCK PRODUCTION SYSTEM-SPECIFIC IMPACTS AND MITIGATION MEASURES

This section includes a discussion of health impacts and mitigation measures specific to the four livestock production system categories of focus for this SEG, listed below. Health impacts vary between these systems, and it is important to consider these differences in impacts when selecting a livestock production system for use in USAID activities.

- Rangelands and extensive grassland production systems
- Mixed crop-livestock production systems
- Intensive production systems
- Urban/peri-urban production systems (focus on small-scale/household urban)

Each of the sections noted above will provide beneficial as well as adverse impacts and mitigation approaches.

5.4.1 RANGELANDS AND EXTENSIVE GRASSLANDS PRODUCTION SYSTEMS

5.4.1.1 BENEFICIAL IMPACTS

When managed properly, rangelands provide a source of highly available micronutrients that can be essential to human health, particularly in low-income regions. Additionally, rangelands are essential to the maintenance of biodiversity, which the UN has noted as a potential important factor in limiting disease spread, both among humans and livestock. (Godde, et al. 2020).

5.4.1.2 ADVERSE IMPACTS

Many grasslands and rangelands have been improperly managed and homogenized for livestock production, which is detrimental to native vegetation and biodiversity (Oklahoma State University 2014). These negative impacts towards biodiversity can reduce the dilution effect described above in Section 5.3.2.2 (UNEP 2020).

MITIGATION FOR ADVERSE IMPACTS

To preserve heterogeneity and biodiversity in rangelands and grasslands, native species should be maintained in grasslands and rangelands (Oklahoma State University 2014).

5.4.2 MIXED CROP-LIVESTOCK PRODUCTION SYSTEMS

5.4.2.1 BENEFICIAL IMPACTS

Mixed crop-livestock systems can increase diversity in household diets, leading to improved human health, especially for smallholder subsistence farmers (Sekaran, Lai, et al. 2021). Diversity in mixed crop-livestock systems can also increase protein content in vegetation grown in the area, which can enhance the diet of livestock.

5.4.2.2 ADVERSE IMPACTS

Mixed crop-livestock production systems are commonly found on smallholder farms that are connected to poor hygiene and reduced biosecurity (World Bank 2021). In these systems, there are commonly few measures in place to limit contact between other animals, humans, and wildlife (World Bank 2021). Typically, animals are raised outdoors in mixed-crop livestock systems, leaving them more vulnerable to contact with disease vectors and predators (World Bank 2021). Contact with disease vectors can increase disease transmission both between livestock and between livestock and humans (World Bank

2021). Livestock that are vulnerable to predators also may have increased stress levels, which are associated with reduced disease resistance (World Bank 2021).

MITIGATION FOR ADVERSE IMPACTS

To improve animal welfare and limit disease spread in smallholder mixed-crop livestock systems, vaccination campaigns should be put into place (World Bank 2021). Additionally, where possible, measures should be put into place to reduce contact between livestock and other animals, humans, and wildlife (World Bank 2021). Preventing livestock from encountering predators can reduce stress and improve disease resistance. Additionally, disease transmission in livestock should be monitored closely to encourage early detection, prevention, and control (World Bank 2021).

5.4.3 INTENSIVE LIVESTOCK PRODUCTION SYSTEMS

5.4.3.1 BENEFICIAL IMPACTS

Intensive livestock systems have the potential to increase the ability of local economies to afford more efficient sewage and manure management, reducing public health risks (Food and Nutrition Board, Board on Agriculture and Natural Resources, Institute of Medicine, and National Research Council 2012). Additionally, in some cases, intensive systems can improve pathogen control (Food and Nutrition Board, Board on Agriculture and Natural Resources, Institute of Medicine, and National Research Council 2012). For example, intensive systems have contributed to improved rodent control, reducing trichinosis spread in pork (Food and Nutrition Board, Board on Agriculture and Natural Resources, Institute of Medicine, and National Research Council 2012).

5.4.3.2 ADVERSE IMPACTS

Intensive livestock systems involve crowding of animals, which can compromise hygiene and increase the use of antimicrobials (World Bank and FAO 2021). This can contribute to increased antimicrobial resistance.

Additional health risks can be posed by intensive livestock systems (Hribar 2010). Manure from intensive systems can contain plant nutrients including nitrogen and phosphorus, pathogens such as *E. coli*, growth hormones; antibiotics; chemicals used as additives to the manure or to clean equipment; animal blood, silage leachate from corn feed; or copper sulfate, which is used in footbaths for cows (Hribar 2010). Each of these contaminants have the potential to runoff into local water sources, including groundwater, creating significant human and wildlife health risks (Hribar 2010).

Intensive livestock systems also reduce air quality in the surrounding areas, increasing the risk of lung disease and other health effects (Hribar 2010). There is evidence to indicate that children living near intensive livestock farms have increased rates of asthma (Hribar 2010). Additionally, farm workers are at increased risk for acute and chronic bronchitis, chronic obstructive airways disease, and interstitial lung disease (Hribar 2010). Occupational asthma, acute and chronic bronchitis, and organic dust toxic syndrome have been reported to be as high as 30 percent in employees of intensive livestock farms (Hribar 2010).

Intensive livestock farms and waste from intensive livestock farms can serve as breeding grounds for insect vectors, such as houseflies, stable flies, and mosquitos (Hribar 2010). Manure lagoons are sometimes used to store manure on intensive farms, which can serve as breeding grounds for mosquitos. Houseflies breed in manure, and other flies breed in decaying organic material, including livestock bedding (Hribar 2010). Flies can agitate livestock and decrease animal health and can also contribute to the spread of antibiotic resistant bacteria and other microbes (Hribar 2010). Additionally, mosquitos can spread zoonotic disease (Hribar 2010).

MITIGATION FOR ADVERSE IMPACTS

Mitigation measures for antimicrobial resistance and improper waste management, including manure, can be found in Section 5.3.2. Best practices for waste management and site selection should also be used to mitigate impacts to air quality and the spread of insect vectors.

5.4.4 SMALL-SCALE/HOUSEHOLD URBAN LIVESTOCK PRODUCTION IMPACTS

5.4.4.1 BENEFICIAL IMPACTS

Small-scale/household urban livestock systems provide food sources to impoverished communities that may typically not be able to afford adequate amounts of food (Alarcon, et al. 2017).

5.4.4.2 ADVERSE IMPACTS

In small-scale/household urban livestock systems, livestock are often kept near humans, increasing the risk of zoonotic disease transmission (Aggarwal, et al. 2020). These systems are commonly found in impoverished areas, with little or no measures in place to regulate quality control or waste control, increasing risks of food-borne illness and water contamination (Aggarwal, et al. 2020).

MITIGATION FOR ADVERSE IMPACTS

Mitigation measures for harm to human and livestock health, described in Section 5.3.2 above, should be followed, as applicable to limit disease spread in small-scale/household urban livestock systems.

5.5 RESOURCES FOR HEALTH IMPACTS

- Pharmaceuticals: An Additional Help Document for ADS Chapter 312 https://www.usaid.gov/sites/default/files/documents/1864/ADS-312-additional-help-508.pdf
- 22 CFR 216 Agency Environmental Procedures https://www.usaid.gov/our_work/environment/compliance/22cfr216
- USAID/BHA Emergency Application Guidelines Pharmaceutical & Medical Commodity Guidance https://www.usaid.gov/sites/default/files/documents/USAID-BHA_PMC_Guidance_October_2020.pdf
- Agricultural Commodity Eligibility and Requirements Relating to Quality and Safety: A Mandatory Reference for ADS Chapter 312 https://www.usaid.gov/sites/default/files/documents/1876/312mac.pdf. (USAID 2019c)

6 SOCIAL IMPACTS

Figure 8. Cattle Herding for Maasai Solar Project Event

Source: Jessie Bryson, USAID/Tanzania

Social impacts of livestock production are highly intertwined with the environmental impacts and vary across and within regions, which makes a deep understanding of the local context crucial to both effective program implementation and environmental and social safeguarding. More broadly, the relevant regional considerations and impacts for communities like those in Latin America may differ considerably from those in another region like Southeast Asia. Knowledge and understanding of social considerations including education, economic and political systems, healthcare, demographics, population size, gender, cultural heritage, local languages, traditions, and history, should be taken into consideration when determining the social impacts of livestock production.

The following actions and considerations are strongly recommended to effectively integrate social aspects:

- Ensure that there is a clear understanding of the institutional arrangements of a community, related to land tenure/use, natural resources (i.e., water, soil) and biodiversity;
- Promote stakeholder engagement or consultation with communities, especially with pastoral groups, agriculturalists, and smallholder farmers;
- Ensure that pastoral grazing lands or livestock production does not overlap with parks and protected areas; and
- Consider opportunities for secondary uses of livestock production byproducts (i.e., manure) to enhance economic activities.

This chapter provides a detailed discussion of social impacts of the livestock sector, their mitigation measures, and other important considerations (i.e., sociocultural implications) for livestock activity design and monitoring. Production-system specific impacts and regional perspectives are included as possible to provide additional context for consideration in activity design. For additional resources regarding social impacts, please refer to the end of the chapter.

6.1 ACTIVITY DESIGN GUIDANCE FOR SOCIAL AND POLICY ASPECTS

Box 14 below lists potential social considerations for livestock activity design. These factors should be assessed at the inception of the activity and utilized in the decision-making process to address potential context-specific social risks to the activity. Please note that these considerations are not comprehensive and are meant to provide examples of important project-specific design context. A holistic review of project-specific social risks should be conducted prior to decision making in the activity design phase.

BOX 14. SAMPLE SOCIAL CONSIDERATIONS FOR ACTIVITY DESIGN

Community Vulnerabilities

- Existing social sensitivities and conflicts in the community
- Vulnerable groups in the community
- Potential for unequal benefit and cost distribution of livestock production among community members
- Potential existing lack of land and grazing resource ownership by livestock owners and managers
- Existing impacts of intensive livestock production on smallholders in the region

Existing Customs and Practices

- Prevalence of customary land-tenure arrangements in the community and their potential impacts on new livestock production activities
- Existing land-tenure practices and traditions and their efficacy
- Stakeholder views and perspectives regarding livestock production in their region
- Impacts of proposed activities on existing livestock management arrangements
- Potential impacts of proposed activities on existing communal livestock management arrangements

6.2 INDICATORS FOR MEASURING SOCIAL IMPACTS

There are a variety of indicators that can be used as part of a monitoring, evaluation, and learning (MEL) framework/approach for social considerations in livestock programming. In general, when developing social indicators, these should be tailored to the activity and consider both quantitative and qualitative indicators. The following section provides several examples of indicators for specific social impacts.

Gender-sensitive monitoring, evaluation, and learning captures and describes the impacts that program activities have on women, men, girls, and boys throughout implementation, and tracks progress in closing gender-related gaps in access, benefit, risk, and empowerment. Gender-sensitive indicators aim to document activities with male and female producers, processors, laborers, and traders at different points in livestock systems to assess a variety of factors, including:

- Whether and where women, men, girls, and boys' benefit along a particular livestock value chain;
- How women, men, girls, and boys' benefit from advantages like better feed, access to veterinary services, lower workloads, higher incomes, and safety;
- Why women, men, girls, and boys are benefiting or not; and
- Who is exercising power or making decisions in livestock systems (USAID 2021c).

The **reach benefit empower framework**, designed by the International Food Policy Research Institute (IFPRI), includes some example gender-sensitive indicators for livestock programming, summarized in Table 6 below.

TABLE 6. REACH BENEFIT EMPOWER FRAMEWORK

REACH	BENEFIT	EMPOWER
Number of women & number of men participating in training on new methods of livestock raising	Levels of satisfaction among women and men with veterinary and training services	Percent of women reporting increased decision-making power over livestock production in the last two years
Number of women & number of men given credit for livestock production investments	Adoption of recommended practices among male and female farmers before and after activity	Percent of leadership positions of mixed sex livestock producer groups held by women
Number of women & number of men who have applied improved livestock technologies	Number of women & number of men starting new small enterprises in animal product processing or marketing percent households in which chores are shared equitably between	Percent of households in which chores are shared equitably between women, men, girls, and boys

The importance of **land tenure** has resulted in its incorporation into the sustainable development goals (SDG) agenda with specific indicators:

- **SDG Indicator 1.4.2:** Proportion of total adult population with secure tenure rights to land, with (a) legally recognized documentation; and (b) who perceive their rights to land as secure, by sex and by type of tenure.

- **SDG Indicator 5.a.1:** (a) Proportion of total agricultural population with ownership or secure rights over agricultural land by sex; and (b) share of women among owners or rights-bearers of agricultural land, by type of tenure

The Living Standards Measurement Study (LSMS) team collaborated with UN-Habitat and the World Bank, to design a standardized and succinct survey instrument to collect the essential data for computation of both indicators simultaneously (World Bank n.d.). The Millennium Challenge Corporation (MCC) also developed a land rights and access indicator, which evaluates whether and to what extent governments are investing in secure land tenure and property rights. This indicator is a composite indicator calculated as a weighted average of three indicators: access to land is weighted at 50 percent, and days and cost to register property are each weighted at 25 percent (Millenium Challenge Corporation n.d.).

When evaluating the social impacts of smallholder farmers that are near or below the poverty line, it is important to understand the impacts in the context of their livelihoods, as livestock is often their most valuable asset. A methodological framework worth noting is the *Sustainable Livelihoods Framework*, which is a holistic approach that considers five basic types of capital: natural, human, financial, physical, and social, and may help to foster a greater understanding of pertinent local contexts at the household level, especially for the rural poor (UK Department for International Development (DFID) 1999). Garnering a holistic understanding of rural livelihoods is key to evaluating social impacts (van Rijn, Burger and den Belder 2012).

In addition to the frameworks described above, USAID has additional tools that may be used to determine social indicators. For example, the Water and Development Indicator Handbook has water, sanitation, and hygiene (WASH) indicators, as well as policy and governance indicators, that help understand impacts on community water resources and water and sanitation sector institutions (USAID 2021d).

6.3 GENERAL SOCIAL CONSIDERATIONS

Section 6.3 discusses important social considerations for livestock activities. These considerations may have significant impacts on livestock activities and should be assessed in the project area community and factored into decision-making throughout the project lifecycle. Considerations discussed in this section include the following:

- Sociocultural Implications
- Gender Considerations

6.3.1 SOCIOCULTURAL IMPLICATIONS

The sociocultural relevance and importance of animals, including livestock, varies between countries and regions and must be taken into consideration during project/activity design as a livestock production activity may generate impediments or unintended consequences for beneficiaries and local communities. Specifically, the religious and cultural role of animals may impact production and slaughter methods as well as consumption trends and value.

Changes in livestock production or availability of animals could impede or alter the sociocultural roles that animals play in a location. These sociocultural factors of livestock are often overlooked but are important aspects to consider when planning and addressing livestock production.

For example, cattle play a variety of important sociocultural roles in many African societies, including a common practice called “dowry” in which cattle are given as compensation by the bridegroom to the family of the bride before marriage. Cattle are commonly used as dowry throughout the African continent and in some parts of Southeast Asia (Mwai, et al. 2015). In Uganda and Rwanda, Ankole cows are the selected cattle breed for “bride price.” These cows are not commercial milk producing, which makes them less profitable. In turn, as they continue to become less profitable, they are bred less and may soon become extinct (Oklahoma State University n.d.), which may impact the feasibility of this common cultural practice. Bride price also influences the likelihood of a woman getting educated, as “people prefer to get wealth at the expense of their daughters’ education.” (Lowes and Nunn 2018).

However, in some cultures, the value of bride prices may increase with the daughter's education (Lowes and Nunn 2018).

As market demand for cattle changes, it can have unintended consequences on important historical cultural practices, like this tradition of dowry payments with Ankole cows. Cultural heritage and practices must be taken into consideration in Africa and around the world when evaluating the social impacts of a livestock intervention.

Livestock is also integral to countries' economies and livelihoods, which can contribute to a community's culture and identity, given the prominence of the sector in the community (Bettencourt, et al. 2015). For example, the culture of cattle ranching in Brazil is prominent and evident through a series of cultural expressions including music, dance, customs, and traditions. Annual folklore festivals are popular and take place throughout Brazil underscoring the importance and identity of cattle ranching in their society. One of the most famous festivals is the *Parintins* Folklore Festival, which revolves around cattle ranching. The festival is recognized as cultural heritage by the National Institute of Historic and Artistic Heritage which began in 1964 and has congregated up to 38,000 spectators per year (Government of Brazil n.d.). *Parintins* is located in the state of Amazonas, Brazil, in the Amazon basin, where cattle ranching has increased since the 1960s and roughly 15 percent of the Amazon rainforest has been replaced and 80 percent of the deforested areas have been converted to pastureland (FAO 2003).

6.3.2 GENDER CONSIDERATIONS

Roles, responsibilities, and labor divisions are in part determined by gender and age across all regions of the world. Male and female roles within livestock production systems vary between regions, and the distribution of ownership of livestock between men and women is strongly related to social, cultural, and economic factors. In some regions of the world typical male responsibilities may include herding, cutting branches for feeding, and administering medicines. Male activities can also include decisions on livestock selection and sales, disease diagnosis, and treatment of sick animals (International Fund for Agricultural Development 2010).

Women have varying degrees of control over income-generating activities in the livestock sector depending upon social, demographic, culture, and other factors around the world. Activities performed by women can include milking, processing, and marketing; however, it is unlikely that women own or control decisions regarding the livestock they manage (International Fund for Agricultural Development 2010).

While women play critical roles in livestock production, they are less likely to own or control land than men. In SSA, women comprise 48.7 percent of agricultural labor, but only 15 percent of agricultural landholders. Even when women do own or control land, the quality of the land is often lower, and the total land area is typically less than land owned or controlled by men (USAID 2016b). Limited ownership of land inhibits livestock agricultural productivity and consequently restricts economic gains (USAID 2016b).

Other gender-related issues include:

- Limited access to gains along the different steps of livestock value chains according to the gender of producers (rights to income generated from livestock), processors (access to processing information and using technology), market agents (access to transportation, safe markets, risk of sexual harassment and abuse), and economies of scale, bringing women to improve their role in the market.
- Women and men have different experiences and capacities to face when it comes to livestock trends (marketization, lengthening of value chains, vertical integration).
- There are regional shocks to the sector, specifically climate change, drought, flooding, animal disease, demographic changes, and political conflict.
- Access to livestock extension [7] and veterinary services, artificial insemination services, participation in planning livestock programs and policies, emerging livestock technologies, and training and involvement as community animal health workers and veterinarians (International Fund for Agricultural Development 2010).

Due to the disparities among genders, it is important to consider gender when evaluating positive and negative impacts of a livestock intervention at the field level. This may be achieved by conducting a Gender Analysis and/or through stakeholder engagement (i.e., conducting women-only focus groups), among other participatory planning techniques that can gauge the gender perspective.

In the past, livestock projects were primarily oriented towards breeding, feeding, and animal health. More attention is needed in the design phase to guarantee women's active involvement in the many project phases and activities (International Fund for Agricultural Development 2010).

BOX 15. USAID GENDER EQUALITY AND WOMEN'S EMPOWERMENT

The 2020 USAID Gender Equality and Women's Empowerment Policy affirms USAID's vision of a prosperous and peaceful world in which both genders enjoy equal economic, cultural, civil, and political rights. USAID works to reach this goal by integrating equality between men and women's empowerment throughout their work. The policy also strives to eliminate gender-based violence, support strategies that secure private-property rights and land tenure for women and improve the access of women and girls to education (USAID 2020d).

MITIGATION MEASURES FOR ADVERSE GENDER IMPACTS

The gender perspective in livestock production systems will be highly dependent upon the local context. Therefore, participatory planning techniques and stakeholder engagement with a focus on gender will be vital to determine potential social risks and opportunities (International Fund for Agricultural Development 2010). It is critical for agricultural programming to engage women in their multiple roles as farmers, paid or unpaid agricultural laborers, agricultural and food processors, traders, livestock keepers, entrepreneurs, and employees (USAID 2020d).

Acknowledging and supporting women's roles as livestock owners and processors of livestock products is key in promoting women's economic and social empowerment. Supporting the decision-making

[7] Doing production-type work assisted by livestock production experts. Subjects include livestock nutrition, animal health, and animal management.

process capacity of women is central to the effective implementation of gender equity. Attention to workload is also important, as women often carry a heavy burden. Women should participate in project design through stakeholder engagement at the project level to ascertain that planned activities do not compromise the interests of women and workload is divided equitably between women and men. Allowing women to have access and ownership to assets is also key in supporting their role in the livestock sector and ensuring the long-term sustainability of a project. (International Fund for Agricultural Development 2010). When women are empowered economically, including in the agriculture sector, their success leads to greater overall community resilience and self-reliance. USAID policy toward addressing gender equality and women's empowerment is described in Box 15. Furthermore, the Women's Empowerment in Livestock Index (WELI) is a tool that facilitates the assessment of women's empowerment in livestock systems.[8]

6.4 GENERAL IMPACTS AND MITIGATION MEASURES

The global demand and production of livestock and related products, especially in developing countries, is rapidly increasing due to increasing population growth, rising incomes, and shifts in dietary choices and lifestyles (Herrero, et al. 2009). Livestock production systems pose potential for both beneficial impacts, including enhancing and expanding livelihoods, food security, and nutrition and adverse impacts such as increasing conflicts, exacerbating land tenure arrangements, and impacting water quality and supply, among others. The following section outlines these potential beneficial and adverse social impacts of livestock production and their corresponding mitigation measures.

6.4.1 BENEFICIAL IMPACTS

Section 6.4.1 describes potential beneficial social impacts of livestock production to stakeholders in the sector. Impacts described include the following:

- Economic Growth, Livelihoods, and Food Security
- Secondary Uses for Manure

[8] PA00Z5PH.pdf (usaid.gov) For further information please visit: Women's Empowerment in Livestock Index (WELI) | International Livestock Research Institute (ilri.org)

Economic Growth, Livelihoods, and Food Security

> **BOX 16. LIVESTOCK DRAFT POWER**
>
> Livestock used as draft animals can expand crop production, productivity, and yields by reducing the labor required per hectare of crops.[1] The main benefit of animal draft power is to allow a larger area to be cultivated per household or per unit of labor. The use of livestock draft has been found to raise the return per day of labor at peak work periods, when the labor constraint is critical (Upton 2004).

In low- and medium- income countries, livestock is considered an important asset held by the rural poor, particularly in pastoral and agropastoral systems, fulfilling multiple economic, social, and risk management functions for both those directly and indirectly engaged with livestock production. These benefits include providing a possible source of income, affordable nutrition, and farming assistance (Roland-Holst and Otte 2006). For example, Box 16 describes the benefits of using livestock as draft animals. Livestock production also contributes significantly to national, regional, and local economies as it relates to incomes, livelihoods, and poverty alleviation. For example, the cost of animal products is generally higher per unit than other agricultural products, enabling higher earnings and greater income generation, especially for the rural poor (Upton 2004).

Figure 9. Oxen Driven Cart in Rural Burma

Source: Irina Mavritsina

Livestock may also offer increased food security, especially for the rural or landless poor, by providing a direct source of food and/or income to acquire necessary food products from the sale of their livestock. For example, in Vietnam, more than 90 percent of cash revenue from livestock are derived from the sales of live livestock versus livestock products (Maltsoglou and Rapsomanikis 2005). This is especially crucial as a safeguard or coping mechanism against emergencies or shocks to livelihoods in variable environments; livestock may provide an invaluable reserve in the case of disaster such as a drought or flood, which may disrupt other sources of income and/or food.

As uncertainty and climatic variability increases due to climate change, these resources become even more important (Upton 2004). As noted, for many poor communities, livestock is an essential asset that is central to their livelihoods and the loss of those livestock assets could result in a decline into chronic poverty with long-term effects on their livelihoods (FAO 2009).

Secondary Uses for Manure

There are several agricultural development impacts stemming from livestock, which are supportive of expanding livelihoods, fostering economic growth, and supporting food security (Herrero, et al. 2013). In addition to providing direct income benefits from livestock production, livestock may also help to increase crop yields, and therefore, support increased incomes and food security.

The manure produced as a byproduct of livestock production can be a source of readily available natural fertilizer, which can be used to increase crop yields and, in turn, support agricultural development, income generation, and food security. Furthermore, manure may be used to produce renewable and reliable energy through biogas generation and the direct burning of cow dung pellets (cow chips) (see Box 17). Given the appropriate availability and access to resources and capabilities, manure can be converted into biogas/fuel for use in homes, providing a relatively inexpensive avenue for poor communities, especially the rural poor, to access energy. The anaerobic processes required to convert the manure into biogas creates a pathogen-free manure as a byproduct, which can be used for natural fertilizer (Aberilla, Gallego-Schmid and Azapagic 2019). The direct burning of cow chips is also a source of energy. Cow chips are used a source of energy to mainly heat household stoves especially in India, South Africa, and Nepal (Szymajda, Laska and Joka 2021). Compared to biogas generation, cow dung burning as a source of energy is less complex and cheaper especially for poor rural populations. Raw cow dung is also widely available. However, burning cow dung emits high indoor particle concentrations consequently affecting the health of those using it for heating and cooking (Mudway, et al. 2005).

BOX 17. CASE STUDY: MANURE TO ENERGY

Since 2003, the Vietnamese government has supported construction of biogas digesters throughout the country with funding from international organizations such as the Netherlands Development Organization (SNV). The Vietnam Biogas Programme has facilitated the construction of 158,500 domestic biogas digesters for more than 790,000 rural individuals across 55 provinces and cities. Through support from SNV, biogas has become a technology that is affordable and sustainable for small-scale farming (Thi Thien Thu, et al. 2012) (SNV n.d.).

6.4.2 ADVERSE IMPACTS

Section 6.4.2 below describes potential adverse social impacts of livestock production to stakeholders in the sector and their mitigation measures. The potential for these impacts should be evaluated throughout the activity design process, and mitigation measures should be implemented as possible. Adverse impacts described in this section include the following:

- Policy and legal issues
- Water supply and management issues

6.4.2.1 POLICY AND LEGAL ISSUES

National government policies or donor interventions have the potential to disrupt or discourage good practices in livestock production and may become a root cause of environmental degradation and/or social harm. For example, some government policies may restrict the movement of livestock within a range area or prevent livestock managers from moving stock from areas that have been depleted of fodder to better supplied areas, which could disrupt productivity and, in turn, income generation, for livestock producers. Regardless of the ownership system, livestock owners seek assurance that they will be able to conduct activities without disruptions and should be actively consulted and engaged during program design and implementation to ensure that policies and decisions are not adversely impacting grazing lands and well-established practices. Privatization of resources and land tenure arrangements (described further below) are two examples of the ways in which political and legal mechanisms may impact communities (FAO 2010).

Increasing Incidence of Conflicts. Ethnically based or resource access-related social conflicts are pervasive challenges in many developing countries. Social conflict over resources is localized and often arises due to issues of pasture and water access, especially with drought. Similarly, unequal access to agricultural land and contested grazing rights have caused conflict in communal areas (Briske 2017). Careful consideration of land and resource access, especially to livestock and pastoral/grazing lands, is essential to avoiding or mitigating social conflict in areas where livestock production may be taking place.

Privatization of communal resources. Where national governments have privatized or intend to privatize formerly state-owned or communal lands, new owners may take measures to hinder or prevent herds from crossing or grazing on their property (i.e., building fencing). These changes in ownership/management of land may inhibit or deprive communities from access, which can have particularly adverse impacts on rural and pastoral communities, especially the rural poor, that were previously reliant on these lands. Risk of environmental degradation is often used to justify state-control over or privatization of communal grazing lands, however, communally managed land-tenure arrangements are often the most sustainable and effective, especially in rangeland systems where sustainable grazing depends on reliable access to local or regional resources under highly diverse circumstances. Communal lands offer producers the ability to maintain access to a variety of resources across extensive land areas. (Briske 2017).

Land tenure insecurity. Land tenure refers to a relationship, whether legally or customarily defined, among people, as individuals or groups, with respect to land. The rules of tenure define how property rights to land are allocated within societies and how access is granted to the land including rights to use, control, and transfer land, as well as related responsibilities and limitations. Essentially, land-tenure systems establish who can use what resources, for how long, and under what conditions (FAO 2002). Land-tenure insecurity involves a risk to a person, or persons', rights to their land being threatened by competing claims. Issues of tenure insecurity are not uncommon for pastoralists throughout the developing world, as they often lack clear property rights because the customary or tribal land they occupy and/or use may be legally owned by the state or others (USAID 2013).

In some cases, national governments have either implicitly or explicitly claimed ownership of rangelands and wildlands and ignored traditional or customary claims, bolstering land-tenure insecurity for certain communities. A lack of confidence in secure tenure or title to rangeland (especially on communal lands) has been shown to reduce the incentive to sustainably manage the land. Often, pastoralists who have lost land to the government will clear other areas (i.e., forests) to acquire new pastures or land for growing feed, which contributes to deforestation. Conversely, secure communal land tenure has been shown to foster greater community investment in the land (i.e., soil and water conservation), which results in reduced land degradation and improved sustainability (Holden and Ghebru 2016). Similar to how granting forestry rights to local communities in the Amazon decreases deforestation, granting grazing rights promotes sustainability (Baragwanath and Bayi 2020).

MITIGATION MEASURES

Prior to implementation, a deep understanding of local context, including political dynamics, cultural considerations, and legal parameters for livestock, is important for effective mitigation of unintended social harm. By understanding the local political dimensions and the laws and policies in place, programs may better design and implement where livestock production can and should occur, with minimal disruption to existing social systems, arrangements, and communities. In addition, active engagement with stakeholders, including local, regional, and national (as applicable) governments, associations, pastoralists, and local communities, is essential.

Discussion with those directly involved in livestock production as well as those indirectly impacted may provide nuanced information on the local context and political realities, which may assist in design and implantation to further ameliorate adverse outcomes (i.e., disruption of traditional land-tenure agreements or defining boundaries on pastoral lands that are customarily left open). More specifically, careful consideration should be taken before making attempts to alter land-tenure arrangements because alterations (i.e., upgrading informal rights to legally enforceable rights) may result in unintended negative impacts on tenure, access, or rights for other groups.

6.4.2.2 WATER SUPPLY AND MANAGEMENT ISSUES

While livestock production offers a suite of potential economic and food security-related benefits, it also poses potential adverse impacts on water quality and supply for communities, which necessitates adequate water management to ensure continued successful crop and livestock production.

There are also often community-based rules or norms for the use of water resources. For example, groundwater resources tend to be less managed than surface water, which can negatively impact or increase the vulnerability of those who rely on groundwater (World Bank 2017). In many cases, groundwater resources are overused, and aquifers become depleted over time. The same aquifers that supply water for animal agriculture often supply water for human consumption, so water shortages that result from over pumping for livestock have consequences for drinking water supply and crop irrigation. For example, as described in Box 18, boreholes used to provide water to cattle may deplete aquifers.

BOX 18. BOREHOLE MANAGEMENT

Boreholes are holes drilled deep into the ground, often at depths of more than 300 meters, to access ancient aquifers to create stationary, permanent watering points. The implementation of boreholes in even the driest regions makes it possible for cattle exploitation year-round. As a result, boreholes have encouraged more centralized grazing. However, by providing much needed water, boreholes facilitate concentrated activity around the wells that bare earth in which graze is exhausted. As the area becomes more arid, cattle then expand their grazing area. More boreholes are drilled, and cattle continue to drink up the water faster than the aquifers can recharge (du Plessiss 2020).

Livestock production is relatively water-intensive, and as livestock demand and production increase, the competition for water resources' use (i.e., livestock production vs. cooking or hygiene) could become significant (Herrero, et al. 2009). This is especially problematic in locations where water is already scarce, either chronically or seasonally, because the diversion of water to sustain livestock potentially limits its availability for other purposes, including access to water, sanitation, and hygiene as well as crop irrigation. This issue is of particular concern in arid and semi-arid regions, where the construction of boreholes to supply water to livestock can lead to unsustainable withdrawal rates and the dangerous depletion of aquifer reserves.

These ramifications on water supply can have additional indirect consequences on human health and livelihoods. For example, a person with limited access to clean drinking water may be vulnerable to adverse health effects, as they could become reliant on contaminated wells as a water source. In addition, having to source and pay for water from vendors could result in an untenable economic burden, especially for those already impoverished. Lastly, a lack of locally available water may require traveling greater distances away from the community for water access, which poses a potential safety concern primarily for women and girls. The excess time spent by girls fetching water can also affect their education, as the time spent collecting water could be used to attend school and enhance their education. There is a significant negative relation between girls' attendance at school and water-hauling activities (Nauges and Strand 2013) .

MITIGATION MEASURES

Understanding local water supply and the regulatory, political, and cultural aspects governing its access and use is fundamental to determining mitigation measures for a specific project prior to implementation. Consultation with local stakeholders and an assessment of local conditions should inform the design of the project/activity and include considerations of existing arrangements and policies within the country and/or region. Coordination with stakeholders to ensure the responsible management of water, including prioritizing access to water, sanitation, and hygiene for the affected area, while balancing needs for livestock production and crop irrigation is also essential.

6.5 LIVESTOCK PRODUCTION SYSTEM-SPECIFIC IMPACTS AND MITIGATION MEASURES

This section includes a discussion of health impacts and mitigation measures specific to the four livestock production system categories of focus for this SEG, listed below. Health impacts vary between these systems, and it is important to consider these differences in impacts when selecting a livestock production system for use in USAID activities.

- Rangelands and extensive grassland production systems
- Mixed crop-livestock production systems
- Intensive production systems
- Urban/peri-urban production systems (focus on small-scale/household urban)

6.5.1 RANGELANDS AND EXTENSIVE GRASSLANDS

6.5.1.1 BENEFICIAL IMPACTS

Overall, range livestock and their products are increasingly important for developing-country economies. Rangeland dwellers are experiencing an expansion of livestock marketing options due to increasing domestic and export demand. As rangelands become more economically developed, pastoral livelihoods may diversify, food security can improve, and livestock production expands. Upgrades in rural infrastructure and public service (in wealthier systems) also occurs as rangeland systems become more economically developed (Briske 2017).

6.5.1.2 ADVERSE IMPACTS

Economic Impacts

As rangelands become more economically developed, wealth stratification widens. This is a common challenge globally and is often triggered by wealthier individuals/groups that have the ability to take advantage of commercial livestock opportunities, build larger herds, and gain *de facto* control over more resources.

In some cases, net human population growth in the rangelands tends to decrease, while overall population growth increases causing male rangeland dwellers (typically) to emigrate in search of employment to then leave women who may not have power in charge (World Bank 2019).

Pastoral household systems are commonly near or below the poverty line and compared to the past, trends indicate that pastoralists are generally getting poorer and thus have higher vulnerability to risks caused by weather, economy, or conflict (Dong, et al. 2011).

MITIGATION MEASURES

Options for improving rangeland systems in the developing world include pastoral land tenure and managing mobility, sustainable rural livelihoods, livestock development and marketing, and conflict and crisis management (Briske 2017).

Government Decentralization. In some cases, government decentralization has shifted development funds to the local level and focused on marginalized rangeland communities in some countries. In the Sahel, decentralization from international development funds has been seen as essential to building more effective health, education, and administrative services as well as improved management of land, water, and grazing (Hesse, et al. 2013).

Diversifying Incomes. Pastoral households are now attempting to diversify incomes by mixing pastoral with non-pastoral activities, leading to increase income generation (Briske 2017). Non-pastoral activities include casual labor, gathering and sale of wild products (i.e., charcoal/water trading), retail shop activities, and wage/salaried employment (Achiba 2018).

Access to Public Services. Access to public services such as potable water, electricity, healthcare, and education remain difficult to reach in lower social rangeland production systems. Developing nations typically do not have the resources to make development investments in rural and/or remote locations (Hewett and Montgomery 2001). There are two categories of population emerging in the rangeland systems of the developing world: traditional mobile pastoralists still largely dependent on livestock and sedentary residents of growing rangeland towns and cities that have more diversified livelihoods. Although sanitation, education, and healthcare facilities are more prominent in urban centers than in the rural setting, access to public services may still be lacking due to social barriers (Hewett and Montgomery 2001).

Public awareness of the need for public services is increasing and appreciation of education is rising among many rangeland systems. In many rangeland livestock production systems, populations, mostly in poorer nations, never had public services. In some areas, access to potable water, electricity, healthcare, schools, and banking services can still be lacking (Briske 2017).

Regional Perspective. In African and some Asian countries, ethnically based or resource access-related social conflicts are pervasive challenges for the rangeland population. Conflicts include disputes over land and water and grazing rights for minority ethnic groups. In some cases, drug-trafficking and conflicts between government and drug lords have disrupted ranching in Latin America (Brown and Keating 2015).

6.5.2 MIXED CROP-LIVESTOCK

6.5.2.1 BENEFICIAL IMPACTS

Mixed crop-livestock production systems are and will continue to be the backbone of sustainable pro-poor agricultural growth in the developing world. There is increased economic return and income stability in this production system. Mixed crop-livestock systems aid in income stability because of the diversified income sources (i.e., agricultural and animal products). Improved mixed crop-livestock production systems can improve productivity and enhance food security.

There is also improved human nutrition as mixed crop-livestock production can help supply both grain and animal protein for family members of smallholder farmers (Sekaran, Lai, et al. 2021). Moreover, more than two-thirds of the human population live in these types of systems, compounding the importance of this type of system for both food security and livelihoods (Herrero, et al. 2009).

6.5.2.2 ADVERSE IMPACTS

Although mixed crop-livestock systems often confer prestige for the associated farmers, they can also be a source of conflict (Thornton and Herrero 2015). Overall, there are major constraints of on-farm integration related to the limited farm workforce available, combined with a loss in the skills and knowledge required to optimize both crop and livestock sub-systems. There is increased labor required, often from women, for weeding (van Keulen and Schiere 2004). In addition, mixed crop-livestock production systems require capital that farmers may not have access to.

MITIGATION MEASURES FOR ADVERSE IMPACTS

Crop-livestock systems can be organized at larger scales than the farm through cooperation among specialized livestock and arable farms. In such an organization, there are smaller increases in farm workloads, complexity of rotations, skills, and infrastructure for the individual farms involved (van Keulen and Schiere 2004).

6.5.3 INTENSIVE

6.5.3.1 BENEFICIAL IMPACTS

Over the past few decades, the demand for animal products has dramatically increased confined intensive livestock production systems. The shift to confined operations dramatically increased what one producer could manage, and thereby increased productivity. Farmers of large-scale operations can achieve significant economies of scale and unit-cost reductions. Typically, intensive livestock production systems generate considerably more income than smaller operations because of the volume of and efficiencies in production. Large-scale operations also pay no sales tax on feed and it costs less to deliver feed to larger operations (Steinfeld, et al. 2010). Box 19 describes women's involvement in intensive livestock systems in Asia.

> **BOX 19. CASE STUDY: ASIAN INTENSIVE LIVESTOCK SYSTEMS**
>
> In Asian intensive livestock systems, more than three-quarters of livestock-related tasks are the responsibility of women. For example, in India, the livestock industry is dominated by women who provide 55 percent of employed livestock production labor and more than 77 percent of the work of raising animals. (FAO 2012).

Customers often have more trust in large-scale producers because of their high-quality animal products. Since these producers have access to markets, they can repeatedly sell to the same clientele, building steady income and buyer trust.

6.5.3.2 ADVERSE IMPACTS

The rapid growth in intensive livestock production systems has forced many smallholders out of production because they are no longer competitive with larger operations that benefit from the technological capabilities. Thus, many smallholders lose their opportunities for growth and poverty alleviation. Smallholders also face problems getting market access to supply chains. Due to their low productive capacity, remoteness, and limited competitiveness with larger producers, they are often left out of the supply chain. While smallholders often receive services from the public sector such as extension research, marketing outlets, and infrastructure, the movement toward demand-driven agriculture reduces the government's ability to fully assist smallholders in the manner demanded by the marketplace (Steinfeld, et al. 2010).

MITIGATION MEASURES FOR ADVERSE IMPACTS

There are a variety of ways that smallholders can gain market access to supply chains. First, producers need access to extension services or technical assistance so they can stay updated on changing knowledge of specialized techniques to ensure the quality of high-value products. They will also need access to sound infrastructure to manage demand from customers and competition from large-scale competitors. Third, they will need access to reliable information on the market and the ability to integrate this knowledge into their practices. Fourth, producers need to ensure that their products meet certain standards to build buyer trust. And fifth, smallholders need to ensure good coordination to deliver products on time and continue to meet market demands (Steinfeld, et al. 2010).

6.5.4 SMALL-SCALE/HOUSEHOLD URBAN

6.5.4.1 BENEFICIAL IMPACTS

Livestock can be beneficial to sustainable rural development by creating higher-value marketable products that can easily be produced at the small-scale, household level. Livestock are also less vulnerable to the volatility common in crop production, making them more reliable sources of income and food for smallholders. Livestock production can also confer significant economic advantages on smallholder farm operations by providing substantial income generation opportunities, agricultural development support, and food security. As the demand for livestock and related animal products continues to increase, there are considerable opportunities for small farmers to participate in local, regional, and even larger food markets more effectively. (FAO 2006). For example, Box 20 describes how common-interest groups have become effective in transferring conservation agriculture practices between farmers.

BOX 20. CASE STUDY: BRAZIL—THE ZERO TILLAGE ASSOCIATION FOR THE TROPICS (ZTAT)

Common-interest groups around the practices of conservation agriculture have become effective in farmer-to-farmer spread of beneficial ideas and practical technologies. Zero tillage in Brazil was introduced by the Zero Tillage Association for the Tropics (ZTAT), a common-interest group promoting zero-tillage farming technology. Farmers and technicians who adopted the technology have resolved challenges regarding sustainability in the humid sub-tropics and humid wet-dry tropics of Brazil. ZTAT initiated and supported this experience and disseminated the technology for this project (FAO 2001).

6.5.4.2 ADVERSE IMPACTS

Many small-scale or household-level production systems are at a disadvantage to foster the potential economic benefits because while emerging market demands call for greater livestock, policies and economic structures tend to favor large-scale producers. Further, a lack of knowledge or capacity for smallholders to understand and address various markets, pricing structures, and other complex questions related to pricing and sales, may hinder smallholders' abilities to access fair or just prices and/or all available markets that would garner the greatest economic gains.

MITIGATION MEASURES FOR ADVERSE IMPACTS

Ensure that smallholder, household operations have access to basic services and technologies (i.e., grazing land and veterinary care) and offer opportunities for capacity-building so they can understand and navigate various markets and pricing structures.

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