

Industrial Food Animal Production in Low- and Middle-Income Countries: A Landscape Assessment



JOHNS HOPKINS
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Executive Summary

Industrial food animal production (IFAP) is the dominant model of producing meat, dairy, and eggs in the United States. It is characterized by high-throughput, input-intensive, specialized and geographically-clustered operations confining thousands of animals in close conditions. Ownership of the majority of the industry rests in the hands of a small number of companies who maintain control over highly integrated production chains. While IFAP is frequently touted as promoting societal benefit through the provision of inexpensive animal products, there is increasing evidence that this production model externalizes myriad public health and environmental costs. These include the depletion of natural resources, the generation of massive volumes of untreated waste, the environmental degradation of land, water, and air quality, the generation of significant quantities of greenhouse gases, the spread of antibiotic resistance, dangerous working conditions, poor animal welfare, and economic disadvantage and reduced autonomy for farmers involved with the supply chain, among other problems.

Globally, per capita meat consumption is significantly greater in high-income countries, though its rate of growth is slowing. At the same time, demand for animal products has been increasing in low- and middle-income countries (LMICs), where livestock production tripled between 1980 and 2004. Evidence suggests that the IFAP model is on the rise in LMICs to meet increasing demand. Even in high-income countries, where regulatory controls and enforcement may exist, public health and environmental problems related to this model of production are well documented. In LMICs, where comparable oversight may not exist, it is possible that such problems may be exacerbated. Thus, characterization of the adaptation and expansion of IFAP in LMICs, and associated risks, is warranted.

Between 2015 and 2016, we collected and synthesized publicly available information on IFAP in ten LMICs, focusing specifically on the beef, pork, and chicken sectors. The countries—Brazil, China, Ethiopia, India, Kenya, Mexico, Myanmar, Turkey, Uganda, and Vietnam—were selected using United Nations Food and Agriculture Organization statistics. The basis for selection included the total number of animals being raised, the density of livestock on agricultural land, time trends in production levels, and geographic coverage. Overall, we targeted countries with higher levels of food animal production.

To identify literature to support our effort, we searched databases of peer-reviewed journal articles (PubMed, Scopus, and US Department of Agriculture’s Agricultural Online Access (AGRICOLA) database). We subsequently used Google Scholar and Google search engines to find additional articles and reports, including “grey literature” (e.g., non-governmental organization reports, conference papers, etc.). We also searched for news stories by using several media sources, databases, and aggregators (Global Meat News, Feed Navigator, Environmental Health News—Above the Fold, and Google News). Once our source material was collected, we extracted the following from each document: publication information, a summary, food animal production statistics on projected trends, livestock industry characteristics, impacts of industrial food animal production, public engagement with food animal production, and comments about the quality of the document.

Our research revealed a number of trends, themes, and gaps in information relevant to animal agriculture in the ten LMICs. There is significant growth in animal production, and IFAP specifically, when the ten countries are taken together, especially for poultry and pigs. IFAP production practices appear to be the most established in Brazil and China, though in general production trends vary greatly by species and geography, as well as by the degree to which certain sectors in each country are industrialized and/or consolidated. IFAP is growing in many of the countries researched, although it is not yet the dominant form of animal production. Large-scale, intensive production facilities—which may be part of an integrated production system—often exist in the livestock sector alongside small household farms raising only a handful of animals each. Some sources report that the inputs (e.g., breeds, feed, etc.) and infrastructure used by these large-scale farms are comparable to those of farms in high-income countries.

Among our specific findings, the landscape assessment yielded several key insights. First, in many countries, there appeared to be substantial national governmental support for industrializing food animal production. In some countries, it is an explicit component of their strategy for economic development. Supportive government policies take different forms, including loans or other forms of credit, direct or indirect subsidies, technical assistance, government-owned infrastructure (such as

slaughterhouses), market deregulation, favorable access to land, and tariffs and other trade policies. In addition to domestic policies, trade and involvement of multinational corporations and foreign governments were also identified as drivers of growth and intensification of IFAP. We found evidence that LMIC governments and companies are working to increase exports to meet demand for animal products abroad, and imports of feed ingredients, veterinary products, and other inputs for a growing domestic animal agriculture sector.

Research on the specific impacts of IFAP in LMICs has been limited, but is sufficient to trigger concern. We found many reports of insufficient regulation of IFAP practices (e.g., inputs used, slaughter, animal waste management) and impacts (e.g., animal welfare, environmental pollution, and public health). In some cases this is a result of inadequate enforcement of existing policies, while in others there appears to be an outright absence of policy. This is especially concerning in countries or regions where certain animal sectors are increasing in scale, density, and degree of industrialization without the necessary infrastructure to handle the large quantities of manure or livestock mortalities.

One crucial area requiring attention is the use of veterinary drugs in food animal production. Sources in various countries pointed to poor animal health and a lack of veterinary expertise (for example, few trained veterinarians or schools of veterinary medicine). These factors contribute to the misuse of antibiotic drugs in animal agriculture, which in turn was linked (with varying degrees of supporting evidence) to the presence of antibiotic-resistant pathogens in animal waste, at production sites, and in the surrounding environment. Beyond antibiotics, other chemical substances that are dangerous to human health when they enter the food supply have also been used as inputs in raising livestock, resulting in further food safety concerns.

On the other hand, we noted that some stakeholders in LMICs who are supportive of IFAP present the industrial production model as a method to address animal disease and food safety concerns, arguing that IFAP operations use biosecurity measures and produce a higher quality, uniform product. These arguments, however, do not take into consideration the conditions of IFAP that may increase disease risks and food safety concerns, including the hundreds or thousands of animals in crowded housing, the routine non-therapeutic use of antimicro-

bials and other veterinary drugs, and large quantities of manure and livestock mortalities that may result in significant health and environmental externalities.

Also related to sustainability and limited natural resources are the scarcity of quality feed and high feed costs, which are major challenges to further expansion of food animal production in nearly every setting researched. These challenges often stem from lack of arable land, water scarcity, or both, limiting resources for feed crop production. Sources in some countries also emphasized that feed crop production competes directly with land and other resources needed for cultivation of crops for human consumption. These factors suggest that major flows of raw materials for feed or manufactured feed across borders will occur, or continue to occur, in order for certain countries to protect domestic food production and food security. Limited access to high-quality feeds, among other inputs, further highlights the importance of trade as an enabling factor for growth of animal agriculture (and IFAP, specifically).

Based on our landscape assessment, and particularly the areas of concern and information gaps related to IFAP in developing countries, we recommend several avenues for future research and intervention. In regards to generation of additional information and analyses, we recommend: (1) more in-depth analysis of government policies promoting the industrialization of food animal production and identification of policy levers to mitigate the impacts of IFAP; (2) a private sector assessment, which identifies major multinational meat-producing companies, their countries of origin, locations of activity, and country-specific production practices; (3) an assessment of major national and international flows of feed or feed raw materials; (4) a focused analysis of the regulation of animal welfare related to IFAP in LMICs; (5) studies of consumer perceptions and preferences regarding animal production and consumption of animal protein; and (6) a planetary boundaries assessment for IFAP expansion in LMICs. For information dissemination, and engagement, we recommend (1) identifying case examples of existing sustainable modes of food animal production in LMICs and developing culturally appropriate educational materials to engage other farmers, and (2) implementing education campaigns for LMIC governments regarding public health and environmental concerns related to IFAP. Finally, in the area of intervention development and/or delivery, we recommend (1) convening nutrition and domestic agriculture experts to identify culturally appropri-

ate and regionally feasible plant-centric diets capable of providing adequate nutrition to the local population, and (2) identifying harm reduction strategies to mitigate impacts of IFAP in LMICs.

This is the first international landscape assessment of IFAP in LMICs to focus on trends in food animal production, related domestic and international policies, environmental and public health impacts, animal welfare, and to outline future directions for research and intervention. We believe that this report will provide a foundation of information for future proposals aimed at addressing environmental and public health concerns in LMICs associated with IFAP. The ultimate goals of this and future work are to increase understanding of the environmental, public health, and animal welfare impacts of expanding IFAP in LMICs, to help catalyze progress toward proper regulation of IFAP around the world, and to reduce demand for IFAP products.

Acronym list

AGRICOLA - US Department of Agriculture's Agricultural Online Access database

AU - Animal unit

CAFO - Concentrated animal feeding operation

EPA - United States Environmental Protection Agency

FAO - United Nations Food and Agriculture Organization

GDP - Gross domestic product

GHG - Greenhouse gas

ha - hectare

IFAP - Industrial food animal production

IGO - inter-governmental organization(s)

LMICs - Lower- and middle-income countries

m.t. - metric tons

NAFTA - North American Free Trade Agreement

n.d. - no data

NGO - non-governmental organization(s)

TPP - Trans-Pacific Partnership

TTIP - Transatlantic Trade and Investment Partnership

Introduction

Historically, the United States has demonstrated a voracious and steadily growing appetite for food products from animals that has only recently shown signs of stabilization (Figure 1). Similar trends have been observed in other parts of the developed world. In order to accommodate dietary patterns so heavily reliant on meat, milk, and eggs, the United States has shifted its agricultural production from a system with origins in decentralized, small-scale, diversified farms into an industrialized one with a dominant production model—termed industrial food animal production (IFAP)—that is geographically concentrated and economically consolidated into the hands of a relatively small number of corporations (1). While this highly specialized system has been shown to dramatically increase the rate of output of animal products, it has done so in a manner that places the health of the public and rural environments in jeopardy and raises a range of animal welfare issues.

typically required for plant-based foods that are directly consumed, resulting in a loss of energy and nutrients (2-4). For example, if consumption of products from grain-fed animals (e.g., meat, dairy, eggs) was cut in half globally, enough additional calories would be available to feed two billion people (2). The finite nature of natural resources threatens the sustainability of such a production model and places enormous immediate-term pressures on numerous planetary boundaries (5).

Animal agriculture contributes greatly to global greenhouse gas (GHG) emissions, thus contributing to climate change, which increasingly disrupts our food production system and negatively impacts public health in a variety of ways (6, 7). In addition to the enormous pressures IFAP applies to finite natural resources, these practices also deplete common goods; the production model relies heavily on the non-therapeutic use of antibiotics, wearing away

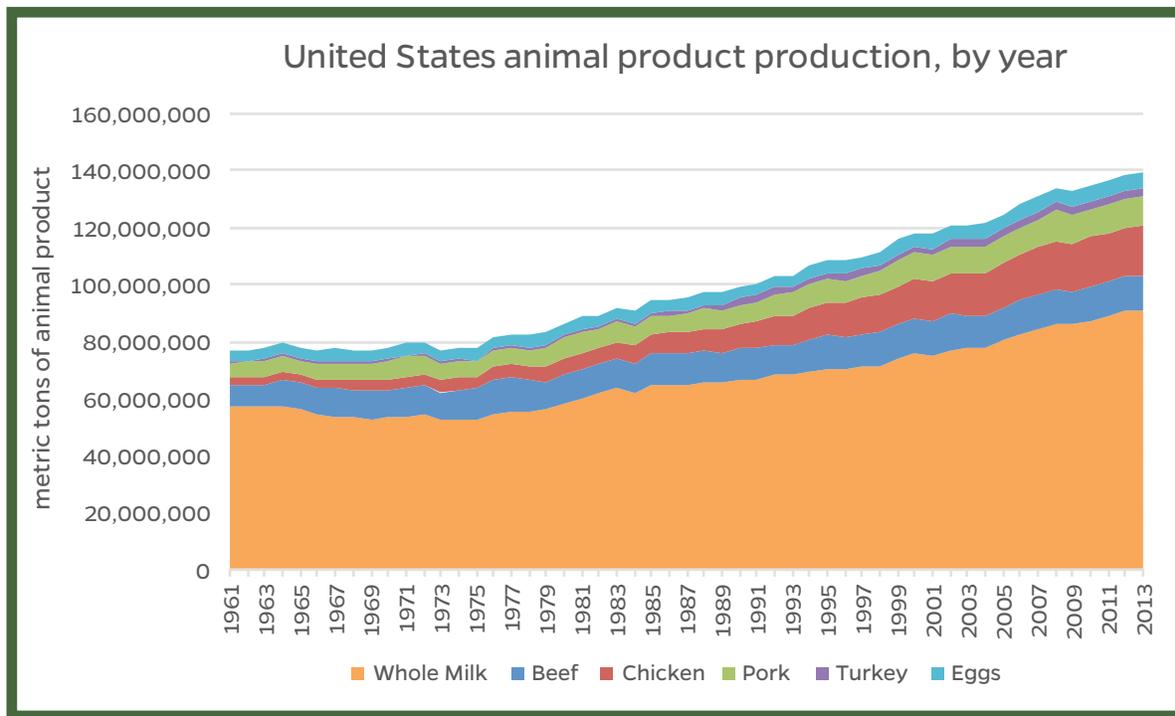


Figure 1: United States production of animal protein types, by year

While some claim that IFAP is responsible for low prices of animal products at the supermarket, these purported savings are accompanied by an array of societal and ecological costs that are externalized by the production model. IFAP is highly resource-intensive and an inefficient way to deliver sustenance compared to fruits, vegetables, grains, and legumes. The energy, water, and land required to produce animal products far outweigh those

at the effectiveness of these drugs and threatening to render them useless for treating human infections (8). As a result, drug-resistant pathogens created in and emitted from IFAP likely play a significant role in the societal burden of resistant infections. In addition to these resource demands, IFAP has been shown to place strain on the non-human environment. There is increasing awareness that the excessive manure generation accompanying



i. Inside an industrial poultry operation in Florida, USA (photo credit: USDA)

IFAP leads to unsustainable nutrient loadings of surface waters and other damages to soil ecosystems (9).

Beyond the ecological concerns and sustainability threats posed by this system, IFAP has been demonstrated to pose myriad health risks to those directly working in its production facilities. Moreover, laborers involved in the production of commodity crops used in animal feeds include pesticide applicators and persons who are more likely to be chronically exposed to pesticides and other hazards (10, 11). Workers in IFAP facilities are routinely exposed to hazardous air pollutants and antibiotic-resistant pathogens (12-14), while those in meat processing plants are at increased risk of infection with those same pathogens (15), as well as being exposed to repetitive motion injuries and other physical dangers related to use of sharp cutting equipment and excessively high line speeds (16-18). In addition, many people employed in these typically low-paying jobs are socially disadvantaged due to immigration status or other factors, have few resources to advocate for safer working conditions or fair pay, and may face undue consequences (e.g., deportation) from doing so (19). Even the owners of certain types of IFAP sites (especially poultry producers), may operate at an economic disadvantage; the contract system typically favors the integrating company and places the majority of economic risk with the IFAP owner, who may perpetually struggle at the margin (20). These site operators typically lose autonomy over production methods and take on excessive debt to meet the demands and conditions imposed by integrating companies. Those unwilling to enter into contract under the IFAP model can be forced out of business, as they are often unable to compete with industrial-scale operations.

Mounting scientific evidence suggests that fence-line neighbors and rural communities are also adversely impacted by IFAP (21). A growing body of scientific literature has documented that pollution originating from animal production sites does not stay contained within farm property lines and can elicit exposures in surrounding communities (22). Exhaust fans designed to control air quality and temperature inside of animal housing structures at IFAP sites have been shown to mobilize an array of air pollutants, including particulate matter, ammonia, hydrogen sulfide, and various volatile organic compounds, endotoxins, and other compounds, many of which have been linked to health impacts in exposed persons (23). The generation and storage of enormous volumes of manure at these sites commonly contributes to odor and other nuisance issues that can meaningfully compromise the health and quality of life for fence-line neighbors. The over-application of this waste to agricultural land results in nutrient mobilization into surface and groundwater sources and the transport of pathogens and other contaminants into the environment (24). Those reliant on groundwater as a source of drinking water, depending on their underlying geology, may be more likely to be exposed to contaminants present in the waste (25, 26). To make matters worse, residents impacted by odors and other releases from IFAP may have limited success in engaging health departments and other state permitting agencies in improving their conditions (27, 28). Further, some research suggests that the presence of an IFAP operation may have impacts on residential property values (29, 30).

Beyond its societal impacts, the IFAP model of production has important animal welfare implications. Nearly all of the approximately nine billion food animals produced each year in the US spend the majority of their lives in cramped, crowded, and unhygienic conditions conducive to stress, the transfer of pathogenic microorganisms, and injury risks (1). The billions of animals produced globally for human consumption likely account for the largest proportion of animal welfare deficiencies occurring worldwide. In comparison, the latest estimate of animals used in research globally, although presented as a likely underestimate, was 115.3 million animals in 2005 (31), and the number of animals raised for the human food supply in 2007 was estimated to be 56 billion (32). If the relative scales of animal research and food animal production are similar today, animals used in research would be equivalent to 0.2% of animals produced for consumption.

While meat consumption in high-income countries is slowing, growth in demand for (and thus production of) animal products has been increasing in low- and middle-income countries (LMICs) (33). This trend is not new; from 1980 to 2004, livestock production tripled in developing countries, but grew only about 22% in wealthier countries (where production and demand are already quite high) (34). Multinational corporations (often American and Chinese) involved with the IFAP supply chain do not only export meat, dairy, and eggs to meet demand in these markets, they also export the technology and inputs necessary to implement the IFAP model. Existing evidence suggests that in some cases within LMICs, multinational corporations own and operate IFAP production sites, often across multiple continents. Even in cases where the IFAP model arises without external influence from multinational corporations, its adoption in LMICs can create dependencies on resources that must be imported (e.g., feed, fuel, drugs, and equipment).

LMICs may be particularly vulnerable to the externalities of IFAP, since many of the regulatory controls established in industrialized countries may be absent. As a result, regulatory oversight and enforcement can be limited or nonexistent. Such concerns, however, may not be relevant for all forms and scales of animal agriculture. It is important to acknowledge that a moderate increase in animal-based foods in populations suffering from malnutrition, stunting, and food insecurity may be beneficial, as animal products are a concentrated source of protein, fat, and calories (35). Also, livestock are kept by farmers in LMICs to prevent or lessen food insecurity and to diversify their incomes. These complexities necessitate a careful consideration of the different models for food animal production in LMICs and their potential public health and ecological impacts.

Many countries across different regions of the world may be affected by IFAP, and data are not readily available to accurately track the expansion of the IFAP model and its societal and ecological impacts. In addition, IFAP production practices, regulations, and food animal species vary. An effort to identify major trends and priority countries and topics is a necessary first step towards stimulating and informing coordinated work to address IFAP internationally and promoting more sustainable forms of agriculture and dietary improvements.

This report details a landscape assessment of the food animal production industry, specifically focusing on the



ii. Aerial photo of industrial poultry operation near the Chester River in Maryland, USA. Photo credit: Jane Thomas, Integration and Application Network, University of Maryland Center for Environmental Science

beef, pork, and chicken industries in LMICs where IFAP is currently occurring and/or being established. While dairy and egg production were not an explicit focus of this assessment, they are covered to a limited extent.

It is our intent that the results of this landscape assessment will serve as a communication tool that can inform a range of future research projects and funding initiatives and will provide a useful resource to advocacy and policy communities. We believe that this report will help provide a foundation of information for future proposals aimed at addressing environmental and public health concerns in LMICs associated with IFAP. The ultimate goals of this and future work are to increase understanding of the environmental, public health, and animal welfare impacts of expanding IFAP in LMICs, to help catalyze progress toward proper regulation of IFAP around the world, and to reduce demand for IFAP products.



iii. Inside an industrial hog operation, USA (photo credit: Ralph Loglisci)

Methods

Country Selection

As a preliminary screening step, we excluded countries that were considered “high-income” by the World Bank, as well as very small countries or nation-states (specifically, those with fewer than one million inhabitants). Then we selected countries using a combination of perspectives.

First, for each country, we calculated total animal units (AUs) for cattle, chickens, and pigs. For conversion factors, we referred to the Illinois Livestock Management Facilities Act, whose numbers appeared to be based on the US Environmental Protection Agency’s conversion factors when the agency previously defined a Concentrated Animal Feeding Operation (CAFO) using AUs (Table 1). These conversion factors sometimes depend on the type and weight of animals (e.g., swine weighing more versus less than 55 pounds) and/or the characteristics of facilities (e.g., if the poultry facility has a liquid manure handling system versus continuous overflow watering). We did not have this level of information for each country, so there was some uncertainty as to which conversion factors to use. Thus, we tried three different combinations (using the highest conversion factor when more than one was available, using the lower conversion factor when two choices were available, and using an average of the high and low conversion factors). We applied these conversion factors to the most recent data available (at the time of writing) on number of live animals (2013) for each country to get total AUs.

Next, we divided total AUs for each country with its total agricultural area in 2013 to get a density of total AU per hectare of agricultural area. We then identified the countries that appeared in the top ten for both total AUs and AU density. Using “high” conversion factors (Table 2)

yielded three countries that appeared in the top ten for both total AUs and AU density: Ethiopia, Myanmar, and Vietnam. Using an average of “high” and “low” conversion factors (Table 3) yielded two countries: Ethiopia and Myanmar. Using the “low” conversion factors (Table 4) yielded two countries: India and Ethiopia. Thus, we selected these countries: **Ethiopia, Myanmar, India, and Vietnam**. Two countries in particular, Brazil and China, ranked consistently at the top of the list for total AUs; however, they had low AU densities due to their geographic size. We selected **Brazil and China** as well, given the sheer numbers of animals being raised there.

There were two other considerations that went into our country selection. We wanted our country selection to have reasonable geographic coverage. We also wanted to consider species-specific production, as sectors within a country could very well be at different stages of development. Thus, to round out our list to ten countries, we selected four countries based on both region and prominence in terms of animal-specific production¹ and/or AUs, as calculated previously. In Latin America, we selected **Mexico**, which ranked in the top ten for total AUs for every combination of factors used, and in 2012 ranked third in chicken meat production, third in cattle meat production, and fifth in pig meat production (Table 5). In the Middle East, we selected **Turkey**, which ranked 11th or 12th for total AUs, depending on the combination of factors used, as well as ranked sixth and seventh in cattle and chicken meat production, respectively. In sub-Saharan Africa, we selected **Kenya and Uganda**. Kenya ranked tenth for cattle meat production, and in the top ten or very near it for total AUs for every combination of factors used. Uganda was prominent in terms of both total AUs and AU density—besides Ethiopia, it was the only other

Table 1: Animal unit conversion factors

Animal	“High”	“Low”	“Average”
Cattle	1	1	1
Pigs	0.4	0.03	0.215
Chickens	0.03	0.01	0.02

Source: Illinois Livestock Management Facilities Act (510 ILCS 77); the numbers appear to be based on the EPA’s numbers for defining a CAFO, which the agency no longer uses.

1. The most recent data for production at the outset of this study were from 2012.

African country to rank in the top 20 for both indicators—and because of its significant sector-specific production increases. Chicken meat production had increased 45% over the past five years (2007 to 2012), while cattle meat and pig meat production had increased 66% and 37%, respectively, over the past decade (2002 to 2012)².

Thus, our final list of ten countries is as follows: **Brazil, China, Ethiopia, India, Kenya, Mexico, Myanmar, Turkey, Uganda, and Vietnam.**

Table 2: Total AUs and AU density calculated using “high” set of conversion factors

Country	Animal units	Country	AU/ha of agricultural area
China	451,541,129	Dominican Republic	3.53
Brazil	263,925,309	Lebanon	2.84
India	214,322,000	Egypt	2.38
Indonesia	69,962,700	Suriname	2.34
Ethiopia	55,553,700	Nepal	2.23
Mexico	54,611,241	Myanmar	2.12
Colombia	31,278,429	Vietnam	2.09
Nigeria	27,202,629	Laos	1.63
Myanmar	26,717,310	Ethiopia	1.53
Tanzania	25,796,672	Guatemala	1.51
Viet Nam	22,697,760	Jamaica	1.48
Turkey	22,401,105	Ecuador	1.4
South Africa	20,640,000	Honduras	1.33
Kenya	19,507,852	Malaysia	1.24
Thailand	15,967,137	Indonesia	1.23
Bolivia	15,709,295	Costa Rica	1.2
Uganda	14,935,340	India	1.19
Paraguay	14,362,715	Haiti	1.11
Ukraine	13,534,260	Panama	1.09
Philippines	12,136,708	Uganda	1.04

2. Note that the 2012 figure for cattle meat production was based on official statistics, while the 2002 figure was an FAO estimate. Thus, some of the difference may be attributed to methodological differences.

Table 3: Total AUs and AU density calculated using “average” set of conversion factors

Country	Animal units	Country	AU/ha of agricultural area
China	314,000,350	Dominican Republic	2.77
Brazil	244,639,884	Nepal	2.06
India	205,357,950	Egypt	2.01
Ethiopia	55,034,095	Lebanon	1.93
Indonesia	50,624,519	Myanmar	1.76
Mexico	46,371,230	Ethiopia	1.52
Colombia	28,640,364	Vietnam	1.42
Tanzania	25,349,172	Guatemala	1.27
Nigeria	24,242,016	Laos	1.27
Myanmar	22,169,415	Honduras	1.16
Turkey	19,738,993	Ecuador	1.15
Kenya	19,029,030	India	1.14
South Africa	18,344,000	Jamaica	1.09
Vietnam	15,493,755	Costa Rica	1.02
Uganda	14,156,484	Uganda	0.98
Paraguay	13,972,081	Haiti	0.98
Bolivia	13,274,039	Panama	0.97
Thailand	11,967,628	Central African Republic	0.92
Niger	11,096,452	Indonesia	0.89
Uzbekistan	11,091,468	Malaysia	0.84

Table 4: Total AUs and AU density calculated using “low” set of conversion factors

Country	Animal units	Country	AU/ha of agricultural area
Brazil	225,354,460	Dominican Republic	2.01
India	196,393,900	Nepal	1.89
China	176,459,570	Egypt	1.63
Ethiopia	54,514,490	Ethiopia	1.5
Mexico	38,131,220	Myanmar	1.4
Indonesia	31,286,338	Suriname	1.11
Colombia	26,002,300	India	1.09
Tanzania	24,901,672	Guatemala	1.04
Nigeria	21,281,402	Lebanon	1.03
Kenya	18,550,209	Honduras	1
Myanmar	17,621,520	Uganda	0.93
Turkey	17,076,881	Ecuador	0.91
South Africa	16,048,000	Laos	0.9
Paraguay	13,581,447	Central African Republic	0.87
Uganda	13,377,628	Panama	0.86
Niger	10,911,589	Costa Rica	0.85
Bolivia	10,838,782	Haiti	0.84
Uzbekistan	10,609,006	Brazil	0.81
Mali	10,383,794	Nicaragua	0.78
Madagascar	10,345,000	Vietnam	0.76

Table 5: Production in 2012 (metric tons)

Chicken meat		Pig meat		Cattle meat	
China	13,198,476	China	52,308,720	Brazil	9,307,000
Brazil	11,534,972	Brazil	3,330,000	China	6,306,350
Mexico	2,791,639	Vietnam	3,160,048	Mexico	1,820,547
India	2,278,000	Philippines	1,652,881	India	975,800
Iran	1,950,000	Mexico	1,238,625	Colombia	854,232
Indonesia	1,734,011	Thailand	949,299	Turkey	799,344
Turkey	1,723,917	Indonesia	728,750	Pakistan	786,680
Thailand	1,319,000	Ukraine	700,800	Uzbekistan	762,000
Malaysia	1,209,560	Myanmar	620,000	Indonesia	508,905
Peru	1,171,466	India	357,000	Kenya	410,600

Search Methodology Overview

We started our landscape assessment by searching databases that included peer-reviewed journal articles: PubMed, Scopus, and US Department of Agriculture's Agricultural Online Access (AGRICOLA) database. These searches were conducted in February/March 2015. We also conducted searches on Google Scholar and Google between April and June 2015. Media searches were done in June/July 2015 using Global Meat News, Feed Navigator, Environmental Health News—Above the Fold, and Google News.

Specific search terms used for each of the searches can be found in the appendix. As explained in greater detail below, our methods varied slightly depending on the database or source, to account for each one's characteristics and volume of content. In addition, throughout our search process, we kept a running list of organizations engaging in the topic of industrial food animal production. To complement the results found through the searches, we visited the websites of many of these organizations and flagged further documents for data extraction. (Please see this list of organizations in the appendix.)

Specific Search Strategies by Database/Source

Within **PubMed**, a database containing biomedical research literature, we ran three types of searches. The first type consisted of country-specific searches for the concept of food animal production (either all livestock animals in general or one of the three specific animal classes of interest), with a separate search for each of the ten selected countries. The second type was a single general search on the concept of “factory farming.” Finally, the third was a single search that combined the concept of “CAFO” (confined/concentrated animal feeding operation) with either one of the ten selected countries or developing/low-income countries in general. Article titles and abstracts were read to determine relevance, and relevant articles were flagged for data extraction.

For **Scopus**, a database containing peer-reviewed scientific literature, the first type of search we conducted was similar to the first set of PubMed searches: country-specific searches for the concept of food animal production, either for all livestock animals in general or for one of the specific animal classes of interest. For countries generating more than a thousand hits with this search, we restricted our searches to publications since 2000, to English, Spanish, or Portuguese-language sources, to related fields of study (agricultural and biological scienc-

es, environmental science, medicine, veterinary, earth/planetary sciences, social sciences, economics, business, and health professions), and to sources of a certain type (articles, conference papers, book chapters, and books). The second type of Scopus search was a single search for the concept of “factory farming” and one of our countries of interest. The third type of Scopus search was a single search on the concept of “CAFO” and one of our countries of interest or developing/low-income countries. Source titles and abstracts we read to determine relevance, and relevant articles were flagged for data extraction.

AGRICOLA, a database maintained by the US Department of Agriculture, links to resources on agricultural and related sciences. Focusing on AGRICOLA's Article Citation Database, we used the “keyword anywhere” search function to run country-specific searches for the concept of industrialized, intensified, confined, or constrained food animal production. A date restriction (2000 onwards) and language restriction (English-only) were imposed for countries generating several hundred hits or more. We also ran searches for that same concept in relation to developing or low-income countries. Finally, we ran a single general search for the concept of “factory farming,” restricting our inquiries to articles published since 2000. Article titles and abstracts were read to determine relevance, and relevant articles were flagged for data extraction.

Following these database searches, we conducted searches using **Google Scholar** for each of the ten selected countries and the concept of industrial food animal production. We restricted sources to articles only (no case law), to English, Spanish, or Portuguese-language sources, and to articles published between 2005 and 2015 (the year when the search was conducted). The number of hits generated per country ranged from 1,700 to 40,000+, and we reviewed between 100 to 400 results, depending on the country. (Hits became less relevant to our topic of interest as we went further down the list of search results, so we stopped reviewing hits at that point.) In deciding which sources to flag for data extraction, we considered titles, abstracts, or any other summary information provided by clicking on the link. Sources included journal articles that had not been previously picked up through the database searches described above, as well as non-governmental reports, inter-governmental organization reports, university research center working papers, conference reports, government documents, and news articles.

We then conducted general **Google** searches for each country to look for salient sources related to industrialization, growth, or expansion of food animal production, which might otherwise have been missed. We conducted searches for specific livestock animals, as well as food animal production in general. We focused on finding documents (not web pages), which provided some indication of the methods used or objectivity of the source. We did not download news articles at this point, because we conducted a media search separately afterwards. We did not filter by date, though the source's date was a factor in determining relevance and whether to download it. We reviewed several hundred results per country, again applying the principle of stopping our review when results clearly became less relevant to our topics of interest. In deciding which sources to flag for data extraction, we considered titles, abstracts, or any other summary information provided by clicking on the link.

For the media sources, we conducted searches using several media databases: Global Meat News, Feed Navigator, Environmental Health News—Above The Fold, and Google News. Given the resources we had available, we did not look for domestic media coverage besides articles that might have come up through the Google News search. For **Global Meat News**, we read every news article mentioning one of our selected countries, restricting to articles in the past year if there were over a hundred articles for a given country. We also read the news articles, published at any point, which mentioned one of our selected countries and the concept of intensification, growth, or expansion. In deciding which articles to flag for data extraction, our strategy was to be selective in choosing articles that directly addressed *how* IFAP was being practiced in that country, not just articles that recited statistics to show increasing meat production. We also looked for coverage of special issues that we were interested in, such as market integration, governmental policies on food animal production, land acquisitions, etc.

For **Feed Navigator**, we examined the headline of every news article, published at any point, which mentioned one of our selected countries. We read the articles with the most relevant headlines. Our strategy was to include those news articles for data extraction that made a connection between feed production and animal production (i.e., feed as one input to producing beef, pork, or poultry, rather than just feed production for its own sake). The exception was that we also included articles that targeted specific topics of concern to us, such as feed

additives or overseas land acquisitions for the purpose of producing feed.

In **Environmental Health News—Above the Fold**, we examined every news story published at any time, that included a keyword to indicate animal, meat, or a specific livestock class of interest, and which listed “food production” as the subject. We searched for articles that addressed at least one of our selected countries, and flagged relevant articles for data extraction.

Using **Google News**, we restricted to news articles published in 2010 or later. We conducted searches by country, focusing on growth, expansion, or industrialization of livestock production, either in general or by specific livestock class. Since each news development may be covered by multiple news outlets, Google News will “feature” one news outlet's story for each, listing it first. In general, this is the one that we downloaded if we wanted to include that development. Depending on the country, there were between 17,000 to 3 million+ hits on Google News. We reviewed between 150 to 260 hits per country, depending on how relevant the articles continued to be as we went deeper into the results, and depending also on how much information we had already gathered on that particular country through prior search methods. Again, in deciding which news stories to flag for data extraction, our strategy was to maintain a tight focus on industrial methods used to produce poultry, pork, or beef in the countries we selected. Special topics like mergers/acquisitions came up often in the news, and these were included for data extraction if they made a reference to broader industry trends, like consolidation or vertical integration of the agricultural sector. Stories about business developments by themselves (without relating to this broader context) were not included.

Data Extraction Methods

After collecting documents using the search methods described above, we formulated a template for data extraction consisting of the following categories: basic information about the document, a summary, food animal production statistics on projected trends, livestock industry characteristics, impacts of industrial food animal production, public engagement with food animal production, and comments about the quality of the document. At this point, reviewing the texts of the document made it clear that some of the documents, notwithstanding their titles and abstracts, did not provide information related to our

topics of interest, or were not written such that the information appeared sufficiently comprehensible or reliable; thus, these documents did not undergo data extraction. The number and type of documents that underwent the data extraction process are provided below, by country (see Table 6). Note that this information is meant to provide a general idea of the sources we used, as the precise classification is not always clear between journal articles and other types of documents.³

Table 6: Sources identified for extraction, by country and type

Country	Journal articles	News articles	Others (e.g., NGO/IGO reports, conference papers, govt. sources)
Brazil	26	27	20
China	43	42	18
Ethiopia	28	1	14
India	15	16	19
Kenya	13	3	5
Mexico	10	7	6
Myanmar	5	2	5
Turkey	20	2	12
Uganda	14	11	16
Vietnam	23	9	32

3. For example, one journal article consisted of a commentary written by a government official, while some of the sources counted here under “other documents” were working papers published by a university-based research group.

Country-specific production, trade, and consumption data

To contextualize the country-specific information that proceeds, we present data from the United Nations Food and Agriculture Organization (FAO) describing food animal production in our study's countries of interest. What follows is a series of tables examining various dimensions of animal production to set the stage for more detailed information provided for each country.

The following tables are presented in this section:

- Number of live animals, by country, in 2013
- Animal density (as measured by animal units divided by hectares of agricultural land) by country in 2013
- Animal product-specific production, imports and exports
 - Pig meat (pork)
 - Chicken meat
 - Cattle meat (beef)
 - Cow's milk

Table 7: Live animals by country, 2013

	Pigs	Chickens	Cattle
Brazil	36,743,592	1,248,786,000	211,764,292
China	482,102,701	4,835,178,000	113,644,709
Ethiopia	33,000	51,350,000	54,000,000
India	10,130,000	709,000,000	189,000,000
Kenya	432,979	39,872,000	18,138,500
Mexico	16,201,625	524,271,000	32,402,461
Myanmar	12,725,000	219,377,000	15,046,000
Turkey	3,145	266,153,000	14,415,257
Uganda	2,497,600	31,680,000	12,985,900
Vietnam	26,264,408	234,509,000	5,156,727

Data source: FAO production sheets (live animals). Data reflect the number of animals present in the country at the time of enumeration and include animals raised for labor purposes, breeding, and meat, egg, and dairy production.

Table 8: Animal density by country, 2013

Country	Animal density (AU/hectare), by conversion factor		
	Low	Average	High
Brazil	0.81	0.88	0.95
China	0.34	0.61	0.88
Ethiopia	1.50	1.52	1.53
India	1.09	1.14	1.19
Kenya	0.67	0.69	0.71
Mexico	0.36	0.43	0.51
Myanmar	1.40	1.76	2.12
Turkey	0.44	0.51	0.58
Uganda	0.93	0.98	1.04
Vietnam	0.76	1.42	2.09

Data source: FAO production sheets (live animals), FAO inputs sheets (land). Animal density was calculated by dividing total animal units (AUs) by agricultural area (hectares). Total animal units for each country were calculated by multiplying numbers of live animals (pigs, chickens, cattle) by their corresponding conversion factors from the Illinois Livestock Management Facilities Act in order to account for the varying size and weight of the different animals. Three conversion factors (low, average, and high) were applied (see Methods).

Table 9: Pig meat production, imports, and exports

	Production (mt)			Imports (mt)	Exports (mt)	Net (mt)
	2002	2007	2012	2012	2012	2012
Brazil	2,798,000	2,990,000	3,330,000	0	83,516	3,246,484
China	37,931,476	43,933,037	52,308,720	590,060	122,229	52,776,551
Ethiopia	1,495	1,665	1,875	2	0	1,877
India	468,580	385,000	357,000	219	116	357,103
Kenya	14,400	16,200	12,950	49	362	12,637
Mexico	1,070,246	1,152,003	1,238,625	385,266	461	1,623,430
Myanmar	193,020	410,736	620,000	21	n.d.	n.d.
Turkey	37	n.d.	0	0	0	0
Uganda	84,000	105,000	115,000	11	0	115,011
Vietnam	1,653,595	2,662,700	3,160,048	n.d.	9,963	n.d.

Source: FAO production sheets (livestock primary). Data exclude processed livestock products, e.g., cheese and canned meats. Net balances were calculated by adding imports to production and subtracting exports. "mt" = metric tons, "n.d." = no data.

Table 10: Chicken meat production, imports, and exports

	Production (mt)			Imports (mt)	Exports (mt)	Net (mt)
	2002	2007	2012	2012	2012	2012
Brazil	7,050,000	8,988,035	11,534,972	2,136	3,560,370	7,976,738
China	9,173,395	10,724,950	13,198,476	1,458,988	721,133	13,936,331
Ethiopia	54,064	46,240	60,480	1	0	60,481
India	1,088,000	1,755,000	2,278,000	0	4,015	2,273,985
Kenya	19,689	23,460	23,654	1,827	50	25,431
Mexico	2,075,758	2,542,493	2,791,639	603,525	4,317	3,390,847
Myanmar	300,790	726,497	1,080,000	97	n.d.	n.d.
Turkey	696,160	1,068,453	1,723,917	385	300,596	1,423,706
Uganda	53,625	43,550	63,000	682	37	63,645
Vietnam	338,402	358,800	525,961	515,697	476	1,041,182

Data source: FAO production sheets (livestock primary). Data exclude processed livestock products, e.g., cheese and canned meats. Net balances were calculated by adding imports to production and subtracting exports. "mt" = metric tons, "n.d." = no data.

Table 11: Cattle meat production, imports, and exports

	Production (mt)			Imports (mt)	Exports (mt)	Net (mt)
	2002	2007	2012	2012	2012	2012
Brazil	7,139,000	9,303,000	9,307,000	6,223	7,496	9,305,727
China	4,853,389	5,845,638	6,306,350	25,089	2,216	6,329,223
Ethiopia	352,500	363,000	338,150	3	4	338,149
India	958,375	1,018,092	975,800	0	433	975,367
Kenya	318,650	445,000	410,600	1	438	410,163
Mexico	1,467,574	1,635,040	1,820,547	2,974	35,977	1,787,544
Myanmar	81,000	130,196	215,000	314	0	215,314
Turkey	327,630	431,963	799,344	25,436	14	824,766
Uganda	115,000	174,150	191,280	0	1	191,279
Vietnam	102,454	206,145	293,969	n.d.	0	n.d.

Data source: FAO production sheets (livestock primary). Data exclude processed livestock products, e.g., cheese and canned meats. Net balances were calculated by adding imports to production and subtracting exports. “mt” = metric tons, “n.d.” = no data.

Table 12: Whole cow's milk (fresh) production, imports, and exports

	Production (mt)			Imports (mt)	Exports (mt)	Net (mt)
	2002	2007	2012	2012	2012	2012
Brazil	22,314,700	26,137,266	32,304,421	12,104	24	32,316,501
China	13,355,933	35,574,326	37,784,491	151,495	32,812	37,903,174
Ethiopia	2,478,969	2,629,521	3,804,991	103	n.d.	n.d.
India	34,612,000	46,822,000	59,805,250	0	9,544	59,795,706
Kenya	2,890,685	3,202,387	3,732,960	12,233	4,758	3,740,435
Mexico	9,658,282	10,345,982	10,880,870	28,464	7,426	10,901,908
Myanmar	525,114	980,314	1,300,000	369	n.d.	n.d.
Turkey	7,490,630	11,279,340	15,977,837	0	8,801	15,969,036
Uganda	700,000	1,085,000	1,207,500	1,593	9,418	1,199,675
Vietnam	78,453	234,438	381,700	7,400	760	388,340

Data source: FAO production sheets (livestock primary). Data exclude processed livestock products, e.g., cheese and canned meats. Net balances were calculated by adding imports to production and subtracting exports. “mt” = metric tons, “n.d.” = no data. “Whole cow's milk (fresh)” only includes fresh whole milk from cows and is a single item within the “milk, excluding butter” aggregation. For example, it excludes skim milk and milk from other animals.

Table 13: Livestock product consumption by country (kg/capita/yr), 2013

	Pigmeat	Poultry meat	Bovine meat	Milk, excluding butter
Brazil	12.60	45.00	39.25	149.28
China	38.60	13.73	5.23	33.18
Ethiopia	0.02	0.66	3.61	44.14
India	0.28	1.88	0.81	84.50
Kenya	0.29	0.47	9.54	94.86
Mexico	15.23	30.12	15.33	111.87
Myanmar	11.31	21.87	4.94	31.48
Turkey	0	19.02	10.34	165.83
Uganda	3.35	1.78	5.29	31.63
Vietnam	35.00	12.36	7.44	16.36

Data source: FAO food balance sheets. Data are expressed in primary commodity equivalents, e.g., the total quantity of whole milk involved in producing all milk-derived products (excluding butter). The most recent data for Turkey and Uganda were from 2011.

Country-specific information

In this section, we present a brief overview of food animal production trends observed in each of the ten selected countries. While these contextual overviews only broadly discuss salient and general characteristics of food animal production in each country, the full country-specific profiles in the appendix of this report contain detailed information on: quantitative production data from the Food and Agriculture Organization, industry characteristics, regulation of livestock production, IFAP impacts, and public engagement with IFAP. We direct readers interested in specific countries or regions to the country profiles. References for the context overviews are also contained in the full country profiles presented in the Appendix.

Brazil

For the past three decades, Brazilian agriculture has experienced a transition to an increasingly globally connected and industrialized food system. This is particularly true for the pork and poultry sectors, which have become more commercialized, capital intensive, large-scale, vertically integrated, and concentrated. In these sectors, larger profit-oriented operations have replaced smaller subsistence-oriented farms over the past three decades. At the same time, many smaller-scale producers have been absorbed into vertically integrated pork or poultry supply chains. The growth in poultry and swine production in Brazil has been made possible, in part, by the growth in the domestic feed sector. Maize and soy produced in some regions of Brazil are transported over large distances to reach other regions where animal production is concentrated.

Cattle ranching has also expanded in scale, a trend promoted by subsidies of agricultural and livestock inputs, subsidized credit, and other financial incentives. Although a minority of cattle is raised exclusively in feedlots, feedlots are increasing in both numbers and size, and the country's overall feedlot capacity has expanded dramatically over the past few decades. Feedlots are mostly owned by large meat-



packing companies and are promoted as a way to achieve greater efficiency and productivity. Some stakeholders argue that intensification will reduce deforestation pressures by reducing the amount of land converted to pasture.

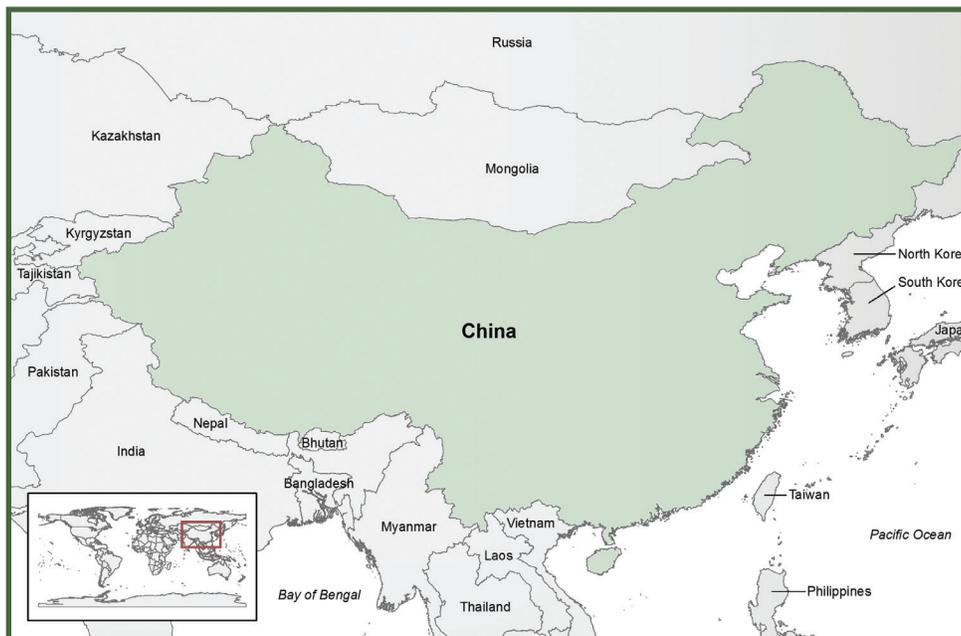
In the context of expanding livestock production, domestic legislation on animal welfare has been deemed insufficient by various researchers. Regulations on feed additives, wastewater discharge, and protection of forested areas on farmland do exist, but implementation and enforcement are challenging. There appears to be little research on the impacts of industrial food animal production on occupational health and public health. A handful of studies addressed some environmental impacts of livestock production, such as water use, deforestation, and GHG emissions.

China

A clear shift to industrialized, large-scale livestock production has occurred and continues to be promoted in China. Among the major demographic factors that have contributed to this trend are increasing population, rising incomes, and urbanization. During a period of enormous economic growth in China (1978 to 2004), animal agriculture's share of gross domestic product (GDP) doubled, from 17% to 34%. Globally, China leads meat production for chicken, pork, and cattle, ranking either as the first or second country in terms of volume of output. For pork in particular, China's production was over ten-fold greater than that of the second highest pork-producing country in 2012. At the largest and most intensive end of the production scale, pigs are produced on commercial farms that raise at least 3,000, and as many as 50,000 or more, annually.

Domestic public policies have been influential in the industrialization process. Various stakeholders view integration, consolidation, and expansion of the scale of livestock production in China as being associated with greater profits, higher quality, more efficient use of natural resources, better food safety, and fewer zoonotic disease risks. At the same time, small-scale producers are blamed for food safety and other problems, and are portrayed as inefficient and difficult to monitor. One distinctive feature of the Chinese livestock sector is the emergence of "specialized" household-level production, as traditional backyard livestock production has declined. For example, in 2010, nearly half of the country's pigs were raised on medium-scale specialized household pig farms producing 50 to 3,000 pigs per year. Like commercial operations, specialized household farms are considered confined/concentrated animal feeding operations, and rely on large slaughterhouses and processors.

Officially designated "dragonhead enterprises" are large-scale companies that meet certain criteria for scale of production, use of technology, and management. In the pork and poultry industries, these enterprises receive government support and lead expansion and vertical integration. The trajectory toward large-scale, intensive livestock production has been accompanied by small, independent



farmers' departure from the sector. However, the extent of concentration and consolidation is less than the United States. There are still many small-scale slaughterhouses and processors, though the country's 12th Five-year Food Industry Plan (2010 to 2015) set a target of a 50% reduction in small-scale slaughterhouses by 2015 through mergers and acquisitions.

Meanwhile, the development of China's livestock sector has also become increasingly linked to entities and resources abroad, with Chinese agribusinesses acquiring interests in foreign companies, overseas agricultural land, live animals, and feed crops. One motivation for involvement abroad pertains to the domestic shortage of feed and resources for producing feed, because of the scarcity of land (only 12% of the country's area is arable land), labor (due to urbanization), and water availability.

The dramatic growth and current scale of food animal production in China has attracted significant attention from the media, civil society, and research sectors. The country was the largest producer and consumer of antibiotics in 2014, and several studies have noted with concern the overuse and abuse of antibiotics in animal agriculture. Some research has investigated the connection between these practices and the prevalence of antibiotic residues in water, as well as antibiotic-resistant pathogens in livestock manure and areas where manure has been applied.

Ethiopia

Ethiopia's livestock sector has historically been characterized by extremely low productivity and a mostly subsistence orientation. Traditional production is low input, based on pastoralism or mixed crop-livestock farming. Improving livestock production is seen as a form of poverty alleviation and a way to increase national GDP. Rather than work toward increased output *per se*, the government's main effort—the National Livestock Development Project, the first cycle of which began in 1958—aimed to increase household income through improved livestock rearing. The Second (1973-1981) and Third (1975-1992) Livestock Development Projects included construction of slaughterhouses and a program for small-scale cattle fattening operations, respectively. The Ministry of Agriculture has also established “poultry multiplication and distribution centers” to encourage poultry farms to increase their flock sizes.

At present, there are emerging intensive and semi-intensive beef production systems, with some feedlots containing capacity on the order of a hundred heads of cattle, and a few with capacity as high as 5,000 heads in certain regions of the country. However, productivity, as indicated by live weights and carcass weights, is much lower in Ethiopia than in the United States (average weights in Ethiopia are less than half of those in the US). With respect to poultry production, traditional and small-scale systems continue to dominate, but there are now large-scale industrial production facilities in urban areas, some run by private companies and others by the government. The largest commercial farms are raising over 10,000 birds intensively in confined conditions, but these operations account for only one or two percent of the country's total poultry meat supply. In the poultry sector, there is at least one integrator, but in general the livestock industry is not very integrated. Though not always invoking the term “vertical integration,” official and non-governmental sources have suggested that increasing vertical linkages and supply chain development could help overcome farmers' poor access to markets.

Stakeholders wanting to expand and industrialize livestock production in Ethiopia have identified several barriers to



growing the sector. Some challenges are directly related to food animal production (such as a lack of animal health expertise, support for breeding, and other livestock extension services), and others stem from the broader issue of rural underdevelopment (such as natural resource scarcity, weak incorporation of technology, and poor infrastructure in terms of transportation, energy, and marketing). In particular, feed availability and quality are key constraints in Ethiopia. Pastureland, which is typically communally owned, is described as being degraded, over-grazed, or privatized. Cultivation of fodder crops is not common due to competing pressure for farmland. Currently, most grain produced in the country does not go toward feeding livestock, as small producers cannot afford grain-based feed, and only the large-scale commercial operations located around the capital use grain-based feed regularly. Rather, most domestically produced grain is used for domestic human consumption.

While public and other private initiatives have contributed to some industrialization of livestock production, which could help improve nutrition and food security, the externalities and consequences of this development, as well as the need for more resources (including scarce land and water) as inputs, are important considerations that have received limited attention to date in the Ethiopian context. Similarly, there has been some evidence that antibiotics are being used inappropriately in livestock production, though this issue and its public health implications have not been studied in detail.

India

India has an expanding livestock sector, with decade-specific growth rates ranging from three to five percent during the 1980s, 1990s, and 2000s. Increased government investment in the sector coincided with its expansion early on, but private spending, which has risen since the 1990s, has now taken on a greater role. The consumption of non-vegetarian foods has increased with rising consumer purchasing power. Chicken is the most widely consumed meat, while eggs are increasingly incorporated into vegetarian diets. However, the level of livestock production varies substantially among India's 29 states. Mixed crop-livestock production still constitutes an important part of animal production, though commercialization of livestock production, especially poultry, has advanced significantly due to private sector initiatives.

Industrialization has been less pronounced in the pig and beef cattle sectors, and there do not appear to be integrators in those sectors. For poultry production, several private agribusinesses serve as vertical integrators, contracting poultry farmers who raise tens of thousands of birds per cycle. Farms that raise about a thousand birds at a time may also participate in contract farming arrangements. Other farms either operate independently or participate in less formalized vertical coordination mechanisms with intermediaries for the purpose of obtaining inputs or selling outputs. Density of poultry production is particularly pronounced in certain areas of the country.

There have been a couple of references to smaller production units getting absorbed into larger companies or supply chains, but the degree of concentration or consolidation in the poultry industry or other livestock sectors is not clear. One key concern among researchers and organizations is whether participating in contract farming is beneficial for smallholder producers. Some broiler producers, for example, perceive that contract farming arrangements are inequitable, and may participate only temporarily in vertical integration arrangements in order to achieve a certain scale of operation and acquire more experience before trying to shift back to being independent. At the same time, there are indications that government policies (such as subsidies)



favoring large-scale producers may be in effect, and these policies may be “distorting” the market to the detriment of smaller-scale producers.

Productivity and efficiency remain key concerns for the government and livestock farmers, along with the challenges of feed shortage and animal disease. Also noteworthy is the focus on nutrition-related concerns; increased livestock production efficiency has been seen as a means to address stunting and other impairments related to micronutrient deficiencies. Livestock productivity, as measured by indices such as meat yields, is limited by the shortage of feed and fodder. Crop residues (the parts of the plant that are left over from what is typically used by humans, like bran, broken rice, rice husks, etc.) are a major component of feed, but have limited nutritional value. In addition, the use and abuse of veterinary drugs—which are of unchecked quality—have emerged as key concerns. In the poultry sector in particular, various sources documented that antibiotics were being used prophylactically, incorporated into animal feed, and leaving residues in meat. However, research on the public health impacts of these and other industrialization trends has been limited. In fact, the popular view is that small-scale producers—as opposed to industrial-scale producers—are responsible for disease outbreaks and other bio-security hazards. There has also been limited attention to environmental impacts from industrialized food animal production, with only a few sources briefly expressing concerns over contamination from animal waste and decomposing carcasses.

Kenya

In Kenya, economic liberalization in the mid-1990s was accompanied by restructuring of the Ministry of Agriculture, Livestock Marketing and Development, which put greater emphasis on facilitating the private sector, providing extension services to farmers, and making food animal production more efficient. For example, rangeland research was geared toward increasing productivity and beef output. In poultry production, the Ministry has implemented an extensive poultry program over several decades, which has sought to improve the productivity of indigenous chickens and has encouraged smallholder farmers to raise poultry as a business. Extension services have been offered not only by the government and private producers, but also by NGOs and community organizations.

There are signs of industrialized livestock production of broilers and pigs, as there are large private agribusinesses serving as vertical integrators, large-scale farms that raise animals in confined conditions, and some degree of industry concentration in those sectors. As efforts to scale up and expand the livestock sector continue, domestic meat consumption, especially pork and poultry, is expected to rise dramatically over the next decade and a half. Many animals, however, are still raised in systems characterized by minimal inputs and low outputs. For example, the government has banned free-range pig keeping since the 1970s, but there are still small-scale farms engaging in this practice in slums and other resource-poor areas.

In the beef sector, there are small-scale farms with mixed dairy-beef production, large-scale pastoral or commercial ranches, and intensive feedlot systems. However, feedlots



are extremely limited in scope because their need for a large supply of grain-based feed competes with the supply of grain available for direct human consumption. In pastoral ranching, inputs are low and animals graze on natural pastures, while in commercial ranching, either natural or cultivated pastures are used as the main feed component.

Most information sources addressing the topic of livestock health tended to focus on vector-borne or contagious diseases, rather than animal health issues linked to stress and illness caused by practices common in industrialized animal agriculture (e.g., dense confinement, abrupt weaning, long journeys to feedlots). However, there was some indication that veterinary drugs were not being used properly in cattle production, leading to the development of drug-resistant parasites. The proper disposal of animal waste has been recognized as a challenge, and some suggest that existing regulations on livestock manure may be insufficient in this regard. There was no information about occupational health impacts of industrialized food animal production in Kenya, and information on the public health and environmental impacts of this type of production was very general.

Mexico

The Mexican government has promoted industrialization of livestock production through various policies, including direct and indirect subsidies, provision of credit, technical assistance, and other programs promoting large-scale production and slaughtering facilities. One defining characteristic of Mexico's livestock sector has been the country's trade relationship with the United States. Competition from cheaper imports from the United States has significantly shaped trends in meat production, especially following the North American Free Trade Agreement (NAFTA). Among the impacts of NAFTA cited by researchers, livestock production increased in scale, level of production, and extent of vertical integration, as smaller producers who could not remain competitive exited the sector. Along with this development, multinational agribusinesses inserted themselves into Mexico's agricultural sector and became major industry players there either by purchasing Mexican companies or by engaging in joint ventures with them.

Although vertical integration and other characteristics of industrialized animal agriculture are present in Mexico, the extent of industrialization varies depending on the type of livestock. For swine production, concentrated animal feeding operations have expanded over the past four decades into various states. While there are still many small- and medium-sized producers, who account for the majority of the pigs produced in the country, it is predicted that hog producers will continue to merge over the medium- and long-term to increase scale and productivity. As for poultry production, vertical integration and contract farming are defining features of the sector. Facilitating factors leading to these developments include Mexico's proximity to the United States, as well as Mexican government policies favoring major poultry companies, many of which are multinational. For beef production, there are both small-scale, pasture-based cattle ranches and concentrated feedlot production of cattle. An increasing number of cattle are



being produced under semi-intensive or intensive feeding systems, where the animals spend at least some of their lives in feedlots.

Several sources referred to the use of veterinary drugs and growth promoters in IFAP in Mexico, sometimes resulting in unapproved or unacceptable levels of substances discovered in meat carcasses and products. One perspective is that the contamination problem is greater among small municipal slaughterhouses, street food vendors, and “mom and pop” restaurants, since major supermarkets source their meat from large, private slaughterhouses that are regularly inspected by federal authorities. However, we are not aware of an empirical study that has been carried out to prove or disprove this hypothesis.

There was limited information on the impacts of animal waste and other environmental consequences of industrial food animal production. Disposal of swine wastewater was described briefly in a few sources as a challenge, due to issues like inadequate waste treatment, proximity to community drinking water sources, contamination of aquifers by fecal bacteria, foul odors/decreased air quality, and deficient federal, regional, and municipal regulations. There was no research on occupational health impacts at industrial food animal production facilities. For public health impacts, one study documented a particularly high concentration of antibiotic-resistant pathogens near an urban-based industrial dairy operation in northern Mexico.

Myanmar

Myanmar, located in Southeast Asia, is a country with relatively recent but substantial growth in its livestock sector, beginning with its 1988 transition to a market economy and the government's promotion of the sector. As is characteristic of the region, factors like urbanization, increased purchasing power, changing food habits, and liberalization are driving a livestock "revolution." At the same time, smallholder farming remains the predominant form of animal agriculture. Small farming systems with integrated livestock-crop production for subsistence are the dominant profile of rural households.

Information about Myanmar's adoption of industrial methods for producing food animals is limited. There is intensive, integrated poultry production, which relies on farms producing on the order of a thousand birds, but this type of production accounts for only a few percentage points of the country's total production. It is also not clear whether "integration" has reached the full extent of vertical integration found in industrialized countries, where slaughtering, processing, and marketing also occur within company-owned infrastructure. For swine farms, there are only a few large farms that raise 500 or more pigs, and these may be privately or publicly owned.

It appears that livestock production is not very concentrated, given that small-scale farms are dominant and medium-scale farms are considered competitive. It is unclear whether slaughtering and processing capacity is concentrated, however. In reference to livestock development in the Southeast Asian region, one study commented, but did not provide or cite supporting data, that vertical integration and increasing scale were detrimental to smallholders who could not compete with highly advanced technology and large-scale production.

The use of exotic breeds and artificial insemination techniques has been cited as a factor contributing to increasing livestock production. The country is thus far self-sufficient in terms of livestock feed, which is manufactured by large companies, and only feed supplements and additives are imported. Antimicrobials are also imported from abroad and



used without adequate veterinary supervision for treating disease, preventing disease, and promoting growth. There have been several studies by veterinary researchers based in Myanmar documenting relatively frequent detection of antibiotic-resistant pathogens in poultry, swine, and cattle. It is not clear, however, at what production scale (industrial or non-industrial) abuse of antimicrobials is more likely to occur. Although the government is trying to increase monitoring of food safety issues, which include the use of banned drugs and chemicals, there is no legal framework or institution that regulates and enforces control over the use of antimicrobials in food animal production. We found no research on environmental, occupational, and other public health impacts of industrial food animal production in Myanmar, and information on livestock housing/confinement and other conditions related to animal welfare was very limited.

Turkey

In Turkey, there has been a shift from extensive farming to more intensive, capital dependent types of farming. The government's Five-Year Plans in the 1960s and 1970s stressed "modernization" and capitalization, and continued market deregulation and liberalization occurred in the 1980s and thereafter. Poultry, red meat, and dairy output have increased. With government support, the poultry sector has developed the most in terms of number of live animals and integration of the production chain, and exhibits the highest degree of industry concentration. In that sector, large-scale integrated broiler companies use contract farming and advanced technology to produce enough meat for domestic consumption and significant exports to neighboring countries.

In the cattle sector, animal numbers peaked in the 1980s, and production gains are attributed to the use of "improved" breeds. Over the past several years, the government has actively promoted dairy production and feedlot expansion, offering financial support for the establishment of larger-scale cattle farms in the East and Southeast Anatolia regions.

Some consider agricultural industrialization in Turkey to be at a very early stage, with significant presence of small farms of less than five hectares. As the country's demand for meat surpasses its supply, advocates for expanding livestock production in Turkey face many challenges, including animal disease, domestic policies, insufficient government investment, and rural-to-urban migration. One particular difficulty is an insufficient supply of animal feed (including raw feed materials), resulting in high feed prices that comprise a significant percentage of the total production cost. The government has criticized the feed sector for being fragmented—filled with small and inefficient players—and has devoted a substantial proportion of the agricultur-



al budget to fodder crop cultivation. According to official sources, though the country is relatively well positioned in terms of freshwater resources and arable land, natural resource management (for example, of pastures) has room for improvement.

Our landscape assessment did not find any research on the administration of antimicrobials, growth hormones, or other chemical substances to livestock animals, though animal disease was cited as a challenge. Evidence regarding the impacts of industrial food animal production in Turkey is limited, but several sources raised concerns about animal welfare conditions and environmental pollution from animal waste and odors. However, these concerns were not necessarily related to large-scale or intensive livestock production.

Organic livestock production appears to be emerging in Turkey, as well. Although there appear to be some standards and regulations in place, the extent to which there is a functioning certification program and the level of public confidence in "organic" products is not clear. Some studies conducted during the past several years indicate that there is now a modest amount of public awareness of issues like genetically modified organisms, use of antibiotics and other chemical inputs, and farm animal welfare.

Uganda

The livestock sector, especially pig production, is growing in Uganda. The government has supported the development of commercial livestock production by implementing animal health standards, providing better advisory services, supporting research, and improving disease control, nutrition, genetics, and marketing. However, current livestock production is still only able to meet half of the country's demand for animal protein. The scale of livestock production varies based on geography, with more extensive systems of subsistence-based production present in the arid and semi-arid regions, and more intensive, though still generally small-scale, market-oriented production found in urban and peri-urban settings.

In the beef sector, large-scale commercial ranches raise as many as 7,000 heads each but account for only 2% of the total (beef) cattle production in Uganda. The majority of cattle in Uganda are grazed on pastures, many of which are communally owned. While the Ugandan government has implemented a strategy to improve animal health, nutrition, and farmer training, which has led to expanded cattle production, productivity gains are lower than necessary to meet growing demand. In the poultry sector, there are a few large-scale broiler companies. Intensive production occurs on farms raising flocks of over one thousand birds, and some of these are contract farms. For pig production, although there are few farms that raise more than 500 pigs at a time, intensive production is on the rise because of land scarcity and growing awareness of commercial pig farming opportunities.

Other than a few references to contract farming in the poultry sector, there was little information about the extent of vertical integration or industry consolidation in the livestock industry. Meat processing is essentially monopolized by one company, Quality/Fresh Cuts, which covers 85% of Kampala's processed meat market and produces a range of packaged meat products (beef, pork, and poultry).



Like many of the other countries surveyed in this landscape assessment, challenges faced by the livestock industry include poor breeds, inadequate feed, animal disease, insufficient veterinary services and quality drugs, expensive inputs, and lack of market access. More specific to Uganda, other factors that may have hampered livestock development are the conflict between the Lord's Resistance Army and the Ugandan army, forced displacement, and cattle raiding.

There are several problems with the feed supply in particular, including feeds containing fewer nutrients than required, feeds being deliberately mixed with materials to increase weight, feeds that have been moistened, and feeds that contain toxins harmful to humans (as well as animals). Commercial feed is used by intensive poultry and swine operations, but obtaining feed is a challenge due to the contamination problems cited above, as well as cost. In general, the Ugandan feed industry is considered underdeveloped.

There are also problems related to the use of veterinary drugs, which are readily sold without a prescription, inappropriately stored and handled, and administered by farmers themselves. A few studies have documented the presence of antibiotic-resistant—including multidrug-resistant—pathogens isolated from the feces of livestock. However, we found no other studies on the impacts of industrial livestock production in Uganda, in terms of occupational or environmental health.

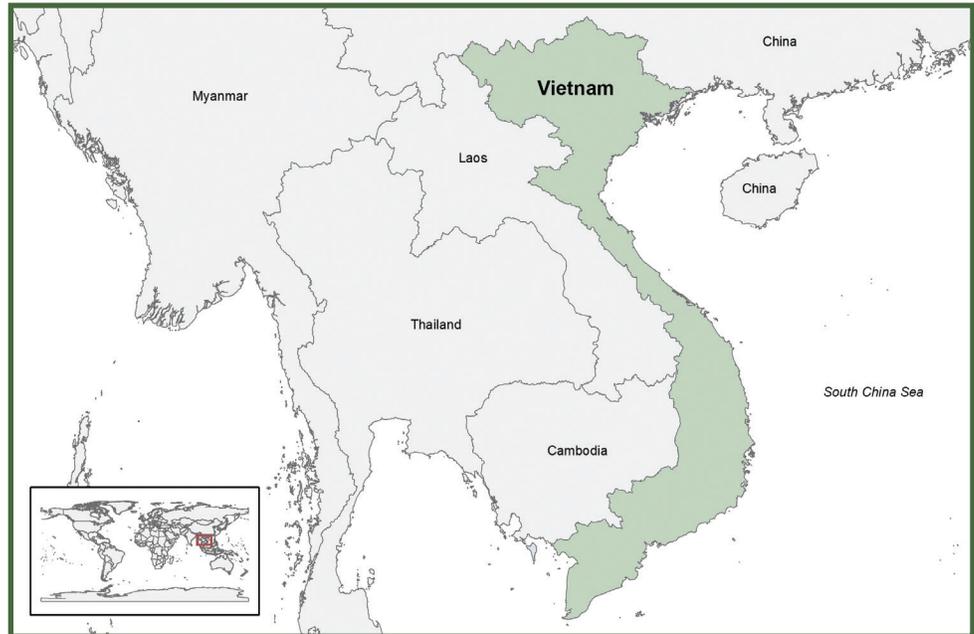
Vietnam

Animal production in Vietnam has grown substantially in recent years, particularly in the poultry and pig sectors, propelled by government strategies to restructure, industrialize, and intensify production. Urbanization, increasing consumer purchasing power, changing food habits and preferences, and trade liberalization continue to drive this transformation. Promulgated in 2008, the government's National Strategy for Livestock Development aims for large-scale and intensive operations to account for 70% of meat production by 2020, with scale increases made possible through favorable land, credit, tariff, and other policies.

Although there are still many small livestock farms, the presence of large-scale commercial enterprises, multinational agribusinesses, and integrators has already been documented in Vietnam. Intensive large-scale industrial chicken production is modeled after the industrial systems of high-income countries, and production is concentrated in urban areas and the Red River and Mekong River deltas. The largest operations are often joint ventures or wholly foreign-owned enterprises, and multinational companies contract large domestic farms raising 2,000 to 100,000 birds.

Pig production in Vietnam has expanded over the past several decades. The government aims for industrial-type operations to account for 37% of production by 2020, and for Vietnam to become an exporter of pork. Intensification varies by region, though in general there has been an expansion in scale of production and concentration of production into fewer and larger farms. Concentration has been promoted at the national level and within certain provinces. Pig contract farming has also developed since 2000.

Within the framework of the 2020 livestock development strategy, vertical integration and the participation of large-scale traders are promoted through favorable land, credit, tariff and other policies. However, monitoring the precise extent of vertical integration in the livestock in-



dustry is difficult due to a lack of updated statistics. There are also other types of vertical coordination and looser forms of integration. The prevalence of contract farming in the swine and poultry sectors has motivated studies on its efficiency, effectiveness, and impact on small farmers.

Feed prices are higher in Vietnam compared to surrounding countries because domestic feed producers and the market for feed are not well organized. There is a dependence on imports, and trade policies are not effective or transparent. Although the cultivation of crops used for livestock feed has increased as part of the government's strategy, the country still relies heavily on feed crop imports, and balancing soil conservation with the goal of feed self-sufficiency has been a challenge. Against this backdrop, foreign feed companies have stepped in and acquired a dominant role in domestic feed production. Concentration has been noted in the animal feed sector.

Another challenge is the lack of regulations, or under-enforcement of regulations, related to food animal production. Livestock disease monitoring systems are very weak in Vietnam, and antibiotic use without veterinary supervision is common. Some studies have characterized antibiotic use in greater detail and studied antibiotic resistance in isolates from chicken and pig farms. Even industrial-scale operations may lack waste treatment facilities and have little awareness of laws regarding waste management. A few sources warned about the potential consequences of intensified animal production on surrounding communities, including social and public health impacts, as well as environmental impacts. Few of these sources, however, involved empirical research.

Discussion

The results of our landscape assessment reveal important trends, themes, and gaps in information relevant to animal agriculture in the ten LMICs. There is significant growth in animal production, and IFAP specifically, when the ten countries are taken together, especially for poultry and hogs. Production trends vary greatly by species and geography, as well as by the degree to which certain sectors in each country are industrialized and/or concentrated. In many of the countries researched, IFAP is growing, although it is not yet the dominant form of animal production. The IFAP model appears to be most established in Brazil and China.

Domestic Policies Driving Growth in Animal Agriculture

In general, we found that national governmental policies favor significant growth and industrialization of animal agriculture and reflect the view that industrialization of animal agriculture is an opportunity for economic growth in response to the rapidly growing demand for animal products. These countries aim to be responsive to demand for animal products both domestically and in other countries as incomes of some segments of these populations rise. Further, development of the livestock sector has been declared to be an important component of the overall development strategies of several countries. Supportive government policies take different forms, including loans or other avenues of credit, direct or indirect subsidies, technical assistance, government-owned infrastructure (such as slaughterhouses), market deregulation, favorable land access and tariffs, and other trade policies.

The resources we identified in our assessment also point to a lack of regulatory policies addressing animal agriculture or facilitating the monitoring or mitigation of environmental and public health impacts. There are numerous ways IFAP can harm the environment and threaten the health of workers and residents of nearby communities. In contrast to the number of resources we found describing national policies favorable to expanding industrial animal agriculture, descriptions of well-established regulatory systems for animal agriculture in the ten countries were rare. In some countries, we identified concerns reported by researchers, NGOs, or other stakeholders over inadequate regulation of IFAP, production inputs and practices, impacts on the environment and

public health, food safety, and other issues. These results are especially important in certain animal sectors, which are increasing in scale, density, and degree of industrialization without the necessary systems to handle large quantities of manure and livestock mortalities. It is also critical to consider that regulations are necessary but not sufficient for mitigating the consequences of IFAP, since monitoring and enforcement require significant resources. Thus, countries experiencing significant growth in animal agriculture may need both strong regulations and enhanced resources to enforce them. Given that public health and ecosystem risks stemming from IFAP have been documented in high-income countries (1), adoption of the IFAP model in more resource-constrained LMICs may pose additional challenges that must be anticipated and evaluated.

Veterinary Inputs and Disease Control

We identified the oversight of veterinary drugs in agriculture as an important policy deficiency. In the majority of our study countries, it was reported that veterinary drugs, including antimicrobials, could be purchased without a veterinarian's prescription and were often misused. In the case of antimicrobials, these production practices can lead to the dissemination of antibiotic-resistant pathogens through the production environment, which may reach workers, surrounding communities, and ultimately the general public through the management of animal waste and processing and consumption of animal products, posing environmental health and food safety concerns. Other veterinary drugs can also cause food safety and environmental contamination problems. In recent years, attempts have been made in some high-income countries to address the misuse of antibiotics in IFAP, with varying success. These changes have been driven by research showing the environmental and public health risks and expressions of consumer concern. More information is needed regarding perspectives on agricultural antibiotic use in LMIC and whether the antibiotic use practices in high-income countries will influence practices in LMICs. In light of the oft-reported lack of animal health expertise and low availability of veterinary services in some LMICs, many sources reported a need to strengthen extension programs to provide more of these services.

Some stakeholders in LMICs who are supportive of IFAP present the industrial production model as a method to address animal disease and food safety, arguing that IFAP operations use biosecurity measures and produce a higher quality, uniform product. We found evidence in some countries of concern among consumers about the quality and safety of animal products; this reasoning may resonate in LMICs. These arguments do not address the conditions that may *increase* disease and food safety concerns, including hundreds or thousands of animals in crowded housing, routine use of antimicrobials and other veterinary drugs, production of large amounts of manure, and large numbers of livestock mortalities requiring proper disposal.

Animal Welfare

There was little information available regarding the living conditions of animals in the study countries. The majority of available information described the conditions of animals that are *not* produced intensively or in large-scale systems (e.g., indigenous chickens produced at the village level). A small number of resources discussed housing or animal welfare laws in industrial production, but only provided general information indicating that: i) when confined animal housing conditions in LMICs are similar to IFAP operations in high-income countries, and ii) current animal welfare laws are seen as inadequate by some stakeholders.

Consumer demand and voluntary actions by companies have resulted in some progress in high-income countries away from the most abusive production practices (e.g., cages for egg-laying hens and crates for gestating sows), but it is unclear whether incremental or even more meaningful advances will be adopted amidst rapidly growing food animal production in LMICs. Every year there are millions more animals produced in LMICs, with important implications for animal welfare. In the ten study countries alone, the number of animals produced each year increased by more than 200 million (138,779,000 chickens, 53,716,468 pigs, and 7,814,260 cows) between 2008 and 2013.

International Trade and Access to Inputs

In addition to domestic policies, trade and involvement of multinational corporations and foreign governments were also identified as drivers of growth and intensification of IFAP. We found evidence showing that LMIC govern-

ments and companies are working to increase exports to meet demand for animal products abroad, as well as imports of feed ingredients, veterinary products, and other inputs for a growing domestic animal agriculture sector. For example, corporations that produce animal feed identify areas with significant growth potential and collaborate with stakeholders in the country to foster industry expansion and use of their feed products. Trade agreements and geography also play a role in intensification; Mexico's move toward industrialization is largely driven by its proximity to the US and passage of the North American Free Trade Agreement (NAFTA). The fate and impact of pending trade agreements, including the Trans-Pacific Partnership (TPP) and Transatlantic Trade and Investment Partnership (TTIP), are unclear, but they could promote the expansion of IFAP in some areas by loosening trade barriers for inputs and/or animal products.

Limited access to high-quality feeds, veterinary supplies and services, and productive breeds were factors cited as barriers to expanding animal sectors in many of the countries, further highlighting the importance of trade for the growth of animal agriculture (and IFAP, specifically). We found resources stating that there was direct competition in some countries, including Ethiopia, Kenya, and Uganda, for nutrient-dense, plant-based food for human and animal use; this indicates that raw feed materials or high-quality animal feed may need to be imported from a country with lower rates of food insecurity in order to protect domestic food production and security. China has addressed this limitation by becoming the top global importer of soymeal; it is largely used for livestock and fish feed and comes mostly from the United States, Brazil, and Argentina (36). Alternatively, Brazil is able to produce (and export) feed ingredients, which has allowed the country's domestic livestock sector to grow. If companies and countries that export IFAP inputs increase exports to LMICs, allowing IFAP to expand, there will be a corresponding increase in demand for resources used to produce animal feed (land, freshwater, fertilizers, etc.). It is more efficient to feed people plant-based foods directly due to the efficiency losses inherent to animal agriculture, especially industrial forms that rely on inputs of high-quality feed instead of low-input production methods (e.g., grazing). Globally, about 36% of calories from crop production are used in animal feed (5), and 12% of those calories ultimately enter the human food supply as meat, dairy, or eggs (2).

Leading researchers in the fields of global agriculture systems and sustainability have expressed concern over the increasing consumption of animal products; this is largely due to the potential land clearing for growing more feed crops, a rise in GHG emissions, and higher demand for limited resources, including land, freshwater, and fertilizer from mined phosphate (5, 7, 37, 38). On the other hand, populations experiencing malnutrition, stunting, and food insecurity benefit from a moderate increase in consumption of nutrient-dense foods, including animal products. Also, keeping livestock can benefit farmers in LMICs through increased food security and diversification of income. Stakeholders working on expanding access to these foods for populations most in need should strongly consider operation scale and pursuit of non-industrialized production models. It is advised that LMIC governments and other stakeholders partner with experts in disciplines such as nutrition, ecology, sustainable agriculture, and public health to develop modes of agricultural production that meet nutrition goals while protecting natural resources and preserving health and animal welfare.

It is also crucial to recognize that high-income countries have the most elevated intakes of animal products, which have been linked to various chronic health conditions and a sizeable environmental footprint. According to FAO food availability statistics, the United States consumes up to three times the global average of animal products (39). Ideally, if consumption were reduced in high-income countries, it could help offset the impact of increasing demand for feed inputs in LMICs. Shifting to more plant-based foods in high-income countries, and/or slowing the growth of animal production in LMICs, is difficult due to cultural, political, and economic factors, though there is some evidence of growing interest in plant-based foods in the United States and other countries (40-42).

One question stakeholders should try to answer is this: How can LMICs develop their animal agriculture sectors in a manner that protects the environment, public health, and animal welfare while lifting farmers out of poverty and contributing to a safe, secure food supply? As described above, there is evidence that LMIC governments and multinational/domestic corporations are working to implement the IFAP model globally, but have not paid enough attention to the documented problems occurring in countries with established IFAP.

Information Gaps and Limitations

This is the first international landscape assessment of IFAP in LMICs to focus on trends in food animal production, related domestic and international policies, environmental and public health impacts, and animal welfare. It outlines future directions for research and interventions (described below). The number of resources we found varied by topic and country, likely due to actual differences in research and media coverage as well as the limitations of our methods. Search methodologies for any landscape assessment may result in resources being missed for various reasons, and this is even more likely in our case due to the international scope and inclusion of several topic areas related to IFAP. Our search methodology could have missed relevant resources that were not indexed in the chosen databases/search engines, did not contain our search terms, or were not written in English, Spanish, or Portuguese. To address this, we used several databases/search engines utilizing a series of relevant search terms.

We observed a significant disparity in number of resources by country. We found the most resources relevant to IFAP in China and Vietnam, and the least for Myanmar. Regarding topics, we identified a limited number of resources on environmental and public health impacts, animal welfare, and public engagement on the issue of IFAP. More information was found on domestic policies and availability of inputs. These results most likely reflect a lack of resources available to study these topics.

Recommendations for future research and intervention

Based on our landscape assessment, particularly the areas of concern and the information gaps we found related to IFAP in developing countries, we recommend several avenues for future research and intervention. The list of recommendations, presented in no particular order, is geared toward researchers and funders not necessarily based in LMICs; partnerships with local organizations and researchers, however, is central to many of the proposed strategies.

Following the recommendations is a table with classifications and ratings for each recommendation based on feasibility, cost, and potential impact, rated as low, medium, or high. The *feasibility* rating gauges the complexity involved in pursuing the recommendation, including factors such as time required, ease of access to the necessary sources of information, partnerships needed with local organizations, expertise required, and logistical complexity that the recommendation may entail. The cost rating reflects an estimated measure of resources, including laboratory costs, personnel costs, travel costs, and other expenses. The measure of potential *impact* is our best approximation of how likely the recommended action will lead to meaningful change in the foreseeable future. These ratings should not be interpreted as precise measures, but we nonetheless hope they can provide guidance for decisions regarding how to prioritize resources and actions.

1) Analyze government policies promoting the industrialization of food animal production and identify policy levers to mitigate the impacts of IFAP.

As our landscape assessment revealed, government support for IFAP can take multiple forms, including legislation, economic policies (taxes, subsidies, and procurement arrangements), zoning policies, trade agreements, guiding documents, development strategies/plans, and other regulatory frameworks. On a country-by-country basis, compilation of this information will be helpful for determining the influence of governmental action on IFAP, the projected growth, pace, and profile of IFAP in that country, and potential avenues for influencing policymakers to mitigate the impacts of IFAP.

2) Conduct a private sector assessment to identify major multinational meat-producing companies, their countries of origin, locations of activity, and country-specific production practices.

As our landscape assessment has shown, private actors have and are playing an important role in bringing IFAP to developing countries. Their actions, however, are not well documented or understood. It will be important to identify the major multinational companies engaging in IFAP and understand how they may be translating their practices across different settings. For example, if a corporation alters its practice in one country (e.g., reducing the use of antibiotics), will it also adapt that practice in other countries? Such information will help inform whether these actors apply new practices selectively, or whether advocacy efforts in one country can lead to improvements in other countries.

3) Assess major national and international flows of feed and raw materials used in feed.

As shown in the preceding discussion, feed can be a major constraint or facilitator of IFAP. Moreover, trends in feed production and use are also related to food security because they entail a diversion of resources away from products that can be used for direct human consumption. Tracking major flows of feed and feed raw materials across borders can help identify countries that are ramping up food animal production (and thus importing large amounts of feed), as well as countries that may be producing and exporting feed and related raw materials to the detriment of their own food security.

4) Conduct a focused analysis of the regulation of animal welfare related to IFAP in LMICs.

Building on preliminary studies of animal welfare regulations in a few of the selected countries, we recommend a more comprehensive and in-depth comparative analysis of the normative frameworks in place to protect the welfare of food animals in developing countries. The analysis should consider the entire lifespan of the animal, from conditions while raised on-farm to transport and pre-slaughter management.

5) *Conduct studies of consumer perceptions and preferences regarding animal production and consumption of animal protein.*

As seen in developed countries, public pressure is often used to change IFAP practices for the better. Building on preliminary studies of consumer opinions about meat consumption and livestock production practices, further research to understand public perception within developing countries is recommended. Understanding the issues that matter most to the public (e.g., drug resistance, food safety, organic farming, environmental damage, etc.) would allow public health practitioners, researchers, and others to design interventions and studies that highlight the relationships between those issues and IFAP. Such interventions and studies would be more likely to have an impact, given their relevance to public opinion. Further, understanding consumers' willingness to spend more money for sustainably produced animal products may help motivate companies to improve their practices. On the other hand, if consumers do not seem willing to spend more money, then we will have identified a priority topic for raising public awareness.

6) *Conduct a planetary boundaries assessment for IFAP expansion in LMICs.*

Contextualize the increasing rate of IFAP production within the framework of Planetary Boundaries, specifically considering the domains (biosphere integrity, climate change, novel entities, stratospheric ozone depletion, atmospheric aerosol loading, ocean acidification, biochemical flows, freshwater use, land-system) will be impacted by the resource demands of this style of production.

7) *Identify case examples of existing sustainable modes of food animal production in LMICs and develop culturally appropriate educational materials to engage other farmers.*

Pointing to the problems caused by IFAP will be of limited use unless viable alternatives are also identified. Given that the demand for animal protein appears to be rising in many developing countries, there is pressure to meet that demand. Learning about case studies of alternative systems and better practices from within a country can be helpful for other regions of the country and even other countries. In identifying alternatives that work and do not work, it will be important to gather information about multiple dimensions. In other words, instead of consider-

ing only the ability of alternative production systems to compete economically with traditional industrial models and match the latter's output, environmental sustainability, animal welfare, nutrition, and other public health outcomes should also be considered.

8) *Implement education campaigns for LMIC governments regarding public health and environmental concerns related to IFAP.*

The landscape assessment did not yield much information about the current levels of knowledge of policymakers in developing countries about industrial food animal production, even though it appears that many of them support industrialization. Thus, efforts to assess their knowledge gaps and campaigns to sensitize policymakers about the environmental and public health impacts of IFAP could be a promising way to influence how livestock sectors are being developed.

9) *Convene nutrition and domestic agriculture experts to identify culturally and regionally feasible and appropriate plant-centric diets that provide adequate nutrition to local populations.*

The scaling up of food animal production in a developing country may be part of an effort to improve the population's nutrition outcomes through increased consumption of more animal protein. This is often part of the justification for intensifying and expanding food animal production. However, the scientific basis of this justification is not always clear. As various sources observed, increasing food animal production could actually be detrimental for food security if it means diverting crops that could be consumed directly by humans to manufacture animal feed instead, or if industrialized food animal production relies on environmentally unsustainable practices that compromise the ability to use land and water resources in the future. Therefore, we recommend research into plant-centric diets that are culturally and environmentally appropriate (for local conditions) and can meet the nutritional needs of the population. It is crucial that this research draws on the participation of local communities and organizations.

10) Identify harm reduction strategies to mitigate impacts of IFAP in LMICs.

Recognizing that IFAP is dominant in some areas and intensifying in others, and that some amount of further industrialization may be inevitable, we recommend research on harm reduction approaches to mitigate the impacts of these processes. Various domains can be considered, including animal welfare, environment (GHG emissions, deforestation, soil health, water quality), public health, occupational health, socioeconomic conditions

of contract farmers, etc. Measures to be considered include zoning, setbacks, improved waste management, elimination of antibiotics for growth promotion and disease prevention, and better animal housing conditions.

Table 14: Analysis of recommendations

Recommendation	Type	Feasibility	Cost	Impact
Analyze government policies promoting the industrialization of food animal production and identify policy levers to mitigate the impacts of IFAP	Assessment and analysis	Medium	Medium	Medium to high
Conduct a private sector assessment, which identifies major multinational meat-producing companies, their countries of origin, locations of activity, and country-specific production practices	Assessment and analysis	Medium to high	Low to medium	High
Assess major national and international flows of feed or feed raw materials	Assessment and analysis	High	Low	Medium
Conduct a focused analysis of the regulation of animal welfare related to IFAP in LMICs	Assessment and analysis	High	Low to medium	Medium
Conduct studies of consumer perceptions and preferences regarding animal production and consumption of animal protein	Assessment and analysis	Medium to high	High	High
Conduct a planetary boundaries assessment for IFAP expansion in LMICs	Assessment and analysis	Medium	Medium to high	Medium
Identify case examples of existing sustainable modes of food animal production in LMICs and develop culturally-appropriate educational materials to engage other farmers	Information dissemination and engagement	Medium	High	High
Implement education campaigns for LMIC governments regarding public health and environmental concerns related to IFAP	Information dissemination and engagement	Low to high	High	Low to high
Convene nutrition and domestic agriculture experts to identify culturally-appropriate and regionally-feasible plant-based diets capable of providing adequate nutrition to the local population	Development and/or delivery of interventions	High	High	Medium to high
Identify harm reduction strategies to mitigate impacts of IFAP in LMICs	Development and/or delivery of interventions	High	Medium to high	Low to medium

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Appendix A: Search terms employed in literature identification and selection

I. Journal article databases

Terms used in all databases (PubMed, Scopus, AGRICOLA)	Terms used only in PubMed and Scopus	Terms used only in AGRICOLA
<ul style="list-style-type: none"> ▪ Production ▪ Meat ▪ Animal(s) ▪ Poultry ▪ Broiler(s) ▪ Chicken(s) ▪ Beef ▪ Cattle ▪ Pork ▪ Hog(s) ▪ Pig(s) ▪ Industry/industries ▪ Industrial ▪ <i>Country names, with “Burma” also used for Myanmar</i> ▪ Low income country/countries ▪ Developing country/countries ▪ Emerging country/countries ▪ Global South ▪ Factory farming 	<ul style="list-style-type: none"> ▪ Food ▪ Agribusiness(es) ▪ Agriculture ▪ Factory farm(s) ▪ CAFO(s) ▪ Confined animal feeding operation(s) ▪ Concentrated animal feeding operation(s) ▪ Third world 	<ul style="list-style-type: none"> ▪ Confined/confinement/confine ▪ Constrained ▪ Intensification/intensify/intensive

II. Google Scholar

- Industrial
- Animal production
- Meat production
- Pig production
- Hog production
- Broiler production
- Chicken production
- Poultry production
- Beef production
- Cattle production
- *Country names, with “Burma” also used for Myanmar*

III. General Google search

- Animal
- Agriculture
- Food
- Industrialization
- Intensification
- Industrialized
- Livestock
- Production
- Chicken
- Poultry
- Beef
- Cattle
- Pig
- Pork
- Swine
- Factory farming
- Meat
- Growth
- Expand/expansion
- *Country names, with “Burma” also used for Myanmar*

Appendix B: Full country profiles

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Brazil



Overview

For the past three decades, Brazilian agriculture has experienced a transition to an increasingly globally connected and industrialized food system. This is particularly true for the pork and poultry sectors, which have become more commercialized, modernized, capital intensive, large-scale, vertically integrated, and concentrated. Brazilian agrifood companies have also extended their reach internationally, acquiring natural resources abroad, such as land, as well as major stakes in foreign companies.

Food and Agriculture Organization of the United Nations (FAO) statistics on food animal production

Brazil had a total of 263,925,309 animal units (AUs) in 2013, resulting in an overall livestock density of 0.95 AU per hectare (ha) of agricultural area. The numbers of live animals raised in 2013 were 36,743,592 pigs, 1,248,786,000 chickens, and 211,764,292 cattle. FAO 2011 estimates of livestock densities, by specific animal class, were 0.14 pigs per ha, 4.71 poultry birds per ha, and 0.78 cattle and buffalo per ha.

In 2012, production was 3,330,000 tonnes of pork, 11,534,972 tonnes of chicken, 9,307,000 tonnes of cattle meat, and 32,304,421 tonnes of cow's milk. From 2002 to 2012, pork, chicken, cattle meat, and cow's milk production increased by 19%, 64%, 30%, and 45%, respectively. The five-year period of 2007 to 2012 saw increases of 11%, 28%, 0.04%, and 24% for pork, chicken, cattle meat, and cow's milk, respectively.

Production, imports, exports, and net balance by livestock product

	Production (mt)			Imports (mt)	Exports (mt)	Net (mt)
	2002	2007	2012	2012	2012	2012
Pig meat	2,798,000	2,990,000	3,330,000	0	83,516	3,246,484
Chicken meat	7,050,000	8,988,035	11,534,972	2,136	3,560,370	7,976,738
Cattle meat	7,139,000	9,303,000	9,307,000	6,223	7,496	9,305,727
Milk, whole fresh cow	22,314,700	26,137,266	32,304,421	12,104	24	32,316,501

Industry characteristics

1) Scale

Pig and poultry farms in Brazil have increased in size, with smaller subsistence-oriented farms being replaced by larger, industrial-scale farms over the past three decades [1-3]. A joint International Food Policy Research Institute (IFPRI) and FAO project, which sampled farms in Brazil in 2002 to 2003, revealed the following typology of farms by size: small-scale swine farms had 100 sows (female pigs) or fewer, medium-scale swine farms had 101 to 1,000 sows, and large-scale swine farms had over 1,000 sows. For broilers, small farms had 10,000 birds or fewer, while large farms had flocks of over 10,000 [1].

Significant, sustained growth in meat production is expected at least through 2022, with the Brazilian Ministry of Agriculture projecting ten-year increases (2012-2022) in production of 21%, 46%, and 23% for pork, chicken, and beef, respectively [4].

As farms have become larger and more specialized, small- and medium-scale operations have exited the market [1]. Small-scale producers tend to have less education, experience in livestock production, fewer landholdings, limited access to markets, credit and capital, as well as higher input prices and lower output prices [1]. Although large and small broiler farms may make similar profits per animal, smallholders manage to achieve this by not “costing” family labor¹; larger farms tend to be more profit-efficient, reaping more profit for resources inputted [1].

1. Although the source did not define what it meant by “costing,” our interpretation is that not “costing” family labor means not assigning a value to the labor of family members when calculating the total cost of inputs, efficiency, and other indicators related to production. See Delgado CL, Narrod CA, Tiongco M, Barros GSC, Catelo MAO, Costales A, et al. Determinants and implications of the growing scale of livestock farms in four fast-growing developing countries. International Food and Policy Research Institute, 2008.

In fact, a study comparing Brazil, India, Thailand, and the Philippines found that Brazil is the country where independent smallholder producers are least likely to survive, as they can no longer compete with other producers who can reap economies of scale or source inputs from larger producers and thereby reduce transaction costs [1]. This latter group includes small farms that now participate as growers in a vertically integrated pork or poultry value chain (see sub-section on “vertical integration” below). The absorption of small farms into vertically integrated systems may be one of the reasons why pig production is concentrated in farms with fewer than 100 ha (according to 2006 agricultural census data) and described as a “family activity” [3].

In terms of cattle production, there are small, medium, and large ranches. Landholdings are becoming smaller and more fragmented due to increasing property values and intensification, and small-scale ranchers, after acquiring access to new technologies, tend to become more specialized or semi-intensive [5]. Smallholders are also allocating more of their land to pasture and cattle ranching, especially of a more intensive form [5]. Expansion of the scale of cattle ranching has been promoted by subsidies of agricultural and livestock inputs, as well as subsidized credit and other financial incentives [5]. A survey of one municipality in the Brazilian Amazon revealed that between 1996 and 2000, average herd size increased from 69 (76% non-dairy, 24% dairy) to 99 (78% non-dairy, 22% dairy) head, and the stocking rate from 1.59 to 2.49 heads of cattle per ha of cleared land [6]. Although there are many small-scale cattle ranchers in Brazil, they only own 18.6% of the productive cattle land, according to official 2006 statistics, and these farmers have limited access to infrastructure, machinery, and information [7].

2) *Industry consolidation or concentration*

As part of the industrialization of the livestock sector, production of pork and poultry has become more concentrated, while the processing industries have become more consolidated. There are still many farms, but a small percentage of farms accounts for most output and exports [8]. Broiler production in the Southern Region² of Brazil, where industrialization of the pork and poultry industries began three decades ago, is a salient example of this trend. Between 1974 and 1992, the number of broiler operations in the region classified under the largest size category (500,000 or more broilers sold) increased by 67%, while the total number of operations decreased by 24% [2]. As a percentage of national sales, the largest operations were responsible for 70% of total sales in 1974 and 97% by 1992 [2]. In the Southern state of Rio Grande do Sul, poultry production tripled between 1992 and 2008 despite the decrease in number of farms between 1996 and 2006, and two companies—Sadia and Perdigão—account for 50% of broiler manufacturing [9].

Pork production in Rio Grande do Sul has also experienced a similar trend, with production increasing dramatically between 1995 and 2008, with the number of farms decreasing over that period [9]. As the most important avenue for distribution and accessing the market is through large food processing companies, only pig farms that can access capital, scale up, and demonstrate ability to meet production levels imposed by meat processing companies can survive [9].

Meat processing is also reported to be increasingly concentrated. The three main slaughterhouses—Marfrig, JBS, and Minerva—took over an increasing share of the market, especially from 2005 onward, and during the 2008 financial crisis they grew by buying out several small- and medium-sized companies [7]. For example, as of 2009, in Rio Grande do Sul, the top five pork processing companies controlled 63% of the market, while the top five poultry processing companies controlled 85% of the market [9]. There is also increasing concentration of breeding companies, with only four suppliers of broiler genetics [10]. Other sources argue, however, that there is greater competition in the Brazilian poultry sector than in the respective sectors in Mexico and the United States [11].

2. In addition to being divided into 26 states and one federal district, Brazil is also divided officially into five regions: North, Northeast, Center-West, Southeast, and South.

3) *Vertical integration*

The Brazilian pork and poultry sectors are extremely vertically integrated [3, 12]. Vertically integrated poultry production was introduced in Brazil by the company, Sadia, in 1961 [11]. As of 2012, more than 90% of poultry raising occurred within vertically integrated systems [12]. Pork production, which is based in the Southern Region but is expanding to the Central-West Region, is also characterized by many large enterprises contracting smaller farmers and supplying them with feed and technical assistance [3]. In the Southern state of Rio Grande do Sul, for example, 80% of pig farmers were vertically linked to food processing companies as of 2009 [9].

There are some positive reviews of these systems, with researchers affiliated with Embrapa³ attributing modernization, increases in productivity, and improved meat quality to vertically integrated production [3]. The mechanism of contract farming has also supposedly allowed some smaller farms to make a “smoother transition” (i.e., survive the industrialization process), access better support than independent growers, and even make more profit per output compared to independent growers [1]. Other researchers argue that profit margins have actually decreased for integrated farmers, who have to pay for more expensive inputs and even take out loans to cover costs [9].

Beef production is characterized by much less integration and a lack of linkages between input suppliers, farmers, processors, and retailers [13]. Nevertheless, processing companies, particularly those that have a large share of the domestic and export market, are increasingly investing in their own feedlots as a way to regulate prices, quality, and supply for their plants [14].

4) *Inputs*

a) *Breeding stock*

Cattle genetics is an important topic in Brazil, where animals need sufficient heat tolerance to survive the climate [15]. The lineage of Zebu cattle from India is found in 80% of beef cattle [14]. To promote the use of genetic technologies and planned cross-breeding, the Brazilian Ministry of Agriculture has created a Special Identification and Production Certificate (Certificado Especial de Iden-

3. Embrapa is the Brazilian Agricultural Research Corporation (Empresa Brasileira de Pesquisa Agropecuária), which is affiliated with the Ministry of Agriculture, Livestock, and Food Supply.

tificação e Produção), which allows superior breeding stock from commercial herds to attain the same status as pedigree animals [14]. Improved cross-breeds are said to have contributed significantly to productivity gains in cattle production [16].

Our review of the literature found less discussion about poultry and pig breeds. One source argued that the common use of hybrid breeds in pig production was a “tool for market development and domination” because positive traits are lost in the next generation, forcing farmers to buy new breeding stock [10]. The same source reported that pig and cattle genetics have a “very narrow genetic base” [10].

b) Feed

Growth in poultry and swine production in Brazil has been largely attributed to growth in the feed sector [1]. Commercial broiler diets contain (mostly transgenic) maize and soy as the principal ingredients [17], while pig feed is similarly based on corn and soybean meal [3]. In the Southern Region, where much pig farming is concentrated, feed ingredients are often transported from long distances. For example, 98% of the soybean used for swine feed comes from the Center-West Region, transported over 1,713 km, and only 2% is produced in the Southern Region itself, transported over 494 km [18]. Maize, which is the main energy source in swine feed, comes from the Central-West Region (17%) transported over 1,559 km, and the Southern Region (83%), transported over 154 km [18].

Concentrates,⁴ which are used more in swine and poultry feed than cattle feed, make up a larger proportion of feed compared to other roughage in more industrialized systems of production [19].

Regarding beef production, some argue that although feedlots are increasing in Brazil, the animals are still predominantly grass-fed because they spend most of their lives in pastures, with comparatively little time in feedlots, and the feed given to them while they are in feedlots has a high percentage of roughage [14, 20]. Less than 10% of

Brazilian cattle are currently raised in feedlots [21].⁵ It was maintained that raising more beef in feedlots would raise productivity above “below average” levels [21]; however, others argue that Brazilian beef production is already efficient because it costs 60% and 50% less to produce beef in Brazil than in Australia and the US, respectively [14].

Feed conversion rates are a principal concern. Feed conversion efficiency is thought to increase for all animals—pigs, poultry, and cattle—as systems move from extensive to more industrialized [19]. In Southern Brazil, vertically integrated swine production has a feed conversion rate of 2.51, leading to attainment of a slaughter weight of 125 kg over 171 days from growing to finishing [18]. These figures can be compared to those reported in a US pork industry analysis that states that feed conversion rates in 2013 were 2.66 and 2.50 for “conventional” finishing (the final stage in swine production) and wean-to-finish production, respectively [22].

c) Antimicrobials, growth hormones, and other additives

We found relatively little discussion about the use of antimicrobials and growth hormones in animal agriculture unless it was tied to restrictions on Brazilian exports. For example, the media reported extensively on Russia’s reaction to finding the growth promoter ractopamine in Brazilian pork and beef. Russia had imposed a meat embargo on Brazil in June 2011 when inspectors found violations of Russia’s veterinary and sanitary rules at Brazilian plants [23]. Russia allowed some imports thereafter, but maintained a ban on three states, including Rio Grande do Sul, because of concerns about ractopamine [23]. In November 2012, Brazil temporarily banned the use of beta blockers promoting muscle growth, including ractopamine, and anticipated that the ban would remain in effect until the country could set up a system to separate out pork and beef exported to countries that banned ractopamine [24].

Despite promises made by the Brazilian veterinary service to Russian officials, the latter found in 2013 that Brazilian companies did not have a reliable system to prevent the use of ractopamine and threatened to ban all pork and beef imports unless Brazil could respond adequately [25]. Further problems continued when Russia’s veteri-

4. Concentrates are high-energy ingredients that include fats, cereal grains, high-protein oil meals/cakes, and agro-industrial byproducts (such as those resulting from sugarcane, animal, and fish processing). They are distinguished from roughages, which include pasture grasses, hay, silage, and straw.

5. The source did not specify whether the statistic referred to cattle raised *exclusively* in feedlots, but given that the figure was so low, it might be inferred that this is what it meant.

nary surveillance agency found ractopamine in pork from Brazil in 2014, despite a bilateral agreement saying that Brazil would not use growth promoters in animal products exported to Russia [26].

There have been reports of other additives affecting export potential as well. In May 2010, Brazil voluntarily stopped exporting to the US because of anti-parasitic medicine residue found in beef [27]. Given the importance of the EU market for Brazilian exports, meatpacking companies have also attempted to regulate the use of antibiotics to address EU concerns [27]. Canada. However, banned imports from two poultry plants in São Paulo and Minas Gerais in August 2011 when it detected antibiotic residues in the meat, and it wasn't until a few years later that export approval was restored [28].

Regarding broiler production, Brazilian researchers conducted a trial with commercial broilers that found that “broilers fed diets containing a probiotic, prebiotics, synbiotics, or no additives performed as well as those fed a diet including an antibiotic, but the meat quality was improved” [29].

d) Facilities for housing, slaughtering, and processing

Broiler production in Brazil is more mechanized than swine production, and feeding and processing are typically more mechanized than systems used to control environmental/climate conditions [2]. Operated mostly by integrated farmers, poultry production facilities are characterized by a “high degree of confinement,” with birds concentrated in closed sheds or other housing [12]. The industry reports that the current average density is 34 kg/m², which was presented as progress in terms of animal welfare [12] and is attributed to Brazil's warm climate [30].

Housing facilities on intensive pig farms typically involve gestation crates for sows, although other alternatives are being promoted, reportedly in response to increasing concern for farm animal welfare [31]. For example, Embrapa is providing technical support for the Free-Range Intensive Pig Production System (Sistema intensivo de produção de suínos criados ao ar livre), a system for raising pigs used by several producers in Brazil, in which sows are raised outside on pastures where they can build nests and root [31].

Regarding beef production, both the number of feedlots and the size of feedlots have increased in Brazil [20], and consequently the number of cattle fed in feedlots increased from 785,000 in 1991 to 3,870,000 in 2012, representing a five-fold increase over twenty years [32]. Feedlot operations in Brazil, however, are still generally smaller than those in the US [32]. Feedlots, which are mostly owned by large meatpacking companies, have been described as being unprofessionally managed, with little control over the amount of feed administered per pen [20].

Moreover, while the use of feedlots for beef cattle has increased, this practice mostly occurs during the dry season because of reduced pasture availability [32]. In this regard, a 2009 survey found that the animals are only spending 7% of their lives in the feedlots [20]. Even in the regions with the highest rate of confinement to feedlots, the Southeast and Southern Regions, the percentage of confined heads⁶ are 4.7% and 4.0%, respectively [32].

Nevertheless, some sources say that the rise of feedlots—especially for finishing cattle—has enabled the beef sector to have shorter production cycles, produce higher and more consistent quality beef, increase productivity, and meet growing demand [20, 33]. The industry believes that more intensified production, facilitated by feedlots and other advanced technology systems, is necessary to make cattle production more efficient, as well as to improve meat consistency and quality [21]. In fact, feedlot capacity is projected to more than double from 2 million to 4.5 million by 2023 [21].

We identified very limited information about slaughtering and processing facilities, with one source referencing processing plants that have the capacity to process over 2,000 animals daily using modern equipment [14].

e) Land use and land acquisitions

The principal land-related issue we observed in the literature surrounded the use of land for cattle production. Given the negative perception of deforestation for the purposes of cattle ranching, especially in the Brazilian Amazon, many researchers and Embrapa have attempted to show that cattle production has increased due to intensification, rather than expansion of extensive pastures

6. The source did not specify whether these figures referred to exclusively confined cattle. Given the low percentages, we might be able to infer that this is what was meant.

[20, 32, 34-37]. Components of intensification include increased stocking rates, improved grasses, more productive breeds, and better management (in terms of health, nutrition, feeding practices, etc.) [5, 35, 38].

On the other hand, there has been some recognition that intensification may lead to greater deforestation over the long run because labor and capital will be attracted to the business [5]. In other words, intensification may make cattle ranching as a livelihood appear (or in fact be) more profitable, thus persuading those who did not originally pursue it to do so; with more people engaging in cattle ranching overall, there may be greater net deforestation. In addition, the literature is not settled on whether large landholders or others are causing more deforestation. However, the proportion of deforested land on each landholding is increasing for all sizes, according to agricultural census data [5]. Following the granting of financial incentives and subsidized credit to the livestock sector, which encouraged cattle ranching to expand into the Brazilian Amazon throughout the 1970s, 1980s, and 1990s, the national government has tried to implement norms to get landholders to protect the environment and maintain forest reserves [5]. Moreover, according to one study in southeastern Pará, supply-side “zero deforestation agreements” signed by meatpacking companies have resulted in the decision by some slaughterhouses to stop sourcing cattle from properties that deforest, as well as lower deforestation rates by supplying ranchers [39].

Regarding land acquisitions overseas, Brazilian agribusinesses have land investments in Bolivia for soy cultivation and cattle ranching, a situation seen to be at odds with indigenous land rights and environmental protection [40]. In fact, some Brazilians reportedly marry Bolivian citizens, create companies through associations with Bolivian citizens that might exist only on paper, or pressure the state to reform regulations that respond to their interests in order to bypass regulations on foreign direct investment or to obtain loans [40].

For its part, Brazil-based Marfrig was reported in 2010 to have purchased 150 ha of land in Córdoba, Argentina to build a feedlot worth 20 million USD with capacity for 22,000 cattle [41]. Brazilian agribusiness giant, JBS, is currently one of the US’s largest beef processors and

operates one of the world’s biggest feedlots in the United States [42].⁷

5) *Waste management*

Essentially all of the sources we found addressing waste management focus on swine manure management. The amount of manure generated by confined swine production is considered a major public concern by Embrapa [3]. Currently, the main method used to manage manure is to store liquid manure and then apply it to land [3, 18, 43]. Storage facilities in approximately 80% of integrated farms consist of open slurry tanks without a cover [18]. The challenge is that the volume of manure exceeds the land’s capacity to recycle nutrients, and transporting manure over more than a few kilometers is not economically feasible [3, 43].

An add-on technology to this waste management method is to use biodigestors to produce energy and fertilizers [3]. In this regard, the other 20% of vertically integrated swine farms have biodigestors that use a burning process to convert methane into carbon dioxide, and thereafter manure is applied as organic fertilizer [18]. The problem with this method, however, is that nitrogen and phosphorous are not removed from the effluents, and the digested effluents and sludge still need to be land-applied [43].

Composting, another option that has been promoted, would turn liquid manure into solid material, reducing manure volume and increasing concentration of nutrients so that the waste is easier to handle and transport [43]. There is some evidence to suggest, however, that composting would actually be one of the most environmentally harmful ways of managing swine manure [18].⁸

6) *Transnational corporations*

We did not find any information about other transnational companies acting within Brazil.

7. The news source did not specify the location of this feedlot. However, JBS’s US-based subsidiary, JBS Five Rivers Cattle Feeding LLC, has a total feeding capacity of more than 980,000 heads of cattle in Colorado, Kansas, Oklahoma, Texas, Arizona, and Idaho. See JBS Five Rivers Cattle Feeding LLC, available at: <https://www.fiveriverscattle.com/pages/default.aspx>, last visited Feb. 16, 2016.

8. The authors found that composting is the most detrimental way of managing manure, in terms of all environmental impacts except for marine eutrophication. The categories of impacts studied were (i) climate change; (ii) terrestrial acidification; (iii) freshwater eutrophication; (iv) marine eutrophication; (v) terrestrial ecotoxicity; and (vi) natural land transformation, as well as energy demand and biodiversity loss.

7) *Regulation of livestock production*

Several topics of regulation were discussed in the literature, as follows:

Feed additives

The Ministry of Agriculture, Livestock, and Food Supply inspects the industry under the authority provided by the National Plan for the Control of Residues and Contaminants (Plano Nacional de Controle de Resíduos e Contaminantes—PNCRC), which prohibits the use of hormones in Brazil's chickens and makes sure that all types of "anabolic substance are absent from poultry" [12]. We found less specific information on the regulation of antibiotics, however. While one source claimed that antibiotics and growth hormones were regulated and that beta-agonists were even banned in cattle [20], the use of these substances continues and infrastructure for enforcing regulations remains inadequate, as the above subsection on "antimicrobials, growth hormones, and other additives" shows.

Animal welfare

One law review [44] argues that a major deficiency in Brazilian legislation is that animal agriculture is often exempted from animal and environmental laws, which already have weak enforcement mechanisms. There are only voluntary standards on animal welfare, such as those contained in Embrapa's 2007 technical manual on good practices in poultry production [45]. Although farm animal welfare could potentially fall under the 1998 Environmental Crimes Act, which penalizes animal cruelty, slaughtering is not covered, and the law was challenged by some legislators [44]. Moreover, many animal farms operate informally—an official estimate of 40% is cited—and therefore outside the sphere of regulation [44].

Studies comparing Brazilian animal welfare legislation to that of other developing and developed countries have drawn similar conclusions. Robins and Phillips (2011) found regulations of chicken production to be "negligible," while Silva and colleagues (2009) described Brazilian norms for broiler and swine welfare as being out-of-date, deficient, and much worse than the other countries analyzed—EU, Australia and the US—with respect to the topics of transportation, management, and housing environment. For example, regarding housing conditions, there is no regulation of aspects like ammonia concentrations, temperatures/heat stress risk, or noise level expo-

sure [30], nor are there norms on swine transportation, both within-farm and farm-to-slaughter [46].

Waste, sanitation, and other environmental issues

Various sources noted that Brazil has no uniform federal regulations for the land application of animal manure or the disposal of dead animals [1, 43]. Regulated by the states, there is regional variation on the regulation of applying animal waste to land [43]. As one example, Santa Catarina state, where 19.3% of the national swine herd is based, establishes a maximum volume of 50 cubic meters of manure per hectare per year [18]. There are, however, national-level restrictions for discharging wastewater into surface water [43] and disposing wastewater from processing plants [1].

In 1998, requirements for sanitation in slaughterhouses and meatpacking factories were standardized for all of these plants, regardless of their size [5]. The Federal Inspection Service (Serviço de Inspeção Federal—SIF) conducts sanitary inspection of slaughtering and processing [12], however, we did not find information discussing its performance.

Forest management, as affected by livestock production, is another domain where legislation has been passed. For example, the 2012 Forest Code requires landowners to maintain a minimum percentage of forested land within their properties—80% for the Amazon, and 35% for the Cerrado region [7]. The law establishes a Rural Environmental Registry (Cadastro Ambiental Rural [CAR]), which mandates registration for all rural properties in the country. The CAR, however, is not effective in every state because of lack of funding, limited capacity, and differences among states as to how information is collected [7]. Enforcement of forest management is a challenge in general because there aren't enough human resources dedicated to monitoring so many farms [1]. According to the IFPRI-FAO source, larger farms, as they get bigger and more industrialized, receive increased scrutiny by authorities as compared to smaller farms—a phenomenon that favors smaller farms [1]. Separately, the same study found that since certain regulations were stricter in some regions than others, farmers were relocating concentrated livestock production from the Southern Region to the Center-West Region, which had fewer environmental regulations [1].

Animal disease and biosecurity

Since the late 1980s, according to one source, there has been a general deregulation of the livestock sector, along with a cut in public spending on animal health services and programs during the first half of the 2000s [8]. There is one initiative by the Ministry of Agriculture known as compartmentalization, a process that involves a company keeping tight control over its entire production process, so that even if there is a health problem in some part of the country (e.g., outbreak of Avian Influenza), that company can continue to export poultry [12]. As described by the poultry industry, compartmentalization essentially requires integration of the whole production chain “from the feedmill [sic], parent bird farms, and genetic material, all the way to broiler farms and slaughterhouses” [12].

Impacts of industrial food animal production

1) Impacts on worker health

We found no information about the impacts of industrialized livestock production on occupational health in Brazil.

2) Impacts on surrounding communities and others

There were only a few sources that discussed the impacts of industrialized livestock production on communities. One report, written by a consultant for the League for Pastoral Peoples and Endogenous Livestock Development,⁹ mentioned that market concentration was leading to the exit of smallholders from the sector, and in some cases, rural-to-urban migration when no alternative employment could be found in the area [10]. A case study from Rio Grande do Sul, conducted by a Swedish economic historian, found that small-scale farmers perceived a loss of autonomy due to “rigid requirements” imposed by integrating companies, but had no choice except to become integrated with large meat processing companies as they lacked access to supermarkets and retailers [9]. As these markets demanded uniform products and consistent quality, it was “almost impossible” for a small-scale farmer secure market access [9].

On the impacts of Brazilian-owned foreign agribusiness operations, one critique of land investments in Bolivia

9. The League for Pastoral Peoples and Endogenous Livestock Development was founded in 1992 by a group of veterinary and other professionals, and became registered as a non-profit in Germany the following year. It conducts research and emphasizes indigenous knowledge and institutions for the development of livestock production. See League for Pastoral Peoples and Endogenous Livestock Development—Organisation, available at <http://www.pastoralpeoples.org/about/organisation/>, last visited Feb. 16, 2016.

was that few of the earned profits were being reinvested domestically, with economic benefits only being felt by Brazilians [40].

3) Impacts on natural resources

Several issues concerning impacts on natural resources were addressed in the reviewed literature. Deforestation was a key concern, however it was often attributed to extensive cattle ranching, rather than industrialized production, as described in the sub-section on “land use and land acquisitions.” A few studies addressed negative impacts of intensified cattle ranching, such as attraction of new producers into the business leading to increasing deforestation, decreasing soil quality due to overgrazing and trampling, increasing use of herbicides, fungicides, and insecticides, and increasing methane emissions from more animals [5, 20, 37]. Despite this, these studies resisted criticizing intensification. The authors argued that since methane emissions per unit product had decreased, this was a sign of greater efficiency [20, 37]. Another study argued that, if proper management were applied, then chemical inputs could be reduced, animal health wouldn’t necessarily suffer, and water use could be made more efficient [37].

The IFPRI-FAO study found that, in general, larger farms cause more environmental harm than smaller farms [1]. Regarding poultry production, the industry has argued that poultry farming in Brazil has a low environmental impact compared to other countries because feed is produced and available within Brazil, and less energy is needed for ventilating and heating poultry houses due to the climate [12]. The IFPRI-FAO study found that broiler production was less environmentally harmful than swine production (generating less excess nitrogen and phosphorus from livestock waste), and broiler manure was valued as a fertilizer. Nevertheless, environmental costs were being internalized to a greater extent by smaller broiler producers than by larger ones [1]. The same disparity was observed among swine producers, as well [1].

Based on our landscape assessment, intensive swine production generally seemed to raise more environmental concerns than intensive cattle or poultry production. Much of the impact derives from the animal waste, which contributes to freshwater eutrophication, terrestrial ecotoxicity, and greenhouse gas (GHG) emissions [18, 43].

Lastly, the impacts of feed production for intensive live-stock farming have also been discussed to some extent. These include natural land transformation, GHG emissions, loss of biodiversity, freshwater eutrophication, marine eutrophication, terrestrial acidification and greater cumulative energy demand [18]. Regarding water in particular, one study highlighted that more concentrate-heavy feeds¹⁰ are used in industrial systems as compared to other systems, and the water footprint of concentrates is about five times higher than the water footprint of roughages [19]. The water footprint, however, also depends on origin of feed and feed conversion efficiency. Industrial poultry production, for example, has a lower water footprint compared to grazing due to the former's better feed conversion efficiency [19]. Industrialized pork production uses less surface water and groundwater than grazing pork systems, but the opposite is true for beef production in Brazil [19]. The researchers hypothesized that grazing and mixed cattle production systems in Brazil use less surface and groundwater than industrial systems because feed consists mainly of pasture and crop residues (the parts of the plant that are left over from what is typically used by humans, like bran, broken rice, rice husks, etc.), which require little irrigation.

Public engagement with industrial food animal production

1) Transparency and access to information

We did not find any information on transparency or access to information relevant to IFAP. However, one study noted that it was difficult to find quantitative data on contract farming in Brazil [10].

2) Public awareness and attitudes

There has been some research that aims to assess the public's awareness of issues surrounding livestock production, especially animal welfare and environmental sustainability. While these studies show some concern about the topics, it is less clear whether this concern ultimately translates into consumption behavior or willingness to pay higher prices.

A survey of 475 respondents in eight cities conducted by De Barcellos et al. [47] is illustrative: Respondents were

10. Concentrates are high-energy ingredients that include fats, cereal grains, high-protein oil meals/cakes, and agro-industrial byproducts (such as those resulting from sugarcane, animal, and fish processing). They are distinguished from roughages, which include pasture grasses, hay, silage, and straw.

asked to evaluate different pig production systems and report their pork consumption behavior. Most respondents (72%) were classified into one group marked by preference for farms housing the animals on litter and farms that made some effort to protect the environment, but weak feelings toward environmental protection and little knowledge about pig farming in general. There seemed to be a second group of respondents who were very environmentally conscious (16% of the sample), and a third group (12% of the sample) who favored extensive farming and animal welfare, cared about the environment, and were most opposed to industrialized production.

There were some "conflicting preferences," however, within the clusters [47, p. 9]. For example, even though the third cluster preferred attributes of extensive farming, they also preferred slatted floors and similar quality pork products—traits of intensive farming. One general conclusion was that most people had little knowledge about pig farming. Moreover, the authors could not deduce any logic in the way attitudes mapped onto consumption patterns.

Other surveys have shed further light on these issues. A 2008 Brazilian Institute of Public Opinion and Statistics survey found that 85% of respondents were willing to pay more for products causing less harm to the environment, and a 2007 World Society of the Protection of Animals survey found that 74% of Brazilian consumers thought that farm animals needed improved treatment [31].

Nevertheless, CGIAR reports that there is an "Attitude Behavior Gap" on the part of Brazilian consumers, meaning that they manifest attitudes in favor of environmental protections but don't want to pay more for sustainability; they are only willing to pay more for quality [7]. This is reported as an obstacle to convincing more producers to undertake sustainability certification processes [7].

Similarly, Robins and Phillips [48] have criticized the fact that there is little research on broiler chicken welfare, and that the research that does exist is focused more on the production benefits of improving animal welfare. In other words, only aspects of welfare that are linked to profitability—like mortality, health, and performance—are studied; animal mental health and affective states are not [48]. The one identified study of animal welfare in swine and cattle production was in line with this critique, describing how poor pre-slaughter management could lead to bruises on the carcasses and thus economic loss [49].

3) *Media interest in IFAP*

The media sources that we found reflected a generally positive view of overseas acquisitions by JBS and other Brazilian companies. Scandals about the use of growth hormones and other additives attracted media attention, especially when exports were concerned. We found less interest in specific aspects of industrialized livestock production (however, as noted in our section on “methodology,” our search strategy did not involve targeted searching of Portuguese-language media).

4) *NGO or community campaigns, advocacy, and other efforts targeting IFAP*

There was some mention of advocacy and other efforts to address certain aspects of livestock production. Much of the discussion centered around initiatives to stop deforestation, which isn’t necessarily associated with intensive production. (In fact, intensification is often credited for having a forest-sparing effect, as described earlier.) In 2009, the NGOs and the Federal Public Prosecutor’s (MPF) office of the state of Pará simultaneously pressured beef retailers and meatpacking companies to reduce deforestation [39]. The MPF sued ranchers who engaged in illegal deforestation and the slaughterhouses that obtained animals from them. Because of threats of legal action, Brazilian retailers boycotted slaughterhouses sourcing from these ranchers [39]. Individual meatpacking companies then signed a legally binding agreement with the MPF, committing to stop purchasing from ranchers engaged in illegal deforestation. Four of Brazil’s largest meatpacking companies (Marfrig, Minerva, JBS, and Bertin) also signed a zero-deforestation agreement with Greenpeace in October 2009, which prohibited any clearing [39].

Also in 2009, the three largest supermarket chains in southern Brazil—Wal-Mart, Carrefour, and Pão de Açúcar—agreed to stop sourcing from suppliers deforesting the Amazon [5]. The press reported in 2013 that the 2,800-member Brazilian Association of Supermarkets had signed an agreement with the Federal Public Prosecutor’s Office to stop selling meat from cattle raised in the Amazon rainforest [50].

These examples of “supply chain interventions” have attracted media attention and are seen as a promising way to advance environmental protection and other objectives [39, 51]. Overall, two-thirds of federally inspect-

ed slaughterhouses in the Amazon region have signed agreements similar to the one led by the MPF of Pará [39]. There are also partnerships between NGOs and agribusinesses, such as Marfrig Group, the Nature Conservancy, and Walmart Brazil’s collaboration on a cattle processing facility in Pará [52]. The goal of that collaboration was to create a production unit that would respect conservation of forests, soils, and rivers, while expanding the supply of beef whose origin could be guaranteed through a tracking system. World Animal Protection and the multinational agrifood company BRF also announced a partnership that requires BRF to phase out individual sow stalls over a 12-month period [53].

On a related issue, the transnational SAN consortium, which has a Standard for Sustainable Cattle Production Systems consisting of 136 criteria, has already certified a few cattle farms in the Amazon, as well as a slaughterhouse, as of 2013 [7]. Carrefour, a major supermarket chain, started selling SAN-certified beef in Brazil that year [7]. However, as CGIAR noted, one research gap is quantitative assessment of the impact of certification programs, of which there are many in Brazil [7].

Besides environmental sustainability, animal welfare is another topic that has drawn attention from NGOs, advocates, and researchers. Animal welfare experts have supported the transition from gestation crates to group housing for sows [53], while Embrapa has provided technical support for the Free-Range Pig Production Intensive System where sows are raised outdoors [31].

Some well-known, international animal welfare NGOs have conducted case studies of farms in Brazil. CIWF highlighted some positive practices in a few of its pig production case studies, but noted numerous animal welfare concerns, such as mutilations, very early weaning age, limited bedding, antibiotics in feed, close confinement of sows, insufficient climate control for young piglets, high piglet mortality, and intensive fattening [54]. Noting growing demand for free-range pig production, World Animal Protection provided a case study of São Marcelo Ranches, which was the first Brazilian company to attain the internationally-administered “Certified Humane” label for pork production [55]. In this system, pigs are raised at lower density so they have fewer diseases, no antibiotics are used prophylactically, sows are housed free-range, and mutilations like tooth clipping and tail docking are not practiced [55]. That NGO also gave a very positive review of Korin, a cage-free egg and free-range

chicken producer and the first company in Brazil to attain animal welfare certification [56]. According to WAP, Korin only uses plant-based feed, and does not use antibiotics, growth promoters, or other chemicals [56]. It also has contracts with growers who are paid more competitively than regular broiler contract farmers, and sources from local soy and maize farmers [56].

Industrialization and integration attracted less attention and advocacy than the above topics. There was one case study conducted in Rio Grande do Sul that documented local farmer resistance in response to marginalization caused by corporate “land grabs” and vertical integration [9]. These rural communities employed strategies like appealing to alternative markets (e.g., organic niche markets and local street markets) and conducted occupations to reclaim arable land [9].

5) Description of other civil society actors engaged in IFAP

Besides researchers, advocacy groups, NGOs, and the Office of the Federal Public Prosecutor, there was no other mention of civil society actors working on IFAP-related issues.

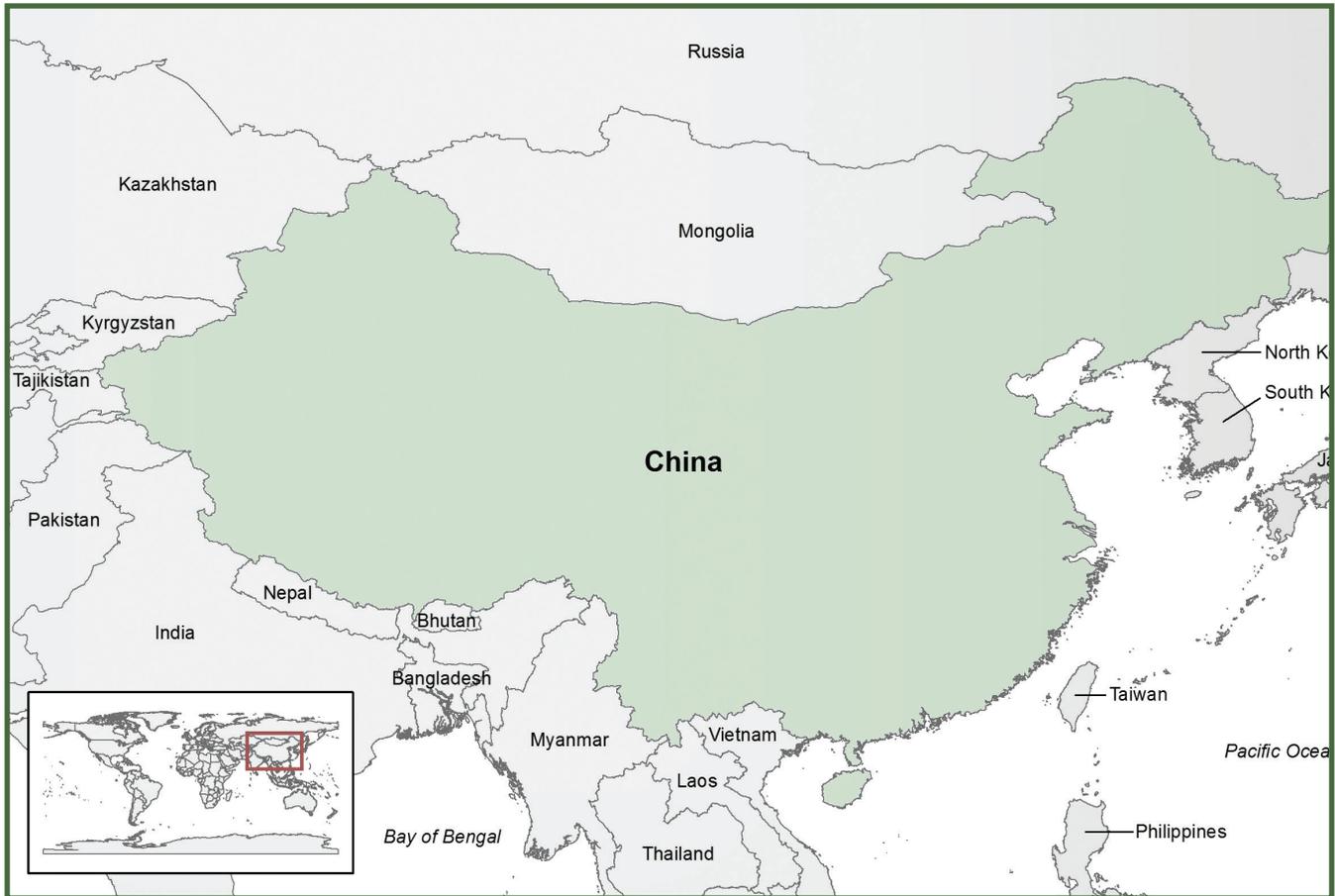
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China



Overview

A clear shift to industrialized, large-scale livestock production has occurred and continues to be promoted in China. Among the major demographic factors that have contributed to this trend are increasing population, rising incomes, and urbanization [1]. Between 1978 and 2004, animal agriculture's share of GDP doubled, from 17% to 34% [2]. Domestic public policies have been influential in the industrialization process. At the same time, the development of China's livestock sector has become increasingly linked to entities and resources abroad, with Chinese agribusinesses acquiring interests in foreign companies, overseas agricultural land, live animals, and feed crops.

Various stakeholders view integration, consolidation, and expansion of the scale of livestock production in China as being associated with greater profits, higher quality, more efficient use of natural resources, better food safety, and fewer zoonotic disease risks [3]. With the changes that have occurred, and the dramatic scale of food animal production in China today, the country has attracted

significant attention from the media, civil society, and research sectors.

Food and Agriculture Organization of the United Nations (FAO) statistics on food animal production

China had a total of 451,541,129 Animal Units (AUs) in 2013, resulting in an overall livestock density of 0.88 AU per hectare (ha) of agricultural area. The numbers of live animals raised in 2013 were 482,102,701 pigs, 4,835,178,000 chickens, and 113,644,709 cattle. FAO 2011 estimates of livestock densities, by specific animal class, were 0.91 pigs per ha, 11.19 poultry birds per ha, and 0.20 cattle and buffalo per ha.

In 2012, production was 52,308,720 tonnes of pork, 13,198,476 tonnes of chicken, 6,306,350 tonnes of cattle meat, and 37,784,491 tonnes of cow's milk. From 2002 to 2012, pork, chicken, cattle meat, and cow's milk production increased by 38%, 44%, 30%, and 183%, respectively. The five-year period of 2007 to 2012 saw increases

Production, imports, exports, and net balance by livestock product

	Production (mt)			Imports (mt)	Exports (mt)	Net (mt)
	2002	2007	2012	2012	2012	2012
Pig meat	37,931,476	43,933,037	52,308,720	590,060	122,229	52,776,551
Chicken meat	9,173,395	10,724,950	13,198,476	1,458,988	721,133	13,936,331
Cattle meat	4,853,389	5,845,638	6,306,350	25,089	2,216	6,329,223
Milk, whole fresh cow	13,355,933	35,574,326	37,784,491	151,495	32,812	37,903,174

of 19%, 23%, 8%, and 6% for pork, chicken, cattle meat, and cow's milk, respectively.

Industry characteristics

1) Scale

The scale of livestock operations in China has received a lot of attention. A research center within the Chinese Ministry of Agriculture (MOA) released a 2007 report stating that a rapid process of intensification had been occurring in the country since the 1980s, with aggregation of production units into large-scale intensive enterprises located in geographically concentrated areas [4]. Intensive feeding operations tended to be located in coastal areas with market or port access or in regions proximate to feed resources [5]. However, the report noted a dichotomy in the livestock sector, as these large-scale industrialized operations coexisted alongside small-scale, traditional backyard production systems [4].

Citing Chinese Ministry of Agriculture statistics from 2003, one source stated that backyard livestock rearing still dominated livestock production: 99% of livestock producers qualified as smallholders, and these producers accounted for 73% of hogs produced, 82% of beef cattle produced, 65% of dairy cattle, and 60% of poultry produced [5]. Thereafter, a 2013 editorial by a representative of the Ministry of Agriculture estimated that 40% of pigs, 75% of beef cattle, and 55% of dairy cattle were raised by backyard farmers (no figures were presented for poultry) [6].

One recurring theme in much of the literature we found was to associate these small farmers with inefficient production, poor quality, monitoring difficulties, and food safety issues, among other problems. For example, one 2008 article claimed that feedlots were better able to control quality and achieve economies of scale than backyard producers [5]. A 2013 editorial maintained that

most backyard production facilities were “backward and unproductive,” and that farmers often shifted from one type of animal to another or stopped cultivating livestock altogether, making the Chinese market unstable and not competitive [6, p. 250]. Further examples of this type of discourse are provided below.

One distinctive feature of the Chinese livestock sector is the emergence of “specialized” household-level production. According to a 2006 study on changes in the livestock sector's productivity, the previous two decades had seen a decline in backyard livestock production, but a rise in specialization, undertaken by both specialized households and commercial enterprises [5]. The study analyzed advances in technological progress for four types of livestock products—eggs, milk, beef, and hogs—and for three types of production systems—backyard, specialized household, and commercial [7]. It found that there had been gains in technological progress for all products and all sectors, but specialized household hog and dairy farms experienced the largest advances [5].¹

A study using a national dataset of rural livestock-raising households to examine household income and decisions to stop raising livestock between 1996 and 2005 found that households that continued to raise livestock over that decade substantially increased their production volumes of meats and milk (especially milk), poultry, beef, and sheep meat [8]. Although use of grain for feed increased, labor inputs decreased over time and output rose substantially [8]. On the economic side, however, real household income from livestock products did not increase by much, despite the gains in output [8].

1. The study authors commented that technical efficiency progressed at a relatively slow pace or even regressed when compared to technological progress. Thus, the authors suggested that there was room for improving productivity of the livestock sector through improving efficiency. See Rae A. China's agriculture, smallholders and trade: driven by the livestock revolution? *Aust J Agr Resour Ec.* 2008;52(3):283-302.

On the future role of backyard producers and specialized household farms, and whether the former might transition into the latter, the 2013 editorial referenced above noted the investment costs of improving facilities were increasing significantly [6]. It cited one example: the cost of building a pig farm for more than 10,000 pigs had doubled over the previous five-year period [6]. Despite this, a 2011 NGO report noted that the intensification of animal agriculture appeared to be accelerating [9]. More specific information on production scales by animal species is provided below.

Scale of cattle production

According to one 2013 study, the predominant cattle farming system is mixed livestock-crop production, where livestock feed is cultivated on the same farm where livestock are raised [10]. In mixed farming systems, both cows and calves are produced [8]. There is also specialized household production focusing on grain-based fattening [8]. Other than these two types of cattle production, which occur in agricultural areas, there are also grazing systems in the Northwestern and Southwestern pastoral areas [8].

Most beef cattle production in China is small-scale. According to a 2010 article that cited official statistics, there were only 200 “large” feedlots with an average turnoff (quantity of fattened livestock distributed to the market) of 1,000 heads per year in China, which is fairly small by international standards [11]. Moreover, these feedlots accounted for a decreasing share of total cattle production [11]. On the other hand, there were around half a million specialized households, producing between 10 to 100 cattle per year, which accounted for 27% of total cattle production in China as of 2005—an increase of six percentage points since 2003 [11].

Various reasons have been cited for why small-scale beef cattle production remains prominent. The same article referred to a lack of consumer demand for high-value beef, such that heavy cattle have less market than light cattle [11]. Feedlots are not as competitive as specialized cattle fattening households at producing light cattle, and have relied on government support in order to remain competitive [11]. The article also explained that breeding operations providing feeder cattle to feedlots and specialized households ranches are almost always small, unspecialized cow-calf households; the only large-scale cow-calf producers in the country are found in the pastoral regions with extensive grazing systems [11]. Other

reasons for the continued prominence of small-scale cattle production, cited by the media, are a shortage of land, farmers’ concern that finishing cattle takes longer than raising pigs, the higher efficiency of breeding pigs compared to breeding cattle, and government subsidies favoring larger pig farms and dairy production [12, 13]. According to the 2010 article, it is not likely that large-scale producers will dominate the market and crowd out small-scale cattle producers.

Further, a media source in 2013 cited a business consultancy report by China Suppliers Institute (not found in English) to support the statement that China’s cattle herd had decreased—from 80 million heads in 2008 to 65 million heads in 2012²—and that this reduction was due to rural-urban migration, government subsidies promoting larger pig farms and dairy production, and the higher efficiency of breeding pigs relative to breeding cattle [12]. In light of this, China is reportedly importing live cattle from Australia for slaughter, and is moving forward on a similar deal with Mongolia [14].

Scale of poultry production

Poultry production in China is concentrated in central and eastern China, with areas of denser production matching areas of denser population [15]. Production has been increasing rapidly in North China (Beijing, Tianjin, Hebei, Henan, Shandong, and Shanxi), which is also a major poultry-producing region [8]. In a 2007 report, one research center of the Ministry of Agriculture described intensification of poultry production as “inevitable,” and anticipated the establishment of larger poultry farms in western and central China [4, p. 26]. The Chinese Ministry of Agriculture classifies farms that produce at least 2,000 birds annually as intensive broiler farms [15].

A senior economic expert with the National Animal Husbandry and Veterinary Service reported that the percentage of broilers sold from breeding farms with an annual capacity greater than 2,000 birds increased from 59% in 2000 to 74% in 2005 [16]. Similar figures were cited in an Institute for Agriculture and Trade Policy (IATP) report: intensive broiler farms accounted for only 2% of farms in 2009, but 70% of the supply [15]. According to that 2014 report, some of the drivers of growth in the poultry sector are the shift to poultry as a healthier meat compared

2. These figures are different from the ones provided by FAOSTAT. We were unable to locate an English-language version of the report to check the original source.

to pork, the higher feed-conversion rate of chickens compared to pigs, and expansion of fast food chains [15].

In the mid-2000s, the government attempted to integrate small poultry farmers into “poultry production clusters” (PPCs) to improve economies of scale and food safety [17]. A production cluster was a designated area within a rural district separated from residential areas, and where several household farms jointly managed livestock production [17]. The clusters shared infrastructure—such as roads and waste treatment facilities—with the idea that they could meet environmental, safety, and technical standards more uniformly [17]. Production clusters were also promoted for pigs and cows; there were some 70,000 livestock production clusters in 2006, according to MOA statistics [17].

These efforts failed after a few years because there was no external authority, the producers lacked technical capacity and faced within-cluster coordination and collective action problems, and the government had limited capacity to work with producers and help them follow the same standards [17]. In addition, it was difficult to access appropriately-situated land and implement a proper layout [17]. From 2008, PPCs were in decline and they are now considered a failure (though no official documents state that conclusion) [17]. The Chinese government thereafter emphasized development of large-scale livestock production rather than small-scale production, preferring fewer, larger producers carrying out large-scale, modernized poultry production that would be easier to monitor and manage [17]. It had concluded from the PPC experience that “small producers [were] not suitable for standard and large-scale production” [17, p. 298]. As a 2014 article recounting the experience noted, this has forced some small producers out of the sector [17].

Scale of pig production, part 1—historic development

Many of the sources found through our landscape assessment described various periods in the history of the hog sector’s development. Originally, pigs were farmed at a small scale, with one 2014 article distinguishing even backyard systems (0 to 2 pigs per farm) from traditional systems (3 to 49 pigs per farm), and stating that about 90% of pigs were farmed in the former and 10% in the latter in 1960 [18]. After farmers were given permission to control pig production and prices in the 1970s and 1980s, pig farming increased and led to an oversupply by the mid-1990s [19]. Since pig farming was not very prof-

itable the industry consolidated, and many small farmers exited the market [19]. The sector became industrialized starting in the mid-1990s, with policy reforms, free trade agreements, and “more efficient” pig species [18, p. 12742]. At this time, pig production increasingly focused on landless industrial systems that obtained feed from external sources and did not have any land base for manure disposal [18].

However, one study, which used data from 1986 to 1999 on a nationwide sample of 650 households across 29 provinces, found that many of the government-subsidized commercial hog farms established in the 1980s went bankrupt by the late-1990s [20]. On the other hand, backyard pig farms had increased even without government support [20]. In poor inland areas, backyard hog production was maintained because of low opportunity costs (i.e., it was difficult to find off-farm employment). The limiting factor was feed, and given access to grain and feed markets, these operations could expand [20]. In the richer coastal areas, backyard hog production had a high labor opportunity cost, and there was less production as labor opportunities improved [20]. The study concluded that market developments could lead to declining hog production in richer coastal areas, while economic development that included feed markets could facilitate hog production in the poorer inland areas [20].

Since 1995, hog production has increased in North China and formed a concentrated axis of production along the Yangtze River [21]. In the “structural adjustment period” of 1997 to 2006, there was a notable change from small-scale to specialized or large-scale pig production operations [22]. Small farmers also exited the market in the mid-2000s due to low profits [19]. Animal disease and harsh weather, however, reduced the pig population in the late-2000s, and the government imported pork from western countries to address shortages [19]. Nevertheless, the number of hogs produced in China was still substantial: according to calculations by the USDA’s Economic Research Service, China had 94 hogs for every 100 acres of cropland nationwide by the end of 2008—more than four times the US figure of 20 hogs per 100 acres [23]. As of 2007, the largest pork-producing regions in China were the Northern Plain, Southwest, and Central regions, accounting for 21%, 20%, and 18% of production, respectively [24].

Despite these developments, pig productivity in China was still considered low compared to other developed

countries. As one 2009 journal article noted, despite high production volume and number of live animals, low productivity—as measured by piglet survival rate, weaning age, age to market, number of market pigs per sow, and weights—persisted, a problem the article attributed to the high number of small-sized farms [25]. Over half of the country’s pigs were being produced on small farms that raised fewer than ten pigs annually, and these farms accounted for nearly 95% of total pig farms [25].

Researchers have examined the issue of productivity in closer detail [7, 21]. For example, one study, which used hog industry data from 25 provinces in China between 1980 and 2008, examined total factor productivity (TFP), an aggregate measure of productivity consisting of the following components: technical progress, technical efficiency, scale efficiency, and allocative efficiency [21]³. The study found that TFP of hog production increased by 64% from 1980 to 2008, and allocative efficiency and scale efficiency improvements were instrumental in this increase. On the other hand, technical efficiency and technical progress had not changed much over that period [21]. Moreover, while TFP grew quickly from 1980 to 1990 due to agricultural reforms that incentivized better allocation of resources, TFP growth slowed down over the subsequent decades [21]. Toward the end of the study period, technological change began to contribute to increasing TFP [21].

One important question examined in the study was whether the country’s gains in hog output were actually due to better productivity—TFP—or to using more inputs, especially feed. The researchers found that TFP’s overall contribution to increased hog production output was less than 40% from 1980 to 2008, suggesting that China’s increased hog production during that period was due primarily to using more inputs [21]. When examining only the final years—2000 to 2008—TFP contributed to 69% of output growth, while inputs were secondary, contributing 31% [21].

3. Technical progress means a shift in production, as there is innovation and technology advances. Technical efficiency is the ability of a firm to maximize output for a given set of inputs. Scale efficiency reflects the extent to which the firm was operating at the optimal scale of production. Allocative efficiency measures the firm’s ability to select and attain the best combination of inputs, given input price and available technology. See Xiao HB, Wang JM, Oxley L, Ma HY. The evolution of hog production and potential sources for future growth in China. *Food Policy*. 2012;37(4):366-77.

Scale of pig production, part 2—recent trends and classification of production systems

The so-called “industrialization period” (from 2007 onward) has seen the emergence of features like vertical integration, consolidation, and scaling up in the pork industry [26]. According to a 2012 agribusiness journal article, three of the largest pig production and pork processing provinces in China are Henan in Central China’s Yellow River Valley and the eastern coastal provinces of Jiangsu and Shandong [27]. These provinces held 64% of the 50 most competitive meat-producing companies in 2005 [27].

Rising labor and feed costs, along with diseases like porcine reproductive and respiratory syndrome virus,⁴ have made productivity increases challenging [26]. Many sources from this “industrialization period” continue to point to the dominance of small-scale, backyard, or traditional production, despite more specialized and commercial operations [21, 27, 28].

Pig producers operate at a wide range of scales in China. Although there are slight differences in the typologies of production systems cited by several sources [18, 19, 29, 30], when taken together the general characterization is as follows: small-scale farms produce fewer than 50 heads per year, and sometimes the term “backyard” is applied to all of these small-scale farms, while in other instances “backyard” (up to two pigs) is distinguished from “traditional” (three to 49 pigs). (As used in this report, the term “backyard” refers more generally to all small-scale farms.) At this scale, pigs are primarily used for their manure (fertilizer) or as a type of financial safety net in hard economic times, and they are sold at local markets or consumed within the household.

Medium farms are described as producing 50 to 3,000 pigs per year. Many of these farms are “specialized household farms,” which are described in a 2014 IATP report as farms that raise pigs as a profession and for sale rather than for subsistence [29]. The operators may be individual families, small-scale companies, or a group of several backyard farmers who have joined to undertake more ex-

4. Porcine reproductive and respiratory syndrome, also known as “blue ear pig disease,” causes such symptoms as reproductive failure, pneumonia, and greater susceptibility to secondary bacterial infection. It is caused by a virus of the genus, *Arterivirus*. See World Organisation for Animal Health—General Disease Information Sheets—Porcine Reproductive and Respiratory Syndrome, available at <http://www.oie.int/doc/ged/D13986.PDF>, last visited May 7, 2016.

clusive pig farming [29]. Specialized farms may operate under contract with larger commercial farms or they may sell to local dealers, who then sell to slaughterhouses, processors, and retailers [29]. They purchase feeder pigs commercially and use feed grain [24]. More emphasis is placed on increasing feed efficiency, making a profit, and improving pig welfare, according to a 2011 paper by researchers at the USDA Agricultural Research Service and Feed Science Institute of Zhejiang University [30].

Finally, there are large-scale, modern commercial farms, which raise at least 3,000 pigs per year, with the largest producing 50,000 or more annually. They sell to urban markets and are described as resembling or reproducing the “factory farm” model of the United States and Europe [29, p. 19]. These farms reflect the sector’s trend to “simplify and specialize with an ability to grow more pigs in less space” [30, p. 169].

According to Chinese Ministry of Agriculture statistics, the percentage of the country’s hogs slaughtered by medium-sized specialized farms rose from 19% in 1998 to 47% in 2009, while the percentage attributed to backyard farms fell from 73% to 39% [21]. Meanwhile, the percentage of pigs slaughtered by large-scale commercial farms rose from 8% in 1998 to 14% in 2009 [21]. By 2010, 16% of the country’s pigs were raised in the large-scale farms, 48% in the medium-sized specialized farms, 34% in farms with three to 49 pigs, and 2% in farms with up to two pigs [18]. Similar statistics were presented for production by Rabobank: in 2010, backyard farms accounted for 37% of production in 2010, specialized farms for 51%, and commercial farms for 12% [29].⁵

Although the numbers may vary slightly, there is agreement that there has been a shift to larger-scale production, and the share of total production from backyard farms is rapidly decreasing [29]. Moreover, IATP describes both specialized household production and commercial operations as “concentrated/confined animal feeding operations or CAFOs,” and both systems rely on large slaughterhouses and processors [29, p. 14]. A 2006 study on TFP noted that specialized household farms and

commercial farms had comparable TFPs, which was attributed to breakthroughs in small-scale pig production promoted by agricultural extension workers and feed industry representatives [7]. The IATP report noted that the government itself was incentivizing specialized household pig production by investing in infrastructure [29].

In addition to the farms described above, there are also government-operated breeder farms, administered by different levels of government (federal, provincial, and county levels), where various breeds imported from the US and Europe can be found [19]. These farms usually raise pigs farrow-to-finishing, and it is difficult to separate pigs by age groups and to control disease [19]. Farms supplied by these breeder operations are typically smaller-scale commercial or backyard farms [19].

2) *Industry consolidation or concentration*

The trajectory of livestock sector development toward large-scale intensive production described above was accompanied by farmers leaving the sector, leading to concentration and consolidation (at least in some regions). One 2009 study used a national dataset on rural livestock-raising households to examine their decisions to stop raising livestock over the structural adjustment period of 1996 to 2005 [8]. The study found that households were more likely to continue livestock production if they had larger endowments of land and labor, if livestock production comprised a larger share of total household income, if the household size was larger, and if the proportion of household laborers who were illiterate was higher [8]. Aggregation into either formal or informal producer associations was described by the authors as one way to address the disadvantages of small-scale production, weak bargaining power, poor technical skills, and low access to higher-value markets [8].

As for slaughterhouses and meat processors, one study noted that, from 2000 to 2007, the number of slaughtering and processing entities decreased from 35,000 to 23,000, and the companies that remained at the end of this period were much larger [31]. One of China’s major development goals, in fact, was to continue reducing the number of slaughterhouses from 21,000 in 2010 to 3,500 in 2015 through consolidation and integration [31]. Additional characteristics of the consolidation and concentration process are discussed below, based on type of livestock animal.

5. A different classification used by INFORMA Economics—which IATP deemed more appropriate because the range of 50 to 3,000 pigs raised per year was considered too large—yielded the following figures for 2009: farms with one to ten pigs accounted for 27% of nationwide production; household producers with 50 to 500 pigs accounted for 51% of production; and commercial firms with over 500 pigs accounted for 22%. See Schneider M, Sharma S. China’s pork miracle? Agribusiness and development in China’s pork industry. Institute for Agriculture and Trade Policy, 2014.

Concentration in the beef industry

There was less information about the extent of concentration or consolidation in the beef industry. Although the beef sector grew rapidly during the first half of the 1990s, there was a “sharp market correction” around 1996 to 1997, with many farms exiting the market [5, p. 293]. As one 2010 case study of the Chinese beef industry noted, an important distinction between the beef sector and the pork sector is that there is a smaller market for beef [11]. Thus, the authors concluded that domination of large-scale producers was unlikely to occur in the near future [5].

Concentration in the pork industry

A 2014 IATP report compared the US and China pork industries, noting that they had both experienced significant growth and consolidation. Concentration of the US pork sector is considered more complete, although China’s sector is heading in the same direction [29].

Concentration occurred to some extent in China during the structural adjustment period of 1997 to 2006 [22]. After farmers were given permission to control pig production and prices in the 1970s and 1980s, pig farming increased and led to oversupply of pigs by the mid-1990s [19]. Since pig farming was not as profitable, the industry consolidated and many small farmers exited the market [19].

Due to the increasing numbers of small pig farmers, the shift to larger farms in China did not take off until the mid-2000s, when the government began to seriously prioritize industrialized operations [29]. Lower profits in the mid-2002 caused small farmers to leave the market [19]. As described in the 2014 IATP report, in the context of greater consolidation, they faced a choice of stopping pig production, becoming specialized pig producers, or becoming waged, and often migrant, laborers [29]. The result for China’s hog industry, according to IATP, has been the “virtual disappearance of extensive and sustainable farming systems run by independent family farmers” [29, p. 32]. One 2012 news article noted that as feed grains became more expensive in 2012, small pig farmers have continued to exit the market and there has been further consolidation of the sector [32].

Other sources have adopted a more critical stance toward small, unspecialized farmers and view consolidation as a desirable outcome. One 2011 study, for example, argued for better supply chain governance, asserting that

a fragmented industry dominated by smallholder swine producers and slaughterhouses made it hard to improve quality and safety by tracing pork “from field to table” [33, p. 312]. Recently, a 2015 paper stated outright that small-scale production was the “source of food scandals”; thus, consolidation was promoted by the government in order to ensure food safety [34, p. 160].

For pork processing and slaughtering, a 2013 article described a state of both fragmentation and integration, with small-scale slaughterhouses and processors accounting for 80% of total pork production while the three largest meat processors in China accounted for 5% [28]. The country’s 12th Five-year Food Industry Plan (2010 to 2015) set a target of a 50% reduction in small-scale slaughterhouses by 2015 through mergers and acquisitions [34].⁶ Some small-scale processors and slaughterhouses have sought protection from local governments, asking them to prevent large pork distributors from entering the local market [34].

In 2013, in a highly publicized acquisition, Shanghui International, a Chinese company, paid \$7.1 billion to acquire US-based Smithfield [34]. Although Shanghui had only half the sales of Smithfield, and Smithfield was performing well, some speculated that Smithfield allowed the acquisition because the Chinese government favored domestic pork producers, and Smithfield could not otherwise compete fairly with Shanghui and other producers in the expanding Chinese market [34].

Concentration in the poultry industry

A 2014 IATP report on the poultry sector noted rapid consolidation, which began in the mid-1980s and accelerated between 1997 and 2009, with the standardization of feeds, facilities, and other inputs [15]. As described above, the decline of the PPC initiative in the late-2000s was accompanied by a preference for fewer, larger producers, and the gradual exit of many small producers from the sector [17]. Because of competition, small farmers have had to either scale up or exit the market, and the pressure to cut costs in order to remain competitive has reportedly been detrimental to production practices [15].

A report by a Ministry of Agriculture research center from 2007 projected that larger poultry farms would be established in the western and central regions, existing large

6. The 2015 source citing the Plan did not provide details about what was considered a “small-scale” slaughterhouse, and we could not find an English version of the Plan itself.

farms in the eastern region would “further consolidate and integrate,” and more small-scale and non-commercial farms would end backyard poultry production [4]. The report speculated that the number of poultry farms in China might be halved by 2020, and that the eastern region would be most affected [4].

Nevertheless, based on data from 2013, the IATP report concluded that the poultry sector was still less consolidated in China than in the United States [15]. In a review of animal welfare regulations in Brazil, China, the United States, and the European Union, researchers at the Centre for Animal Welfare and Ethics at the University of Queensland warned that the market dominance of meat chicken companies affected the animal welfare approach in a given country, as well as the types of animal welfare research that receive funding [35]. Specifically, they asserted that when there is less competition in the market, only aspects of animal welfare linked to profitability are researched. Factors like mortality, health, and performance are studied, while animal mental health and affective states are not [35]. Although the article did not comment on the level of concentration/consolidation in the Chinese poultry sector, it noted that welfare regulations were negligible in China—a point to which we will return in the section on Regulation.

3) *Vertical integration*

In China, consolidation and vertical integration coexist alongside smallholder production, with integration particularly noticeable in the pork and poultry sectors [3]. Integration has been portrayed as a strategy to reduce the impact of market fluctuations [8]. One study of rural livestock-raising households during the structural adjustment period found that in all regions of China except for the Southwest, when the labor allocated to livestock exceeded 40 to 70%, increased specialization in livestock production in 1995 predicted a lower probability of the household continuing that type of production in 2005 [8]. The authors thus inferred that it was specialized, rather than diversified, household producers who suffered the effects of structural adjustment [8]. The probability of exiting the sector, however, was much less in the Northern region, an area where many poultry producers were participating in integrated supply chains. This led the authors to conclude that such participation made specialized household farms less vulnerable to market risk, at least during the structural adjustment period [8].

In contrast to the perspective that vertically-integrated supply chains protect small-scale producers from price volatility, a 2010 article by the China Agricultural Economics Group at the University of Queensland argued that household producers were not, in fact, interested in joining vertically-integrated supply chains, and would break contracts to take advantage of short-term price movements [11]. Contract farming, according to the group, was not as popular as others have maintained [11]. Yet the “coverage” of vertical integration of agricultural production in China nonetheless appears quite high, at least according to official statistics: by 2011, 60% of the country’s crop production area, 70% of pork and poultry production, and 80% of aquaculture operated through a “dragonhead-led” model of vertical integration and contract farming—China’s preferred mode of integration (described in greater detail below) [36].

Integration in the poultry sector

Writing in 2006, a senior economic expert with the Chinese National Animal Husbandry and Veterinary Service described broiler farming as the most integrated and intensive of the livestock sectors since the shift to large-scale integration [16]. In this sector, large-scale integrators have received the designation of “dragonhead enterprises” (DHE) by local, provincial, or central governments, based on meeting the criteria for scale of production, use of technology, and management [15]. DHEs can be either public or private, and their status means that they commit to integrating and scaling up production, they receive “enhanced legitimacy as a trustworthy company in the market,” and they acquire access to certain government programs and subsidies [29]. DHE-led contract farming is the mode of vertical integration in the broiler sector. The contracts are either directly with farmers or with a cooperative, and the farmers are usually based in the same area [15].

In the most integrated (though not predominant) type of vertical arrangement—the fully integrated “grow-out” model—farmers are only charged with growing out the birds, they are simply wage employees who do not own any of the production facilities [15]. Investment banks do not anticipate that this “grow-out” model will be the predominant value chain model in China, as it requires substantial financial capital, land, and management expertise [15].

IATP anticipated that fast food chains and large supermarkets will continue to shift to sourcing poultry meat from

large-scale integrators like DHEs instead of small farmers at wholesale markets, as the former are perceived to offer higher-quality and more homogenous products [15]. In a move that appeared to be in the direction of the “grow-out” model of full vertical integration, Tyson invested hundreds of millions of dollars to build its own poultry farms near Shanghai, with the plan to have 90 large-scale farms up and running by 2015 [37]. The company opted for this strategy to address food safety concerns, rather than relying on contract farmers [37]. As reported by *The Wall Street Journal*, in contrast to typical US contract poultry farmers, who raise about 100,000 birds per year, Tyson’s roughly 4,000 contracted farmers raised far fewer birds—perhaps only a few hundred—per operation. Tyson determined that taking over production through its own farms would allow it to have “direct oversight” [37]. However, the company also had to install electrical lines and build roads and bridges to make its new, large-scale farms possible. An additional challenge to these investments was a lack of agricultural land in China [37]

Integration in the beef sector

A 2010 article reported a low rate of contract farming in China and noted that, in the beef industry in particular, there was a consensus that informal and flexible supply arrangements had replaced formal supply contracts [11]. Moreover, modern slaughterhouses in China had not been able to source enough cattle that met their standards, and therefore had to make purchases on the open market [11]. The article also claimed that both specialized farming households and those that weren’t so specialized “readily renege[d]” on their contracts, abandoning long-term feeding agreements and selling cattle on the open market to benefit from short-term fluctuations in price [11, p. 484].

Integration in the swine sector, part 1—typology and general characteristics

Integration in the swine sector began at least as far back as the mid-90s, at the outset of the structural adjustment period [22]. Official statistics report that by 2005, near the end of that era, half of the country’s arable land and 36% of farming households had been vertically integrated [29].

The integration process has continued, and there are now several different forms of vertical integration described in the literature. One three-mode typology offered by the Institute of Developing Economies describes three ways that an integrating company can link to farmers: 1) di-

rectly, 2) by basing itself in a locality and linking to farmers (creating a an animal-raising village or “base”), or 3) by going through an association/co-op as an intermediary [22]. Contracts can take various forms, as well: oral, signed with the farmer directly, signed through a co-op, or signed directly but negotiated through a co-op [22]. The Institute of Developing Economies report also noted some downsides to integration, including the unequal distribution of benefits to the detriment of farmers and the fact that farmers often break contracts to take advantage of higher demand and prices [22]. On the other hand, the report states that the enhanced ability of integrators to control meat quality is a benefit of vertical integration.⁷

An academic article described a slightly more specific typology: DHEs, specialty co-ops, and government-run specialty wholesale markets [38]. DHEs are supported by the government as the preferred mode of integration, in furtherance of “aggressively capitalistic agribusiness” [38, p. 107]. As recounted by a 2014 IATP report on the pork sector, these entities are appointed by the government provided they meet certain levels of assets, sales, and number of integrated farms [29]. They are primarily processors or distributors, although pig breeders and producers can also attain this status [29]. As a DHE, a company obtains access to subsidies, tax breaks, and greater legitimacy [29]. In 2011, there were 110,000 DHEs and nine of the top ten pork processors were DHEs [29]. The Dragon Head Association, established in 2012, is a forum where companies and the government work together toward greater consolidation and integration. There are currently 110,000 DHEs [29].

The “company and farm” model of contract farming—involving contracts between DHEs and small farmers in China—is similar to contract farming in the US [29], but one 2015 business case study stated that contract hog farming was still not “popular” in China and farm sizes were small [34, p. 159]. Although the authors did not provide a citation for that statement, they claimed that this motivated Shanghui’s takeover of Smithfield, as the move allowed Shanghui to acquire Smithfield’s contract farming system and ensure a safe supply of hogs produced in the United States [34].

7. In this regard, a Reuters news story portrayed it as advantageous that pork processor Smithfield owned its own farms, because this reportedly allowed it to act quickly on its decision to stop using ractopamine as a feed additive. See Reuters. Analysis: Behind China’s U.S. pork deal, fears over feed additives. (5/30/13) Last Accessed 10/15/15. Available from: <http://www.reuters.com/article/us-usa-smithfield-ractopamine-analysis-idUSBRE94T03520130530>

Although DHEs are the primary vertical integration strategy supported by the government, co-ops are also a popular form of vertical integration. Unlike DHEs, co-ops arose spontaneously, were not actively supported by the government, and rely on small farms as their production base [38]. They help producers obtain inputs and credit; facilitate coordination among farmers, butchers, and merchants; provide technical and marketing support; and enhance standardization [38]. A 2011 article noted that co-ops were a significant part of vertically-integrated agriculture: as of 2005, they accounted for as much as 9% of total sales revenues acquired by DHEs, co-ops, and government specialty markets, and 36% of the total number of vertical integration entities [38]. The main reason behind their rise was that growers had more profitable arrangements from co-ops (they could share in the profits from processing and marketing), so preferred to be linked with them [38].

Specialty markets promoted and built by local governments, on the other hand, fall in between the co-ops and the DHEs [38]. With this form of integration, the local governments sponsor local brand names and market local products [38]. In theory, they treat the farmers more fairly in terms of setting prices and regulations than DHEs, but specialty markets are less developed [38]. They accounted for 31% of the sales revenue in 2005 [38].

Integration in the swine sector, part 2—quantitative empirical studies

We found several studies that used quantitative analysis of survey data to better understand the complexities of vertical integration in China. A few studies drew on a survey carried out with 229 Chinese pork slaughterhouses and processors in 2005 in Shanghai and the two eastern provinces of Jiangsu and Shandong [28, 33, 39]. One of these studies, published in 2007, found that integration did not have a significant, direct effect on the firm's performance. Internal integration of a company's own functions contributed more to performance than did factors like external integration and buyer-supplier coordination [39]. From this, the authors inferred that the pork processing industry was still in the early stage of supply chain integration (at least at the time of the survey) [39]. A few meat processing companies had established closer mechanisms for vertically-coordinating with their supplier and retailers around the time of the study, and the study authors recommended more of this type of external integration [39].

The same group of researchers conducted additional analyses on the aforementioned survey data to understand whether vertical integration improved pork quality management compared to individual "spot market" transactions [33]. They found that spot market transactions had a negative impact on the implementation of quality management practices in pork processing firms (e.g., selecting suppliers and quality of meat), while formal contractual governance had a significant, positive impact on implementation of such practices [33]. In addition, they also found that uncertainty in market conditions motivated the formation of closer vertical coordination mechanisms to protect investments and enhance adaptation to changing conditions (such as increased consumer preference for leaner pork or the use of new breeds) [33]. The authors concluded by recommending increasing contractual relationships and integrated governance arrangements [33].

Another study by the authors using the 2005 survey found that buyer-seller coordination—specifically, a more established relationship between the processing companies and their most important suppliers—was found to be significantly related to the processors' perception that customers were satisfied with them [28]. However, pork processors and their suppliers only shared plans, sourcing decisions, and inventories to a limited extent [28]. Processors did not fully involve suppliers or customers in developing strategies and production processes, even though the authors, based on their literature review, considered these elements parts of external integration [28]. In any case, they did not find that external integration was significantly related with company performance [28].

Lastly, a study using survey data from 2010 focused on a sample of 326 pork slaughtering-processing companies in the three eastern provinces of Jiangsu, Henan, and Shandong to explore governance structure choices in the pork supply chain [27]. Of the 326 companies, 81% still used spot market transactions with pig farmers, while the others used long-term contracts (8.3%), co-ops (7.4%) and integration (3.4%) [27]. Uncertainty and asset specificity⁸ were positively related to transaction costs, which were positively related to level of integration [27]. Collaboration advantages—including improvements in logistics,

8. High "asset specificity" means that assets are more valuable for a certain type of transaction and less valuable for other transactions. See Ji C, de Felipe I, Briz J, Trienekens JH. An empirical study on governance structure choices in China's pork supply chain. *Int Food Agribus Man.* 2012;15(2):127.

quality management, and technology—were also positively related to level of integration [27].

4) *Inputs*

a) *Breeding stock*

A 2013 editorial written by a representative of the Division of Animal Genetic Resources at the Chinese Ministry of Agriculture stated that the rapid intensification of the livestock industry was based on foreign-domestic cross-breeds, with most of the imported breeds being high-output international strains designed for commercial-scale production [6]. The editorial noted that the scale-up and intensification came at the cost of diversity of animal genetic resources [6]. The government, across different levels, had invested over five billion Chinese Yuan (over \$750 million USD) to build breeding and conservation farms [6]. A report by the Woodrow Wilson International Center noted that large farms in China used fast-growing species, many of which were the same ones used in CAFOs around the world; these species, however, were prone to disease [40].

For the beef sector, our landscape assessment did not yield specific information about breeds used in production. In the poultry sector, industrial broiler production relies on foreign breeding companies [15]. Cheaper white-feathered breeds from overseas have been replacing China's indigenous yellow-feathered breeds, although the latter are still sometimes raised on intensive farms [15].

For the swine sector, the introduction of pig species deemed “more efficient” was part of the industrialization process that began in the mid-1990s [18], although one source noted that leaner European breeds had been extensively introduced into China around 1900 through Russian, British, and German colonies [19]. As noted by a 2011 IATP report, there were over 100 indigenous pig breeds on traditional small farms, but specialized household and commercial farms now used primarily three major exotic breeds: Duroc, Landrace, and Yorkshire [41].

According to a Division of Animal Genetic Resources representative, indigenous pig breeds are more adaptable to varying environmental conditions and feed, and are more fertile, though they grow more slowly and have higher fat content [6]. A 2009 article reported that 60 to 70% of pork came from hybrids of Chinese native breeds and “high-lean” foreign breeds, while 30 to 40% came from a

Duroc-Landrace-Yorkshire crossbreed [25].⁹ Small farms might still use native breeds or hardy crossbreeds [30].

As part of a process of modernization in the livestock sector, the Chinese Ministry of Agriculture has implemented a long-term pig genetic improvement plan, with an expected duration of 2009 to 2020 [3]. A key element includes support for “core herd” breeding farms to produce breeding sows, “breeding stations” for boars, and programs to distribute semen to farmers [3]. The genetic materials used are based almost entirely on three exotic breeds, and are intended to form the basis of China's future pig herd [3]. One 2015 media source criticized this trend, asserting that with less genetic diversity, diseases were more likely to spread from one farm to another [42].

A 2013 news article reported that Genus, the US-based animal genetics company, was planning further expansion into China [43]. The company had introduced sows that produced twice the number of piglets as the typical sow in China [43].

b) *Feed*

General aspects

Based on feed sources, a 2008 article provided a typology of systems for the Chinese context [44]. In grazing systems, over 10% of dry animal feed is produced on the farm and stocking density is less than ten livestock units per hectare. These systems are found mostly in the north or northwest regions, where there are temperate or arid rangelands. There has been some intensification of agro-pastoral systems, with enclosure of grazing land, new breeds, supplementary feeding, and pasture improvement. However, market forces (e.g., competition for grains from the biofuel industry) and environmental conditions (e.g., over-exploitation of land and pasture degradation) limit capacity for intensification. Grazing systems are losing importance as mixed systems gain importance.

In mixed farming systems, over 10% of dry livestock feed is composed of crop byproducts or stubble, or over 10% of the production value derives from non-livestock farming activities. More chemical fertilizers and fodder crops have been introduced into these systems. Mixed farms with greater specialization more market orientation (especially those producing swine, poultry, and dairy cattle)

9. No citation or year was provided for these figures.

import feed concentrates.¹⁰ Mixed farms are becoming transformed into industrial systems.

Finally, there are industrial systems, where less than 10% of dry livestock feed is produced on the farm and annual average stocking density exceeds ten livestock units per hectare. These systems are increasing, and are usually found in peri-urban locations. Grain-based feed, energy, and other inputs are imported.

Feed conversion tends to increase from grazing to mixed to industrial systems, and this is true for poultry, pork, and beef [10]. Similarly, concentrates make up a larger proportion of feed, compared to roughage, in industrial systems [10]. Among livestock animals, concentrates are used in pork and poultry feed more than cattle feed, and this is true for all types of production systems [10]. Feed production in China has become a multi-billion-dollar industry in China [41].

Feed production as a challenge

China has a policy of maintaining 95% grain self-sufficiency [45]. Maize is grown in the northeast, while wheat is grown in the central, south, and eastern regions [8]. Maize production, compared to rice and wheat production, has increased dramatically, and the predominant use of maize is animal feed [46]. As modernization and consolidation take place, there is increased need for feed grains, especially corn and soy [41, 47]. Greater demand for feed—especially manufactured, compound feed—has led to agricultural intensification of crop production in the form of high-density planting, monoculture growing, and mechanization [47]. Producing grain for feed in China is relatively expensive because only 12% of the land is arable and there is a shortage of water, land, and labor, partly due to urbanization [47].

The feed shortage is exacerbated as animal agriculture intensifies in China [25] and it is described as one of the most significant constraints on increasing animal production [48]. For example, there is a lack of live cattle in China due to feed constraints, which limits dairy production and availability of calves for fattening [49]. One 2012 journal article argued that imports of both grain and protein components of feed were necessary and already occurring, but this rendered animal production less

competitive, and hence not as sustainable or profitable [48]. The authors argued that crop straw was being underutilized as feed, as straw was burnt and wasted when it could serve as a major food source for ruminants [48]. They also recommended transitioning to industrial systems for better feed conversion efficiencies [48].

Acquiring feed through imports and overseas activities

Historically, China was able to meet demand for livestock maize feed by using domestic sources, supplementing animal feed with soybean meals [5]. As reported in 2011 by IATP, the main component of the feed industry has since become imported, whole soybeans, which are crushed to make feed and oil, mostly by foreign firms operating in China [41]. Corn, produced domestically but also imported, competes with soy as a primary component of feed [41].

Soy production for feed was liberalized in the 1990s [47]. Between 2003-2004 and 2011-2012, soy imports increased 253%, from 17 million metric tons to 60 million metric tons [47]. Brazilian soy imports to China, in particular, have increased significantly, driving conversion of natural ecosystems to large-scale soy farms in Brazil [47]. Efforts to reduce deforestation in the Amazon have been accompanied by intensified soy production, which relies heavily on chemical inputs (pesticides and herbicides) [47].

There are different types of overseas investments related to feed [50]. In addition to imports, Chinese companies have invested in contract farming abroad, including in Brazil for soybeans [50]. They have also invested in land and water resources, mostly in Asia, but have at times encountered local resistance [50]. In 2014, an analysis by Rabobank projected that China would need at least 15 million more metric tons of grains over the next ten to fifteen years to meet the needs of livestock production demand [51]. The rising cost of transportation was cited as an additional concern in 2004 because of the impact on the cost of importing feed grains [52].

Animal feeding practices

In Chinese industrial food animal production, feeding regimes have become standardized for weight gain and methods for feeding and watering are mechanized [15]. A few sources discussed specific feeding practices for poultry and cattle, and most focused on swine.

10. Concentrates are high-energy ingredients that include fats, cereal grains, high-protein oil meals/cakes, and agro-industrial byproducts (such as those resulting from sugarcane, animal, and fish processing). They are distinguished from roughages, which include pasture grasses, hay, silage, and straw.

There are two types of household-level cattle production: pastoral/grazing systems in the northwestern and southwestern pastoral zones and cattle production in agricultural areas [8]. The latter consists of either cow-calf production combined with cropping, or specialized households using grain to fatten cattle [8]. Industrial cattle feed relies heavily on maize and rice, which are irrigated and fertilized, as well as concentrates [10].

Industrialized poultry production relies on manufactured feed. Poultry has a higher feed conversion efficiency (and thus a lower feed conversion ratio) than pork, which is a key driver of the industry's growth [15]. Exotic, white-feathered breeds and indigenous, yellow-feathered breeds have feed conversion ratios of 1.8 kg of feed per kg chicken and 2.5 kg of feed per kg chicken, respectively, while it requires 3 kg of feed to produce one kg of pork [15]. Poultry is more affordable for consumers than pork as a result [15]. In the US, a similar difference in feed conversion ratios by animal is also present: US broilers have a ratio of 1.91¹¹, lower than pork's ratios of 2.66 and 2.50 for "conventional" finishing (the final stage in swine production) and wean-to-finish production, respectively [53].

According to a 2012 USDA report on the Chinese pork industry, hog feed is composed of 60% corn and 15% soy-meal, though composition varies greatly across farms, farm size, and regions [23]. A 2011 IATP report stated that commercial pig producers used soy-based feeds, while for small and specialized farms corn was the most common feed ingredient [41]. Though small farms usually give pigs self-produced feed, they are now transitioning to industrial feed and may use purchased feed and supplements at key points in the production cycle [41, 47]. Some specialized household farms, which are considered medium-scale operations, rely on purchased feed, while others use it as a supplement [41].

A 2014 study provided more details on feed components used in different sized systems: in backyard farms producing less than 50 pigs per year, little or no concentrate feed is used, as pigs are fed byproducts of food processing, kitchen waste, leaves, and crop residues [18]. In these operations, pigs take a long time to reach their slaughter weight of around 150 kg due to poor management and low feed quality [18]. A separate study from 2011 reported that time to reach slaughter weight is around 200 days

for traditional pig farms [30], while a 2011 IATP source provided a time-to-market period of 10 to 12 months [41]. In medium-sized and industrial systems where 50 to 3,000 or more pigs are raised, pigs are fed corn or soybean-based concentrate feed, with some food-processing byproducts [18]. The 2014 study described a slaughter weight of 100 to 110 kg, reached in less than 190 days [18]. The 2011 IATP source similarly reported five to six months for pigs produced on commercial and specialized farms [41]. A study conducted in 2005/2006 using a sample of 35 intensive farms observed that early pig weaning was a popular strategy taken from "Western farming practices," which had penetrated even into inland, underdeveloped provinces [2].

A 2011 article noted that the Chinese government was subsidizing pork production by operating feed grain mills at a lower cost and by encouraging development of feed mills to increase feed efficiency and decrease the cost of feed [30]. At the writing of that article, feed costs were 60 to 70% of the total cost of producing a pig in China [30].

c) Antimicrobials, growth hormones, and other additives

In 2014, China was the largest producer and consumer of antibiotics worldwide [18]. Although there are no official statistics on the amount of antibiotics used in Chinese agriculture [54], one 2014 article estimated that 97,000 metric tons of antibiotics were used per year in animal agriculture [55]. This is a significant increase from a previous estimate provided by another source, which stated that about 6,000 tons were used annually around 2003 [56]. The overuse and abuse of veterinary drugs, as well as other substances, have led to numerous food safety scandals in China [55].

There have been a number of site-specific studies documenting antibiotic use on livestock farms. In a 2007 study, researchers collected and tested manure samples from 17 pig, 12 meat chicken, 14 layer, and 28 cow large-scale feeding farms across eight provinces. The study detected residues of multiple classes of antibiotics in all of the manure sample types [56]. Another study tested *E. coli* in water samples collected in 2013 from surface water surrounding small-scale animal farms based in a county of Beijing, which had the highest animal feeding density among its suburbs, as well as fecal samples from several of the farms [57]. The researchers concluded that veterinary antibiotics had been used extensively in live-

11. National Chicken Council - US Broiler Performance: 1925 to Present, available at <http://www.nationalchickencouncil.org/about-the-industry/statistics/u-s-broiler-performance/>, last visited Feb. 16, 2016.

stock farming in the area, and that such use was most likely causing the prevalence of antibiotic residues in the surface water. Almost 90% of the *E. coli* isolates from the rivers were antibiotic resistant, but there was no statistical correlation between the extent of resistance (i.e., resistance frequencies) and the corresponding antibiotic concentrations, suggesting that other factors may affect the formation of antibiotic resistance. Other studies on antibiotic use for specific types of animal production are discussed in the subsections below.

As a 2014 report by the Forum on Health, Environment and Development [45] pointed out, there is a lack of large-scale data on antibiotic resistance in food in China, and there has been no systematic analysis linking intensified animal agriculture to antibiotic resistant bacteria (ARB) [45]. (FORHEAD is an interdisciplinary network of people from China and elsewhere, working in research, government, civil society, and the media.¹² More details on the organization are provided in the final sub-section of this profile.) Nonetheless, FORHEAD noted that several small-scale studies have documented the rise of ARB in food, and that this problem “presumably relates fairly directly” to trends in intensified production [45, p. 37].

Veterinary inputs and swine production

Animal health is considered a major challenge in Chinese swine production. One 2011 source stated that this is especially true for small-scale farms [30], while another 2011 article identified a lack of training and veterinary expertise, even for larger farms [19]. According to the latter, there are neither appropriate quality vaccines nor diagnostic capacity available to farmers [19]. On large farms with farrow-to-finishing systems, animals are not separated by age and quarantine is not practiced. Land scarcity is one reason for the development of these mixed-age systems [19]. A 2013 news article claimed that pig mortality and disease are worsening, and attributed this to both the high density of pig farms and poor management by small farms [58].

In an effort to control and prevent disease, and potentially also for growth promotion, antibiotics are used as feed additives in pig farming, leading to problems with drug residues and resistance. One study estimated that 34 million kg of antimicrobials were used in swine production in 2012, with 70% administered in the finishing phase [54].

12. Forum on Health, Environment and Development, available at http://www.forhead.org/index_en.php, last visited Feb. 13, 2016.

Tetracyclines, followed by sulfonamides, were the most common classes used [54].

Several studies have profiled antibiotic resistance at or around particular swine production facilities. A 2013 study examined antibiotic-resistant genes (ARGs) in three large-scale (10,000 animals per year) commercial swine farms, each in a different region of China [59]. The researchers collected samples in 2010 at three stages of manure processing: manure, manure compost, and application of compost to soil. They found that swine farms in the study used growth-promoting antibiotics and metals (zinc, copper, and arsenic). The levels of metals were on par with other Chinese swine farms, and only slightly higher than in the US and Europe. Although there was not one particular antibiotic or metal concentration level considered excessive, the sheer quantity of additives used was considered “striking” by the researchers [59, p. 3437]. Moreover, the fact that the resistance profiles of the ARGs were similar across geographically dispersed farms, diverse composing techniques, and different antibiotic dosages suggested that similar reservoirs of ARGs were likely found across the country, as well as in other countries with similar livestock rearing practices.

Another study was based on samples of *Enterococcus* species collected in 2009 from two intensive chicken farms in Shandong Province and four free-range mixed poultry-pig farms in Beijing [60]. The researchers tested the bacteria for resistance to 12 antibiotics and found that the vast majority of the bacteria isolates (91%) were multidrug resistant. They concluded that resistance to most antimicrobials was more prevalent in China than in other Asian countries and Europe, underscoring the need for more discriminatory use of antibiotics in poultry and swine production. In particular, there was a high prevalence of highly aminoglycoside-resistant *Enterococcus*, possibly because this class of antibiotics was the most commonly used type in the sampled farms, serving both therapeutic and nontherapeutic purposes.

Besides antibiotics, other chemicals and contaminants are also found among swine production inputs. A 2007 think tank report noted the use of melamine,¹³ a coal-

13. According to the World Health Organization, melamine may cause kidney stones and kidney failure in humans, with signs and symptoms that include irritability, blood in urine, little or no urine, signs of kidney infection, and high blood pressure. See World Health Organization—Questions and Answers on Melamine, available at <http://www.who.int/csr/media/faq/QAmelamine/en/>, last visited May 8, 2016.

based industrial compound, added to swine and fish feed [40]. There are also heavy metal contaminants in drinking water and feed, such as arsenicals and copper sulphate used as growth promoters, as well as pesticide residue in crop/plant feed and mycotoxin residue in commercial feed [40]. One particular problem with metals added to feed for growth promotion or disease control is that they may exert “long-term co-selective pressure for antibiotic resistance” [59, p. 3437].

A 2005 study tested for arsenic in 29 pig feed samples and 29 pig manure samples in eight pig farms in Beijing, which raised between 3,000 to 10,000 heads each [61]. Arsenic, which was administered in swine feed in China traditionally for coloring, was found in 100% of the feed and manure samples. It was generally administered to weaners and grower-finishers [61]. In a third of the pig feed samples, arsenic concentrations exceeded the limit of 2 mg per kg set by the government, but overall there was a wide range in concentrations, leading to the conclusion that there was no standard for arsenic supplementation and each farm applied amounts at its own discretion [61].

Used as growth promoters, clenbuterol (a steroid) and ractopamine (a beta-agonist) have attracted attention from the media, the research community, and policymakers. Generally, antibiotics are used instead of clenbuterol [42], as the steroid was banned from animal feeds in 1997 [31]. However, it is still used illegally to speed up lean muscle growth [31]. When present in food consumed by humans, its health effects include heart palpitations, nervousness, dizziness, nausea, fever, chills, vomiting, and muscle tremors [31]. According to an official report, there were 18 incidents of food-related clenbuterol poisoning in China between 1998 and 2007, with over 1,700 persons becoming sick and one fatality [31]. At least two major incidents in 2006 involved pig products, one affecting over 100 people who had eaten pig lungs contaminated with the steroid, and the other affecting at least 336 people who had consumed tainted pork and pig organs [31]. In 2011, there was a scandal when it was revealed that the major pork processor Shanghui had sourced pigs which had consumed clenbuterol [29].

Ractopamine, a beta-agonist, has also triggered various food safety scandals and policy actions. Producers began using ractopamine in the 1990s as an alternative to growth hormones, as the substance changes the metabolism of animals and can promote lean meat growth [62]. According to a 2013 news article, there has not been an

independent study on the human health impact of consuming ractopamine-tainted meat over the long-term [62]. Nonetheless, it reportedly caused a food poisoning outbreak in 2001, was prohibited from animal agriculture in 2002, and was banned from importation in 2009 [46]. In 2009, ractopamine was discovered to be used in pig farming in Henan, so the government launched an investigation to remove it from animal feed [46]. Following this, a new law banning the sale and manufacturing of ractopamine in China was passed in 2011 [46].

Beginning in March 2013, China required third-party verification that US pork imported into China was free of ractopamine [62]. US-based Smithfield, a source of pigs for China, “quietly” began weaning its pigs off of ractopamine in 2014, and its decision to do so could pave the way for other companies to also stop using the additive [62]. As of 2015, half of Smithfield’s pork was free of ractopamine [34].

Veterinary inputs and poultry production

Similar to swine production in China, animal health is also a major challenge for the poultry sector. In some cases, the issue is portrayed as being more serious for small-scale chicken farmers than larger-scale producers. For example, a 2011 USDA report on Chinese poultry production stated that broiler meat production had shifted toward larger-scale and standardized production using isolated facilities, thereby enhancing disease control and reducing the risk of highly pathogenic avian influenza (HPAI) [63]. The report described HPAI as “China’s greatest avian disease threat affecting mostly backyard and other small operations” [63, p. 3].

Importantly, other sources highlight conditions associated with intensive poultry farming that compromise animal health. A 2014 IATP report, for example, noted that low profit margins forced producers into highly-intensive farming practices [15]. The report cited a farmer in Shandong who stated that the profit per broiler was only 1 Chinese Yuan (equivalent to approximately \$0.15 USD). Thus, to make more money, farmers had to raise a greater number of chickens in the same space. The extreme conditions reduced chickens’ immunity, becoming a “major incentive to misuse and overuse antibiotics and other additives” [15, p. 30]. The report noted that even many smaller and medium-sized poultry farms raised chickens in the same confined and intensive conditions as the larger farms and used antibiotics as inputs [15]. As one news article recounted, around the time when H5N1

was a problem in 2005, poultry farmers were administering the only antiviral drug known to be effective against the virus, Tamiflu, to their flocks prophylactically [64]. The chickens that were administered prophylactic doses of Tamiflu would not manifest symptoms if infected with H5N1, making surveillance a challenge and emergence of resistance to that drug a real possibility [64].

An estimated 4.5 million kg of antimicrobials were used in broiler chicken production in 2012, with 25% administered during the pre-starter and starter phases and 75% administered during the grower and finisher phases [54]. The most common class was coccidiostats (not including arsenicals),¹⁴ followed by arsenicals (which can also function as coccidiostats) [54].

A study examining the prevalence of coccidiosis from 545 large-scale poultry farms in nine provinces over the 2006 to 2010 period found that 97% of the farms used some prophylactic coccidiostats [65]. Oocyst per gram (OPG) faeces¹⁵ and coccidiosis morbidity rates increased when non-prophylactic or low doses of coccidiostats were used, with coccidiosis morbidity found to be the highest in Guangdong province. Moreover, in a drug resistance test, the researchers found that for many of the strains (though not all), drug resistance was correlated with amount of drug incorporated in the feed as additive.¹⁶

The study described previously, which tested samples of *Enterococcus* species collected in 2009 from two intensive chicken farms in Shandong Province and four free-range mixed poultry-pig farms in Beijing, found that 91% of the isolates were multidrug resistant [60]. However, the researchers found statistically significantly more resistance in Beijing free-range chickens compared to Shandong intensively-farmed chickens and speculated

that the style of farming was responsible for this: while the intensive farms used an “all-in, all-out-based system of production, with the primary aim of reducing the transmission of infectious agents,” the free-range farms “preferred to use a wide range of antibiotics, such as penicillin-aminoglycoside synergy or florfenicol, rather than relying on a clean environment to maintain their animals’ health” [60, p. 561]. Thus, based on this study, one should not assume that drug resistance is always greater in industrial/intensive farms than in less intensive/industrial farms; resistance is a concern whenever such inputs are used, especially over the long-term.

Metals and metal-derived additives are also administered in chicken feed for disease control and growth promotion. One 2014 study attributed the free use of metals to “primitive farming techniques and a lack of awareness of environmental concerns” [60, p. 283]. Researchers examined toxic metal accumulation from application of chicken manure to land, carried out by 42 family-run, smaller-scale (800 to 12,000 chickens) poultry farms in the southeastern part of Jiangsu Province [60]. For the manure samples, Zn, Cu, and As concentrations exceeded the corresponding standard¹⁷ for application of compost in agriculture in 66.7%, 14.3%, and 16.7% of the samples. For feed samples, concentrations of Zn, Cr, and As exceeded the National Hygienical Standard for Feeds thresholds in 74.3%, 56.3%, and 34.3% of the samples tested. Moreover, there were significant correlations between metal concentrations in feed and manure, suggesting that feed is the main source of metals in manure [60].

Veterinary inputs and beef production

We did not find any studies on the use of antibiotics or other additives in the beef sector. One 2015 news article reported that China’s largest beef producer, Kerchin Cattle Industry, was launching a new traceability system that would allow consumers to use smartphones to get real-time information on the origins of the beef, and this information would include details of drug residues in the meat [66].

14. Coccidiostats are administered prophylactically in feed to control coccidiosis (a parasitic disease affecting poultry) in commercial chicken production. See Zhang JJ, Wang LX, Ruan WK, An J. Investigation into the prevalence of coccidiosis and maduramycin drug resistance in chickens in China. *Vet Parasitol.* 2013;191(1-2):29-34.

15. Oocysts are cysts containing a zygote (a cell produced by the union of a male and female sex cell) formed by a parasite. The quantity of oocysts per gram (OPG) of freshly sampled feces is an indicator of the extent of infection.

16. The authors did not actually test for drug resistance in the study farms. To examine the relationship between drug use and resistance, they did a separate field trial where they prophylactically gave drugs to some chickens, then infected them, and then tested for drug resistance. They found a relationship between giving the drug as a feed additive and development of drug resistance. See Zhang JJ, Wang LX, Ruan WK, An J. Investigation into the prevalence of coccidiosis and maduramycin drug resistance in chickens in China. *Vet Parasitol.* 2013;191(1-2):29-34.

17. As there were no applicable standards in China for metals in livestock or poultry, the researchers used Germany’s standards for zinc and copper and the Italian standard for arsenic. See Liu Q, Sun X, Hu A, Zhang Y, Cao Z. Characteristics of toxic metal accumulation in farmland in relation to long-term chicken manure application: A case study in the Yangtze River Delta Region, China. *Bull Environ Contam Toxicol.* 2014;92(3):279-84.

d) Facilities for housing, slaughtering, and processing

Animal housing facilities and conditions

A 2005 study sponsored by Humane Society International (HSI) and Compassion in World Farming (CIWF) observed that “Western modern intensive farming technology and practices” had penetrated even remote parts of China and was expected to continue to spread “unabated” [61, p. 52]. The research, based on visits to 55 intensive livestock farms, found that of all the animals, chickens (especially broilers) were the most densely stocked, while beef cattle were kept in uncrowded conditions [61]. According to a 2014 IATP report, chickens in many smaller and medium-sized poultry farms are also raised in the same confined and intensive conditions as in larger farms [15].

The high density of pig farms has reportedly contributed to worsening pig disease and mortality [58]. According to official documents and farmer interviews, overcrowded livestock-raising conditions contributed to 16,000 pig carcasses being dumped into a river that supplied tap water to Shanghai in 2013 [58].

HSI and CIWF also documented that gestation crates were commonly used in pig breeding farms throughout the country and battery cages were used for layers and broilers; both practices were perceived as “Western” and scientific [2, 61]. IATP has observed that chickens are sometimes falsely marketed as cage-free and priced lower than truly cage-free chickens, making it hard for producers of the latter to compete [15].

Regarding the housing structures, the HSI/CIWF study found that ventilation was varied, with broiler farms and beef cattle sheds having poor air circulation and pig farms having some circulation due to their openness [61]. Floors of the housing structures tended to be made of hard concrete; cattle exhibited lameness and pigs could not root [61]. Moreover, sanitation was a problem in some intensive farms, as reflected by waste accumulation, flies, dirty food containers, and odors [61]. However, a 2014 news article reported that some of the newest hog farms were sanitary and high-tech; one “sparkling breeder operation” had video screen monitors, digital ear tags for the sows, and worker dormitories next door to prevent workers from bringing disease from their hometowns [67].

Slaughtering processing facilities and capacity

During the 1990s, large-scale slaughtering and processing companies imported modernized production lines and implemented advanced procedures for slaughtering, packaging, and selling products [31]. Modern methods and systems for stunning, scalding, vacuum blood collection, rapid cooling, chilling, and traceability, among other aspects of slaughtering/processing, have been accepted and incorporated by large-scale enterprises [31]. A 2012 study reported that during the prior decade, over 10,000 pieces of equipment were imported into China for meat processing [31]. Yurun Food Group, the largest food company in China and a vertical integrator, slaughtered over 40 million pigs in 2011, while Shanghui Group has the capacity for slaughtering 15 million pigs per year as of 2012 [31].

The growth of processing capacity appears to have outstripped supply of live animals in the pork and beef sectors. A 2010 study of high-value supply chains in the beef industry noted that there were approximately 20 large (by Chinese standards) modern abattoirs [11]. Despite slaughtering less than 3% of the country’s total cattle, these facilities were seen by policymakers as the “model of the future” and received preferential treatment through measures like tax breaks, low-interest loans, loans underwritten by the government, local monopolies, and assistance in developing “production bases” [11, p. 482]. Despite all of this assistance, there were not enough consumers in the market for high-value beef in China; therefore the market was over-crowded and modern abattoirs were operating below capacity, receiving low returns, and seeking shortcuts to transform cheap beef into premium meat (for example, injecting fat into the meat to give the appearance of marbling, or water to give the appearance of juiciness) [11].

According to media reports from the past couple of years, these challenges have continued. As one 2014 news article reported, subsidies provided by the government to stimulate increases in slaughtering and processing capacities have resulted in facilities (such as those of Shuanghui, Yurun, and Delisi) sitting idly, as there is not enough supply of pigs to keep the facilities operating at capacity [68]. In the beef sector, another 2014 article noted that small beef farmers were still more interested in selling to smaller, nearby slaughterhouses, so large processors faced a “persistent challenge” in sourcing cattle [69]. It has also been difficult to expand the supply because

farmers are deterred from farming cattle (which has a longer production cycle compared to other livestock) and natural resources are scarce [69]. In 2015, Australia became the first country to sign a deal to export live cattle to China [70]. It began doing so that same year, while China made progress toward an agreement to source cattle from Mongolia, as well [14]. One meat-producing region of China, Shandong, also proposed addressing the processing overcapacity issue by allowing duty-free imports of live cattle [14]. According to provincial officials, 70% of the current processing capacity was not being used [14].

e) Land use and land acquisitions

Land scarcity and land use in China

According to a 2011 review article, topography, soil, and temperature conditions restrict cultivation to 15% of the total land area in China, while urbanization, industrialization, and land degradation place further limits on arable land [30]. A 2013 study similarly notes that the amount of arable land per person is much lower than the global average, and has been decreasing due to soil erosion and land conversion [46]. Moreover, much of the arable land faces environmental stresses, and the highest quality arable land is located precisely where the most urbanization is occurring [46]. In China, the amount of freshwater available per person is also significantly lower than the global average [46].

In light of these circumstances, land and other natural resources are key concerns for food production [46], and have been deemed the primary limitations on expanding the livestock sector [30]. In the swine industry, production increasingly focuses on landless industrial systems that obtain feed from external sources and do not have any land base for manure disposal [18]. Given the lack of surrounding land, pig production manure is rarely recycled [18].

A 2014 journal article critically notes that CAFOs in general have been “[c]elebrated as paragons of efficiency” as “the only and most efficient way to address rising meat demand on a limited land base” [36, p. 626]. Agribusinesses lease land—ranging from a few hectares to tens of hectares—from village, township, or municipal governments, and then construct the buildings, a process that is sometimes done quickly and out of the public’s view [36, p. 626]. While packing thousands of animals into indoor spaces raises the amount of protein produced per unit of land (without taking feed production into account), the

environmental and social impacts of this model of production, described in greater detail below, “spread far beyond the CAFO” [36, p. 626].

Overseas investments by Chinese businesses

The government has encouraged Chinese companies, especially large-scale DHEs, to “go out” and invest overseas, as part of an overall strategy to expand livestock production and become more competitive [36, p. 626]. Many of these international investments are feed-related land deals, driven by the “21-9 Challenge”—the country’s population accounts for 21% of the global population but only has 9% of the world’s arable land [36, p. 626]. Chinese companies have sourced feed in Africa, Eastern Europe, Southeast Asia, and Latin America [47].

In 2004, much of China’s soy processing industry was taken over by transnational companies, so the government has tried to regain ground by encouraging “strategic state-owned enterprises” (SOEs) to invest in land abroad for soy production and livestock feed, among other measures [36, p. 626]. In 2008, the government issued directives that advised companies to seek out other countries where soybean was produced or could be produced, acquire or produce soybean, and bring it back to China [47]. One such investment, for example, involves Chinese companies establishing soybean contract farming in Brazil [50]. A 2014 IATP report on the Chinese feed industry documented land acquisition deals for soy production in Brazil at various stages, and similar deals underway in Argentina [47].

According to a 2011 Brighter Green report, Chinese companies were already producing food for Chinese consumption in Congo, Cambodia, Laos, and Indonesia, and an additional five billion dollars had been earmarked by the government to grow food and cash crops in Africa over the following 50 years [9]. In some cases, food was being grown and harvested by Chinese farmers themselves [9]. Although this information was not specific to feed crops, such investments could free up land within China to produce feed crops if food grains were being acquired abroad.

For production of animals, Brighter Green noted that the Chinese government had requested leases for Chinese-operated “mega-farms” and cattle ranches in Mozambique’s Zambezi and Limpopo valleys, as well as lifted its 400% tariffs on imports of agricultural products

from Mozambique [9]. In addition, the memorandum of understanding signed between the two governments in 2007 reportedly included provisions for at least 3,000 Chinese citizens to move to Mozambique and supervise the farms, which would hire local laborers [9]. However, the semblance to an “agricultural colony” raised such controversy that the Mozambican government denied the whole undertaking [9].

An International Institute for Sustainable Development (IISD) report similarly noted that Chinese companies’ investments in land and water, which were based mostly in Asia, have also met with resistance at times [50]. Even the Brazilian government has started pushing back on land acquisitions by foreign entities, leading to several unresolved Chinese investments, according to a 2014 IATP report [47].

On the other hand, a Food Climate Research Network (FCRN) publication recently pointed out that despite the media’s depiction of overseas “land grabs” by the Chinese as a threat, the research suggests that the scale of acquisitions has actually been quite modest [3]. There were 54 confirmed projects, with only 1.4 million hectares operational, and these included both private investments and government demonstration projects, both food and non-food production, and both export-oriented and locally-oriented production [3]. According to the FCRN, leases for the purpose of producing and exporting food crops are the “root of popular concern,” and these account for a small proportion of land [3].

5) *Waste management*

According to a 2013 study, an estimated 1.9 billion tons and 227 million tons of manure excretion and pollution, respectively, resulted from all livestock production in 2010, corresponding to 1.86 tons of livestock manure pollution per hectare of arable land in China [71].¹⁸ With no government intervention (i.e., policies to reduce discharge of manure pollution), total livestock manure pollution is expected to increase 31% to 298 million tons by 2020, with the eastern and southern parts of China experiencing the highest burden [71].

For swine specifically, another 2013 study estimated that 618 billion kg of swine manure were produced annually

[59], while a 2015 source calculated 1.3 billion metric tons of swine manure generated per year, equivalent to 47% of total livestock waste generated in China [34].

Given the environmental and public health consequences of such large quantities of waste (which will be described in the section on impacts below), adequate treatment is a pressing challenge. Since the increase in livestock production in the 1980s, the rate of recycling of organic waste has decreased [1]. There was a decline in the traditional methods of compost preparation and animal rearing, beginning with the more developed eastern coastal region [1].

Describing the situation in the mid-2000s, one group of researchers observed that most livestock production waste was untreated and discharged into the environment [1]. Only 44%, 43%, 10%, and 3% of beef, pig, chicken, and dairy cow waste were treated, respectively [1]. At large-scale production facilities, animal waste was typically separated into liquid and solid parts. Although the solid part was dried and sold as fertilizer or used as compost, the liquid part generally was not treated or recycled. Occasionally, the liquid component was stored in open-air lagoons or diluted with large quantities of water in order to be used for irrigation [1]. In fact, the researchers estimated that 90% of industrial-scale farms had no or very little capacity for waste disposal or treatment [1].

The researchers criticized the industry’s “pattern of reacting once serious pollution had already occurred,” and the fact that animal production plants were often established by local governments or private investors with only short-term economic gain in mind [1]. Accordingly, most production facilities were not designed with manure treatment or disposal in mind. When their polluting activities resulted in “economic difficulties or administrative pressure,” they were unable to raise the money needed for upgrades [1]. In this context, local governments operating these plants often simply continued to pollute rather than file for bankruptcy [1].

Several more recent sources describe continuing difficulties in managing animal waste. A 2014 study noted that animal waste is often stored in lagoons, where antimicrobial-resistant bacteria can survive for a long time and where there may be subsequent spills into soils and rivers [55]. Another 2014 study involving a sample of 42 family-run poultry farms, each raising between 800 to 12,000 chickens per cycle (about 70 days), noted that

18. The article abstract did not specify whether the unit of measurement was a metric ton, a long ton, or a short ton. The text of the article was only available in Chinese.

manure was commonly applied to fields that are part of the poultry farms because of a lack of facilities for organic fertilizer treatment in the area [60]. The manure was intensively and excessively used as fertilizers without any prior treatment by the poultry farmers [60].

For swine production in particular, a few sources differentiate waste treatment practices based on the scale of production. A 2012 USDA report noted that although manure treatment on small-scale farms is rare, large-scale farms are typically required to invest in treatment capacity [23]. Large farms may also receive subsidies from the government to build biogas tanks to manage swine waste; however, the distribution and utilization of huge volumes of biogas slurry and residue are still challenges [34]. A study conducted in Zhejiang province in 2012 described the waste treatment facilities of one large-scale pig farm (raising 180,000 pigs) as a “complete processing system, which included an anaerobic digester, a three-level anoxic/oxic process, five ecological purifying lagoons, and one soilless culture lagoon” [72].

On the other hand, a 2014 journal article by a separate group of researchers maintained that at the system level—from feed to pig production to consumption—medium-sized (50 to 3,000 pigs) and industrial-scale farms (3,000+ pigs) mostly discharge manure into lagoons, landfills, and rivers [18]. Liquid manure is collected but discharged into water bodies with little treatment, while solid manure is composted and then exported to crop farms. For smaller swine production facilities, liquid manure is lost via leaching and discharge into water bodies, and solid manure is collected and applied to crops [18]

According to the researchers, manure discharge has increased significantly due to the rise of landless systems (i.e., intensive animal production operations with no cropland); hence manure is rarely recycled as fertilizer, given the lack of surrounding land [18]. As a consequence, recycling of nutrients in the manure—nitrogen and phosphorous, specifically—is increasingly complicated [18]. Between 1960 and 2010, the total amounts of nitrogen and phosphorous lost to the environment from pig production increased by factors of 30 and 95, respectively, while the relative amounts of nutrient loss have also increased [18]. These trends are attributed to an eighteen-fold increase in the number of pigs slaughtered annually, as well as the shift from backyard to industrial production systems [18]. To reverse these trends, a “se-

ries of management and emission mitigation measures” is needed [18, p. 12747].

6) *Transnational corporations*

A few sources discussed the activities of transnational companies within China. Transnational companies took over much of China’s soy processing industry in 2004 [36, p. 626], but the dominance of these firms over soy processing operations has been scaled back since 2007 [47].

The government has encouraged foreign direct investment (FDI) in the poultry sector, except in relation to rare, unique, or transgenic poultry breeding [15]. This effort has involved measures including tax benefits, easier approvals, and fewer restrictions on foreign shareholding [15]. According to a 2014 IATP report, China’s industrial broiler and egg production depend on “foreign breeding companies that are global oligopolies,” such as Tyson-owned Cobb Vantress Inc., Erich Wesjohann Group (Germany), and Hendrix Genetics (The Netherlands) [15]. Other major foreign players in the Chinese poultry sector include Marfrig, Cargill, Brasil Foods, and Perdue Farms [15].

7) *Regulation of livestock production*

We found sources of information that describe three aspects of how the Chinese government has addressed livestock production: i) focus on food safety; ii) policies promoting industrialization and expansion; and iii) regulatory action/inaction.

Government’s focus on food safety

Food safety is a major concern in China; a number of food scares have resulted in the Chinese government focusing on stricter regulation, modernization, and industrialization of the food chain [73]. In the mid-2000s, a senior economic expert with the National Animal Husbandry and Veterinary Service wrote that the poultry industry was shifting from quantity-oriented to quality-oriented, and urged adoption of more measures to address problems like contamination with pesticide residues and heavy metals [16].

In general, the underlying assumption is that animal agriculture, as traditionally practiced, is unsafe and difficult to regulate. Small-scale production is viewed as the origin of food scandals [34]. The country’s livestock development strategy endorses adoption of foreign technology and production models, and household farms that only

selectively adopt modern farming techniques—such as non-therapeutic use of veterinary drugs and commercial feed—are perceived as backward, with “limited growth potential [...] and epidemic control problems” [2, p. 226]. Wet markets, where Chinese consumers customarily acquire fresh meat, are also seen as a source of disease epidemics, and the government is trying to phase them out [15]. Even specialized household producers are blamed for an unsafe food supply, as they are considered “much smaller and weaker than the firms that contract with them” [15, p. 9]. In the pork sector, the Chinese government views US-style CAFOs as the “solution to food safety problems” and is encouraging specialized farms to “become more factory-like” [29, p. 20]. They are also pushing for greater agglomeration within the pork industry [34].

To confront food safety issues, the government has implemented several systems: the Animal Labeling and Disease Traceability System, the National Monitoring and Control Plan on Animal Drug Residues in Animals and Animal Products, and the Surveillance Plan on Drug Resistance of Animal-Origin Bacteria [46]. It also passed a comprehensive Food Safety Law in 2009, meant to harmonize Chinese and international standards; however, implementation of food safety laws has been difficult [46]. For example, although ractopamine was prohibited in animal agriculture since 2002, its use was discovered in pig farming in Henan in 2009 [46]. The government had to launch an investigation to remove ractopamine from animal feed and passed a new law banning the sale and manufacture of the substance in 2011 [46]. Coordination between different levels of government and various regulators has posed a challenge, and a new Chinese agency, similar to the Food and Drug Administration in the US, was established in 2013 [46].

Government policies that support industrialization and scaling up

In 1979, the Chinese Ministry of Agriculture issued a “Report on Accelerating the Development of Animal Husbandry Industry,” which advocated for policies to encourage more peasant livestock farming, such as provision of grain and land and the opening of the livestock market [2]. In 1980, land distribution to rural households began, enabling peasants to expand livestock production [2]. A major change came in 1985, when the government opened the rural market, ceased procurement of agricultural goods, and removed price control [2, 24, 39]. Farmers were now allowed to sell everything they produced on the open market, and the government encouraged

specialization in farming and construction of large, industrial-scale farms [2]. Beginning in the late 1980s, the government took measures to encourage the establishment of intensive feedlots, aimed at guaranteeing a stable supply of quality animal products [5]. Among other fundamental changes, meat processing companies were able to establish closer vertical relationships with suppliers and retailers [39].

During the 1990s, the government gave even more explicit support to modernization and scaling up through policy incentives, tax breaks, and lax environmental and labor regulations [2]. The number of intensive feedlots increased from the early 1990s [5]. The government saw industrialization as a way to avoid epidemics (as discussed in the subsection above); the paradox, according to one researcher, was that high stocking rates made “disease spread like prairie fire” [2, p. 235]. The government focused on productivity in the late 1990s, introducing foreign breeds and implementing policies to promote their uptake [24].

In the first decade of the new millennium, the government at federal, provincial, and local levels undertook various measures that benefitted both large and small farm operations [19]. These measures included efforts to stabilize profits, ensure insurance for breeder stock, provide subsidies for expanding farms and breeding programs, strengthen the supply of vaccines, and adopt tax exemptions [19]. For example, through “preferential policies,” the government of Chengdu (the provincial capital of Sichuan, the province that continually ranks at the top for pork production) encouraged the establishment of 1,000 pig production farms with over 500 sows at the end of 2007, worth 1.1 billion Chinese Yuan [73]. Another initiative, as described earlier, consisted of the creation of livestock production clusters that declined in the late 2000s and led the government to prefer fewer, larger producers instead of many smaller producers [17].

Toward the end of that decade, the government’s “Number One Document of 2007” on “modern agriculture” promoted the use of modern infrastructure, technology, and industrialization as a way to enhance quality, profits, and competitiveness of agricultural firms in China [11]. The Ministry of Agriculture advanced a plan to subsidize building livestock production zones, places where farmers could congregate their animals to form large-scale farms [23]. Vertical integration was also endorsed, with the government establishing the Office for the Vertical

Integration of Agriculture [38]. The office issued its first report with statistical information in April 2008, which stated that by 2005, half of the country's cultivated area and 36% of farming households had been vertically integrated, either by dragonhead enterprises, co-ops, or government-run wholesale specialty markets [38]. The central government, with some provincial, municipal, and county governments following suit, provided subsidies to selected DHEs, while some provinces, which were too poor to provide subsidies, waived or reduced taxes [38]. At the same time, co-ops received few subsidies and no "substantive government support" [38].

Recent sources have revealed the continuation of active government support for the livestock industry, especially related to the pork sector. According to a USDA report, assistance for the pork sector "varies from year to year and place to place" [23]. When orders come from the national-level government, local government and banks undertake special efforts to implement them [23]. One example of this was the China Bank Regulatory Commission's 2007 instruction to banks to stimulate further expansion of pork production capacity. Commercial banks were ordered to lend to businesses raising or slaughtering pigs, rural credit cooperatives were ordered to give loans to individual swine farmers, and village banks and rural lending companies were ordered to offer production credit [23]. Another national policy, the "Formulation of Development Plan on National Slaughtering and Processing Industry (2010-2015)" issued by the Ministry of Commerce, has encouraged slaughtering and processing companies to integrate with pig producers [27]. Establishment of modern swine farms has also been promoted by reduction of taxes— corporate income tax was reduced from 33% to 25% in 2007—and by foreign enterprises, which the Chinese government urged to set up joint ventures for swine farming in China [30].

In addition to subsidies and tax breaks, the government has also provided free mandatory immunization, grants for large hog farms, subsidized insurance, methane digesters, and assistance in disposing of diseased animals [26]. According to a 2015 media source, there is widespread fraud in the system of government subsidies to pig breeders and slaughterhouses [74]. Slaughterhouses overstate the number of pigs they slaughter to obtain larger subsidies, while local governments overstate their sow numbers to receive more money from the central government [74]. The article also reported that two agricultural officials were convicted in Shaanxi province for

mismanaging government subsidies for disposal of diseased pigs [74].

To address extreme volatility in the Chinese pork sector, the government has set up a national pork reserve system to stabilize the price ratio of hogs and corn [26, 34]. The volatility has been attributed to "cyclical price and weather variations" [26]. One example of this variation is that consumers eat less pork during the summer (because of hot weather) and more pork right before certain annual festivals [34]. Shortage of land and water may also be contributing to price surges [26].

Additionally, given that feed costs on the typical commercial swine farm accounts for the majority of production costs (60-70%, according to sources from the 2000s), the government has also promoted the development of mills to reduce the cost of feed and increase feed efficiency [30]. It has attempted to subsidize pork production by operating feed grain mills at a lower cost (in fact, most feed mills are collectively or government-owned) [30].

In comparison to the pork sector, there was less information about policies promoting expansion of the beef sector. One 2010 article noted that policymakers in China had tried to push the beef sector from low-value to high-value supply chains, without developing mid-value supply chains, which would have been a more "incremental and inclusive modernisation process" [11, p. 480]. By doing this, they created an "overcrowded and over-supplied modern abattoir sector," precipitating a negative cycle whereby processors cut costs, paid less to the producers, and further discouraged producers from being part of the high-value supply chain [11, p. 480]. In the beef sector, there are approximately 20 large modern abattoirs, which slaughter less than 3% of the country's total beef output (as of 2006) [11]. Nevertheless, they are seen by policymakers as the "model of the future" and given preferential treatment through measures like tax breaks, low-interest loans, loans underwritten by the government, local monopolies, and assistance [11, p. 480]. However, when representatives of the abattoirs and the beef industry lobbied the central government around 2007 for subsidies for cow-calf producers, President Hu Jintao and the Minister of Agriculture rejected the proposal on the basis that beef was "no longer a strategic industry in terms of food security" [11, p. 480]. On the other hand, a 2014 news article reported that Chinese officials were encouraging the expansion of cattle breeding and production

into the western hinterlands, “in a sustainable manner” and “according to local conditions” [49].

For poultry production, the government at various levels has incentivized scaling up, intensification, and consolidation through direct subsidies, subsidized loans, and tax exemptions for poultry producers, as it does in the pork sector [15]. According to a senior economic expert with the National Animal Husbandry and Veterinary Services, “intensification promises to be the right track for China to follow to develop its poultry industry” [16]. The expert observed that government policies had encouraged proper waste disposal and construction of supporting facilities [16]. In his view, “[a]unified approach for vaccination, disease prevention and management ha[d] been enforced across the whole country” [16]. He predicted that the Chinese poultry industry would adopt even more industrialized farming methods, as well as produce more processed poultry products for sale domestically and internationally [16]. In this vein, a 2014 IATP report noted that the poultry sector may benefit from government policies even more than pork and beef because it requires less grain and therefore contributes to China’s grain self-sufficiency [15].

As can be seen from the preceding description, the Chinese government is actively supporting intensification and expansion of livestock production, through actions taken at the local, provincial, and national levels. One 2014 report by the Food Climate Research Network notes that although the “general thrust of government policy favors large-scale, industrialized modes of production,” there is nonetheless acknowledgement of backyard production’s important contribution to both rural livelihoods and meat availability in those areas [3]. In light of this recognition, backyard producers have received some support, such as subsidies for installing biogas digesters and raising breeding stock [3].

Regulation of IFAP

Regulation of animal agriculture has been a continuing challenge in China. The country’s first Animal Husbandry Law went into effect in 2006, encouraging development of large-scale farms, genetic integrity, food safety, and zoning for environmental protection [40]. Although the Chinese State Food and Drug Administration was established in 2003, much enforcement “rests essentially in the hands of local government enforcers” [25, 40, p. 27]. As noted by a 2012 study, there are regulations on meat safety and quality, but many administrations are involved

and inter-institutional collaboration is not efficient [31]. There are also animal welfare regulations, a traceability system, and a system for tracking food carbon emissions; these, too, are not well managed [31].

Sources that criticized the lack of effective regulation of industrial food animal production tended to focus on three topics: use of antibiotics or other feed additives; waste discharge and other environmental impacts; and animal welfare. Antibiotics are allowed as feed additives in China [25]. Although the country recently banned 227 drugs, including 150 antimicrobials, for animal agriculture [55], some researchers have pointed out that there is little monitoring of antibiotic residue in animal waste or in feedlot environs in China [56]. According to a 2015 article in the *China Economic Review*, there is also no monitoring of veterinary drug use or drug-resistant pathogens in animal populations, as “[e]xisting laws in China, already spottily enforced, pertain to food safety only so far as consumer health is directly affected” [42]. One reflection of this might be the ractopamine example, described earlier. Starting in March 2013, China required third-party verification that US pork imported into China was free of ractopamine [62].

The *China Economic Review* article noted that the Ministry of Agriculture did report on disease outbreaks, but that underreporting was likely, given that livestock may not show symptoms and those that do are often quickly sold and slaughtered [42]. The scaling up of farms and overuse of antibiotics were key features of industrial farming, which could foster drug-resistant pathogens in the hog population [42]. Such practices “follow US industry templates which, when copy-pasted onto a mainland Chinese canvas, carry with them a clutch of endemic issues that create further complications in a more lax regulatory environment” [42].

Although manure discharge is officially prohibited as per China’s approval of the 1972 “London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter,” there have been delays in implementation, along with “many practical barriers and constraints” [18, p. 12748]. According to the USDA, a number of Chinese cities and provinces had regulations to prevent swine farms and slaughterhouses from operating near waterways and residential areas [23]. In this regard, a 2005 journal article noted that the Beijing area had imposed a regulation requiring treatment of animal waste from production plants using digesters in 2001, while the Shang-

hai municipal government ordered closure or relocation of 259 pig farms by 2005 to reduce pollution [1]. There were some environmental regulations, with recent ones having stricter standards; however, lack of effective enforcement is a problem [1]. Accordingly, the researchers observed that the only policies occasionally enforced pertained to the relocation of animal production facilities [1]. At the same time, “counterproductive policies,” such as subsidies for imported feed and locations of public slaughterhouses, were facilitating peri-urban and large-scale livestock production [1].

On the topic of animal welfare, one 2011 study compared animal welfare regulations in various chicken meat-producing countries, including developed and developing countries [35]. Although the study did not discuss the Chinese situation in depth, it deemed welfare regulations in China “negligible” [35]. A 2012 study noted that “no detailed standards” existed for pre-slaughter management [31, p. 194].

Within the past year, a number of media sources suggest that Chinese officials are acting more proactively in terms of enacting and enforcing regulations related to animal agriculture. The new Chinese FDA, established in 2013 and given ministerial status after officials from the former FDA were jailed for corruption, has reportedly worked to restore the public’s trust in food safety [75]. The agency named the suppliers of meat that were found to have drug residues beyond the allowed thresholds during spot checks of pork and chicken in the first semester of 2015 [75]. Over 20 veterinary drugs, including enrofloxacin, clenbuterol, salbutamol, and ractopamine, were detected, some of which had been banned outright from animal agriculture [75].

Moreover, three new laws came into effect in 2015. One is a new food safety law, considered extremely tough, especially with respect to traceability and labeling requirements [76]. The second is an environmental law that led to closing down of farms and feedlots in several regions [76]. Finally, there is also a new advertising law designed to protect consumers by making companies liable for false or misleading advertising [76]. Companies are also required to disclose feed and antibiotics used on the labels, as well as provide information on inputs and origins for products sold online [76].

Officials are also reportedly putting restrictions on pig farming in the southeastern region of Guangdong, in fa-

vor of promoting less-polluting, higher-value, and high-tech industries instead [77]. In addition, there is a certification known as the “Geographical Indicator” certification, which identifies the meat product’s origin [78].

Impacts of industrial food animal production

1) Impacts on worker health

There was limited information on the occupational health impacts of industrial food animal production, and our landscape assessment did not find any studies focusing on these issues. One IATP report on the poultry industry summarized a few problems, noting that worker health was jeopardized because of the intense competition in the sector [15]. Practices employed to cut costs were leading to accidents, such as a major fire at a poultry plant in Jilin province in June 2013 [15]. The doors had been locked to prevent stealing and facilitate easy monitoring of the factory, and workers were trapped inside when a fire began due to an ammonia leak [15]. According to the report, other problems affecting occupational health in poultry factories include exposure to pollutants, pathogens, toxic fumes, and repetitive strain injuries [15].

A 2007 report noted that CAFO-generated air pollution, including hydrogen sulfide, ammonia, and endotoxin, could increase workers’ risks of upper respiratory diseases, death from asphyxia, and respiratory arrest [79]. However, the concerns were based on studies of CAFOs in the United States, and the authors of the report were inferring that Chinese CAFO workers could face similar problems [79]. A 2011 paper on intensive pig farms mentioned that moving the farms away from cities to less densely populated areas could help improve worker safety; however, it did not discuss what unsafe conditions were currently faced by farmworkers or how the relocation would help [30].

2) Impacts on surrounding communities and others

Various sources discussed the ways in which industrialized food animal production affected the welfare of rural communities and the public at large.

Social impacts

There are several social impacts that may stem from a country or region adopting an industrial model of meat production. A 2011 IATP report noted that the livelihoods of smallholders in China were being destroyed, inequality was increasing, and rural-to-urban migration was rising

[41]. Recommending that subsidies devoted to industrialized livestock production be redirected toward local food systems and farmer associations, the report lamented that “[s]mallholder agroecosystems and the collective systems of knowledge associated with them [were] steadily being dismantled in the rush to industrialize and urbanize” [41, p. 24]. Focusing specifically on consolidation in the pork industry, the authors noted that small-scale farmers were forced either to become specialized producers or to become waged migrant workers [29].

A separate study from 2008 posed the question of whether poor households or rich household benefited from increased production, and determined that the answer depended on the supply chain [5]. If livestock were marketed mainly through traditional supply chains—as occurred in the pork sector—then the poor could benefit and increase their market share, though not their scale of production [5]. On the other hand, if new operators and supply chains were used to market the products—as in the case of the poultry sector—production scale increased, but to the exclusion of poor households [5].

Public health impacts

A number of sources warned about the impacts of livestock production on public health. Food safety issues were frequently mentioned as a problem associated with industrialized meat production, often in relation to use of antibiotics and other animal feed additives. According to a 2011 IATP report, contaminants of animal products have included antibiotic residues, heavy metals from metal-derived growth promoters, and growth hormones. The authors stated that such substances are used in an “endless pursuit of producing more meat in shorter periods of time” [41, p. 20]. Antibiotic resistance resulting from the prophylactic use of antibiotics in livestock production—to prevent disease and promote growth—has been a particular concern. As noted in a 2015 study by researchers at Johns Hopkins University and the FAO’s Pro-Poor Livestock Policy Initiative, many of the classes of antimicrobials used in animal production in China, like tetracyclines, sulfonamides, macrolides, and penicillins, are also used for humans, which means there are implications for antimicrobial resistance and public health [54].

One study drawing on interviews conducted in 2005 and 2006 with workers on 35 intensive animal farms noted that antibiotics were reportedly used “when necessary.” “When necessary,” however, was interpreted broadly, and included times when there was a need to shorten growth

cycles, to prevent/control disease, and to prepare animals for transport to slaughter [2, p. 228]. The interviewees also confirmed that the regulations requiring that drugs not be administered for a period before slaughter were not being followed, and local governments were not enforcing these regulations because they did not want to slow down livestock production [2].

A few scientific studies have focused on documenting the link between antimicrobial use in Chinese animal agriculture and the emergence of antibiotic resistance. A 2013 study, described earlier in the section on inputs, examined antibiotic-resistant genes (ARGs) in three large-scale commercial swine farms, each in a different region of China [59]. The researchers tested samples in 2010 at various stages of manure processing and detected 149 unique ARGs in the samples, over three times the number of ARG types detected in the control samples (manure from pigs never fed antibiotics). This finding suggested that manure was a major source of antibiotic pollution in the environment. Unmonitored antibiotic use was responsible for the emergence of diverse ARGs, which could “potentially confer resistance to all major classes of antibiotics, including antibiotics critically important for human medicine” [59, p. 3437].

Another study, also described in the section on inputs, involved the testing of *Enterococcus* species collected in 2009 from two intensive chicken farms in Shandong Province and four free-range, mixed poultry-pig farms in Beijing [60]. As mentioned earlier, the researchers found that there was a high prevalence of highly aminoglycoside-resistant *Enterococcus*. They hypothesized that this was related to the fact that aminoglycosides were the most commonly used type of antibiotic among the sampled farms [60].

One 2014 journal article reviewed recent studies showing antimicrobial-resistant genes corresponding with antimicrobials used in animal agriculture, which were detected in Chinese individuals’ gut microbiome [55]. The authors concluded that antimicrobial use in animal agriculture was contributing to resistance. They noted that the impact of antimicrobial resistance in livestock, and how it might be transferred to and affect humans, had not been examined closely in China [55].

In fact, several studies examining the link between antibiotic resistance and on-farm practices have not yielded straightforward results. One study, described above

in the section on inputs, tested antibiotic resistance of *E. coli* collected in 2013 from surface water near small-scale animal farms in Beijing [57]. Although it was likely that antibiotic use at the livestock farms was related to the prevalence of antibiotics in the surface water, there was no obvious correlation between the documented antibiotic resistance and the concentrations of antibiotics in the waters, suggesting that other factors may affect the formation of antibiotic resistance [57].

There were also other scientific studies that did not study antibiotic resistance, *per se*, but sought to demonstrate the link between on-farm antibiotic use and antibiotic prevalence in the environment. For example, one study (described earlier in the section on inputs) tested manure samples from large-scale pig, chicken, and cow feeding farms across eight provinces in 2007, and detected multiple classes of antibiotics in all of the manure sample types [56]. The authors warned that given that dung slurry was applied directly as fertilizer, the large amounts of antibiotics in manures could serve as a source of antimicrobial residues in soil and water. Another study from the same year tested wastewater emanating from three swine CAFOs in the Beijing area [80]. The researchers confirmed the presence of eight of the nine antibiotics for which they tested, with tetracyclines exhibiting the highest concentrations, in accordance with survey data suggesting that tetracyclines were the most commonly used antibiotic in Beijing CAFOs.

Though not focusing on antibiotic administration *per se*, a 2013 study sampling eight chicken, pig, and duck farms of various sizes in Zhejiang province for ARGs sought to examine the link between abundance of specific ARGs in animal manure and effectiveness of wastewater systems for treatment of these effluents [72]. Although the researchers were able to show that the livestock farms constituted a huge source of ARGs, they found that some ARGs decreased in abundance after wastewater treatment, while others actually increased, warranting more research to understand the interaction between waste treatment practices and ARGs [72].

A 2005 review article pointed to other sanitary risks deriving from inadequately treated animal waste, such as infectious diseases like diarrhea, typhoid fever, and parasites [1]. A combination of anaerobic (without oxygen) and aerobic (requiring oxygen) treatment for liquid manure and thermophilic composting of solid manure were recommended to reduce the numbers of pathogen and

parasites [1]. Similarly, a 2007 report noted that when waste from CAFO lagoons flooded over or leached into surrounding soil and water, the bacteria and trace metals that entered into drinking and irrigation water could cause bacterial infections and increase the risks of cancer and miscarriage [79]. In addition, carcinogenic arsenic in manure could seep into drinking water sources when manure was applied to soil [79].

Another food safety issue pertained to animal mortality on large-scale farms. The abovementioned study, based on a sample of 35 intensive farms in 2005 and 2006, documented that dead animals in factory farms, instead of being disposed of safely, were often sold to employees or vendors, who in turn sold them to restaurants or other retailers, thus entering the food supply [2]. For example, there was an average 10% mortality rate per year on the egg and broiler farms visited, and three of these farms admitted that they disposed of the dead birds in a manner that allowed them to enter the food market [2]. Such practices, perpetrated by poultry and pig farm owners, traders, and food processors, occurred despite regulations requiring deep burial or other safe methods for discarding dead animals [2].

Other public health impacts of industrial food animal production—mentioned less frequently than those already described—included dietary inequality (namely, differences in meat consumption by class and rural-versus-urban residence) [41], as well as diet-related diseases (Type 2 diabetes, coronary heart disease, and various cancers) and health conditions (high blood pressure, obesity and over-weight), which are on the rise in China and believed to derive partially from greater meat consumption and more fast food chains [2, 41].

3) *Impacts on natural resources*

Many natural resource impacts of industrial food animal production were cited in the literature, including water and soil pollution, resource depletion, greenhouse gas emissions, and reduced genetic diversity.

Contamination of water and soil

The first national pollution census in China, released in 2010, identified agriculture as the biggest source of water pollution [41]. The huge increase in animal waste resulting from industrial livestock production was recognized as a primary source of this pollution [36, 41].

Swine waste, in particular, amounts to 1.3 billion metric tons per year, and accounts for 47% of total livestock waste generated [34]. According to a 2009 review article, “[t]he larger the size of pig farms is, the more serious the environmental pollution is” [40].

Excessive amounts of nitrogen and phosphorous derived from animal waste, either improperly stored or over-applied to fields, leads to runoff into lakes, streams, and coastal areas, often causing eutrophication [41]. The consequences include toxic algae blooms, known as “red tides,” dead zones in the water due to a lack of oxygen, and massive die-offs of fish and plants in the ecosystem [79]. Although several sources discussed these environmental problems and identified intensive animal agriculture as a contributor, we did not find scientific studies that examined this specific cause-effect relationship in China. The sources we found, and the sources cited by those sources, described these problems as being caused by animal waste, human waste, other bio-residues, and municipal effluents, so it is difficult to determine the extent to which animal agriculture specifically contributes to these issues in China and in specific regions in the country [1, 41, 79].

Soil contamination is another environmental impact, resulting from wastes seeping from lagoons and holding tanks into surrounding land [79], or from excessive application of manure to agricultural land [1]. According to a 2005 review article, in the areas near animal production facilities, applying too much animal manure to cropland can lead to nutrient overload, leaching of nitrate or phosphorus into shallow groundwater, and heavy metal accumulation in the topsoil (as animal feed has heavy metal additives) [1].¹⁹ A 2007 report noted that 95% of nitrogen in manure, when exposed to the air, could become airborne and travel as far as 80 to 160 kilometers before settling into the soil [79]. This could reduce crop yields because plants require energy to absorb the nitrogen, or it could reduce plant diversity, as fast-growing, nutrient-absorbing plants out-compete other plants [79]. One

19. Regarding heavy metals, one 2014 study, described above in the section on inputs, examined toxic metal accumulation from application of chicken manure to land carried out by 42 smaller-scale (800 to 12,000 chickens) poultry farms. See Liu Q, Sun X, Hu A, Zhang Y, Cao Z. Characteristics of toxic metal accumulation in farmland in relation to long-term chicken manure application: A case study in the Yangtze River Delta Region, China. *Bull Environ Contam Toxicol*. 2014;92(3):279-84. However, although researchers found significant correlations between metal concentrations in feed and manure, suggesting that feed was the main source of metals in manure, the researchers did not test the correlation between concentrations found in feed/manure with concentrations found in soil.

study focusing specifically on swine waste projected that nitrogen and phosphorous discharged from pig production would increase if business continued as usual [18].

Despite these impacts, there is a reportedly “strong consensus within Chinese policy circles” that increasing the scale of livestock production is beneficial for the environment: the argument is that concentrating waste management allows for more precise techniques, investment in waste management facilities, and easier inspection and regulation due to fewer sources of emissions [3]. However, as a 2014 FCRN report criticizes, there is “only limited evidence that larger-scale land holdings result in improved nutrient use efficiency and that larger-scale livestock operations have lower emissions per unit of output” [3].

Resource depletion

Use of natural resources—specifically land and water—was an impact cited often in relation to feed production. As one 2013 study pointed out, concentrates make up a larger proportion of the feed (compared to roughage) as production transitions from grazing to mixed to industrial systems, and the water footprint of concentrates is about five times higher than the water footprint of roughages [10]. However, the water footprint of a production system depends on origin of feed and feed conversion efficiency. Concentrates are used even more in pork and poultry feed than they are in cattle feed, and this is true for all types of production systems [10]. Focusing on 1996 to 2005 and China as one of the study countries, researchers examined the water footprint associated with grazing, mixed, and industrial systems for producing poultry, beef, and pork [10]. They found that for poultry, the water footprint was mainly driven by feed conversion efficiency, which was higher in industrial systems than in grazing systems. Thus, the overall water footprint of poultry production in China, as in the other countries studied, was lower for industrial systems compared to grazing systems [10]. For pork production in China, the researchers found that while industrial systems had a lower green water footprint (indicating less consumption of rainwater), the blue water footprint (reflecting consumption of surface water and groundwater) increased from grazing to mixed to industrial pork production systems [10]. For beef production, the green water footprint decreased from grazing and mixed to industrial systems, but the blue water footprint was larger in industrial systems in China, as was the grey water footprint (reflecting pollution of surface and groundwater). The reason for the large blue and grey

water footprints of industrial beef production is because concentrates are used in industrial cattle feed, which relies heavily on maize and rice crops that are irrigated and fertilized [10].

Another issue associated with feed production was the conversion of grasslands into cropland for cultivating feed crops [3, 44]. There was some recognition that intensifying livestock production—if it increased agricultural yields—could reduce the pressure on rangelands exerted by extensive grazing systems, and even facilitate restoration of cropland back to grassland [44]. Measures for intensification included enclosing family grazing lands, changing animal breeds, and using forage crops and supplementary feeding. To address grassland degradation from animal husbandry, the government tried two programs (the Grassland Retirement Programme and the Grassland Ecology Subsidy and Reward Mechanism) that gave economic incentives for transforming extensive grazing systems to productive semi-grazing systems [3]. However, the technical, institutional, and marketing support given was insufficient, according to the FCRN [3]. In addition, intensification involves increased inputs (such as fertilizers, pesticides, and energy), and these inputs may exert greater pressure on inland-water ecosystems and reduce biodiversity.

Further, increasing the absolute numbers of animals produced simply requires more feed, and feed scarcity has been a major challenge in China, as discussed earlier. More grain-based feed is needed for intensive farm operations, so this requires converting land to grow grains like corn and soy [9]. As a 2014 IATP report on animal feed in China noted, “[c]heap feed has historically contributed to high profit margins for the livestock industry while catalyzing the conversion of large tracts of diverse forest and agro-ecosystems into feed monocultures” [47, p. 13]. To meet the feed requirements of China’s livestock population, producers rely on feed resources from overseas, as described in detail previously. Brazilian soy imports to China increased nine-fold between 2000 and 2010, and this demand has reportedly fueled conversion of natural ecosystems to large-scale soy farms in Brazil [47], resulting in deforestation, loss of biodiversity, and soil erosion [9]. Further, a 2012 International Institute for Sustainable Development (IISD) report on China’s overseas agricultural investments noted that “very few agricultural projects” had carried out social and environmental impact assessments [50, p. 10].

Greenhouse gas emissions

Various greenhouse gas emissions derive from livestock production. Carbon dioxide is emitted from the use of fossil fuels to produce, process, and transport animals, as well as from using these fuels to produce feed crops or to manufacture fertilizers and pesticides [9]. For example, approximately 14 million tons of carbon dioxide are emitted each year in China from making nitrogen fertilizers for feed production [9]. Carbon emissions are also released when vegetation is cleared to serve as livestock pastures or cropland for growing feed crops [9].

China is one of the world’s largest emitters of methane from farm animals, behind India and Brazil [9]. Methane comes primarily from enteric fermentation—it is a byproduct of the digestive process in ruminants and released by belching and flatulence—and China’s methane emissions from enteric fermentation account for 10% of the world’s total [9]. In addition, methane can come from animal manure, with emissions from industrial farms generally higher than from other farms, due to the way waste is stored and handled [9]. China is the world’s largest emitter of methane from manure [9, 44].

Public engagement with industrial food animal production

1) Transparency and access to information

A 2014 report by an interdisciplinary network of researchers based in China and elsewhere, known as the Forum on Health, Environment and Development, noted a lack of publicly available data regarding food safety in China, which made reporting more difficult [45]. Advocacy NGOs provided much of the information, which the authors supposed likely contributed “to a disproportionate concern about some issues over others” [45, p. 52].

On the issue of overseas “land grabs” by Chinese entities, IATP noted that once word got out about an impending deal, there was backlash and the government denied it, making it difficult to document transactions [47]. The IISD similarly observed extensive secrecy and a lack of transparency surrounding the projects, making it difficult to get a complete picture or find out what was happening with particular projects [50].

Regarding the emergence of drug-resistant pathogens, a USDA expert stated that although there was extensive antibiotic use in swine farming, there was not enough information to determine the extent of the resistance problem

in China [42]. More and higher-quality data are necessary to confront the problem of resistance, according to one representative of the World Health Organization [42].

2) *Public awareness and attitudes*

The general picture deduced from the landscape assessment was that the Chinese public was generally wary of animal agriculture, but not very knowledgeable about specific impacts of industrial animal production. The wariness grew out of various food safety scandals, which were covered widely in the media and often perpetuated the perception that small-scale producers were the ones to blame. There were some indications that public concern about the environment might be increasing but, on the other hand, concern about the conditions in which livestock were raised seemed to derive not from concern for animal welfare *per se*, but from the perception that these conditions were linked to food safety, quality, and taste.

Knowledge and attitudes about IFAP and concern for food safety

A few sources mentioned—though without elaborating—general public ignorance about the impacts of industrial animal agriculture. IATP cited “a common lack of awareness about the costs of industrializing meat on public health and environment” [29, p. 22], while a journal article stated that antimicrobial resistance was a “hidden side-effect” of extensive antibiotic use in industrial farms and had not received much attention [55]. In recent years, the public’s concern about meat production has been stirred by highly publicized food safety scandals, to which they are paying close attention. As one 2012 news source reported, consumer demand for meat fell after food safety scares in China, and agribusinesses like Tyson paused plans to increase production [81]. A 2013 article reported that consumer trust in poultry had decreased due to the use of growth promoters and medications in raising poultry [82]. When Yum Brands, a foreign company that owned KFC, was accused in December 2012 of marketing chicken that had growth hormones and antiviral drugs beyond allowable limits, consumer confidence decreased in the entire fast food sector [83]. A June 2013 article described consumer confidence as “at an all-time low;” in this context, Shanghai’s acquisition of a US company, described above, was meant to give consumers more confidence that American products were safer and worth paying for [84].

Importantly, rather than pointing the finger at industrial production systems, the public has come to believe that small-scale farmers are to blame for food safety issues. As IATP reported, this discourse is particularly prevalent among urban consumers, who “increasingly equate industrial farming as the symbol of modernization and development,” reflecting the “widely popular urban misconception that smallholder farmers are to blame for China’s food safety scandals” [29, p. 22]. Regarding the problem of poor biosecurity and animal health, a *China Economic Review* article explained that consumers believed small backyard farms were the “true source of animal disease epidemics” despite “plentiful evidence to the contrary.” Therefore, large agribusinesses were becoming more popular, benefitting from a “veneer of modernization,” while continuing to overuse antibiotics [42].

The government has contributed to this perspective and enacted policies in accordance with it, as described in the earlier section on regulations. Large agribusinesses, too, have echoed the same discourse. For example, Tyson claimed that the food safety scares “validated” its integrated business model, which was supposedly more effective at ensuring quality and food safety [81]. To rebuild its reputation and bolster its claim that it was safer than its domestic counterparts, Yum announced that it would strengthen oversight, terminate 1,000 small producers in its supply chain, and move toward sourcing from its own farms under a vertically integrated model [83]. The perspective that small independent producers are responsible for food safety problems has also been adopted by some academics (see, for example, Tao and Xie 2015).

Although there have been reportedly few anthropological studies on Chinese consumer attitudes to date [45], our landscape assessment revealed a couple of studies that used survey methods to understand consumer perceptions and values regarding meat production. One, a cross-sectional survey focusing on the pork sector, was conducted in 2008 with 472 participants across six cities in China [73]. The results revealed that Chinese consumers preferred large-scale industrial pig production systems that raised traditional pig breeds to small and large family farms (1 to 50 and 51 to 400 pigs, respectively). They also favored farms that paid maximum attention to food safety, through hygiene regulations and veterinary control, and provided lean meat with consistent quality; they did not prefer imported pig breeds or pigs that were tasty but variable in meat quality.

Reflecting the discourse described above, the researchers stated: “to the modern Chinese consumer, the large-scale, industrial food production system is generally well accepted, as it seems to be leading to food safety . . . Government incentives and the enlargement of the operations are therefore contributing to the overall development of the pork chain” [73]. Moreover, industrial production represented “achievement, evolution, quality, and safety, since pig production [was] moving away from low-cost, family scale systems, where quality inconsistencies and lack of safety assurance were the main problems” [73].

Most respondents were actually “indifferent about the way pork products [were] produced,” with little concern for environmental and animal welfare impacts [73]. Even if consumers were aware of the impacts of pork production and consumption, the transition “from awareness to action” had not yet occurred [73]. For environmental issues, a new topic for China, the researchers stated that the public could benefit from being more empowered or having greater access to information.

A former Tyson representative claimed that consumers in China did not want to pay higher prices. Without mentioning the evidence behind this claim, he stated that among consumers with sufficient purchasing power, 80% would choose the cheapest option, while only 20% would pay higher prices to get what they perceived to be a traceable, safer product [37].

Attitudes toward animal welfare

According to a 2005 report sponsored by HSI and CIWF, the Chinese public was traditionally indifferent to conditions on livestock farms, and only began to care about these issues after there was a connection made to food safety, human health hazards, and animal diseases [61]. Moreover, free-roaming livestock was perceived to have better taste, and it was this perception that motivated free-range farming—not animal welfare [61]. Accordingly, “[t]he welfare of the broilers is at best a byproduct of the profit-seeking operation” [61, p. 47]. As of the mid-2000s, “foreign animal welfare ideas” were making inroads into China, just as Western industrial farming practices had done; however, some Chinese saw “Western criticism of China’s animal welfare problems as signs of Western cultural imperialism and of Western attempts to stop China’s modernization” [61, p. 54].

More recent sources have argued that animal welfare is still not a primary concern for the public, though there may be some indications of change. In this regard, a 2011 Brighter Green report noted that animal rights issues were now covered occasionally by the Chinese media [9]. A 2014 FCRN report noted that in general, public and policy opinion viewed “animals as entities to be used to meet human needs and goals” [3]. Active animal abuse was disfavored, but “welfare” was considered more of an “absence of cruelty,” rather than a holistic concept including good quality of life and health [3]. However, the FCRN noted that recent opinion surveys had shown some genuine interest in animal welfare, and there were also a growing number of animal welfare organizations in China [3].

One nationwide public opinion survey, conducted in 2011 with 6,006 respondents, focused on pigs, broilers, and layers [85]. The results indicated that two-thirds of respondents had never heard of animal welfare as a concept. It is likely that an even lower proportion of the general Chinese population had never heard of animal welfare because the sample was relatively well-educated and young.²⁰ When asked how they perceived factory farms, 22% thought it was “a very good way of production,” 35% thought it was “a scientific way of production,” 24% said it “limited the freedom of pigs and domestic fowls,” and 20% said it was “a cruel way of production.” However, 73% of respondents thought conditions of animals should be improved so that food safety would be improved, and 66% agreed that laws should be established to improve animal welfare. A slight majority of respondents was willing to pay more for pork products where the pigs were raised under better conditions if the quality was also improved. The researchers concluded that the concept of animal welfare had not been “truly popularized in China,” partly because the mainstream media had not familiarized them with this topic [85].

New trends in meat consumption and alternative markets

A few sources discussed emerging trends in the behavior of Chinese consumers. For example, a 2011 Brighter Green report noted that there may be some revival of the “Buddhist traditions of vegetarianism,” as consumption of meat and dairy was being linked to urgent, ecological

20. The sample was not randomly selected. The researchers sent undergraduate students to administer surveys in their hometowns, and the sample was relatively young and educated. See You XL, Li YB, Zhang M, Yan HQ, Zhao RQ. A survey of Chinese citizens’ perceptions on farm animal welfare. *Plos One*. 2014;9(10).

issues such as water pollution [9]. In this regard, a *China Business Review* article noted that surveys from 2009 had revealed more “green” behavior among Chinese consumers, who were opting for environmentally-friendly products [86]. A 2013 journal article, citing studies that had come out in the preceding year, similarly noted that Chinese consumers were becoming more conscious about the environment and interested in buying organic products, including food [73]. As one news article recently reported, demand for organic-certified meat was “reaching fever pitch in China” [78].

Some trends may also be linked to the food safety challenges faced by the meat industry. According to a 2014 report by the Forum on Health, Environment and Development, given the lack of public confidence in “institutionalized mechanisms for ensuring food safety,” in recent years there had been a “rapid growth of interest in alternatives to traditional food supply chains” [45, p. 54]. These alternatives, though still a small part of the market, tried to link consumers directly to the producers/farmers [45]. Some firms were even trying to instill consumer confidence by putting cameras on their feed lots and slaughterhouses, with 24/7 live streaming online [78].

3) *Media interest in IFAP*

Food safety and biosecurity

Food safety issues were prominently covered in media sources. In fact, IATP has noted that at times China’s use of additives is overblown by the media, when in fact the practice is business-as-usual in the United States [29]. For example, clenbuterol and ractopamine, two growth-promoting feed additives used to speed lean meat growth, have been banned in China since 2002. When it was discovered in 2011 that Shanghui, the largest meat processor in China, sourced pigs that had consumed these additives, it was a huge scandal. The government banned production and sale of the additives; meanwhile, the use of ractopamine continues to be supported by the US government, even before the United Nations [29]. Another report has criticized the media for focusing on food safety scandals and acute crises, which make bigger stories, rather than on issues that are more chronic or slower to notice, such as abuse of veterinary drugs [45].

Some media sources blamed small farmers for various problems, such as epidemics, food safety, and market instability (see, for example, *Global Meat News*, Mar. 22, 2012). However, several other sources rejected this no-

tion. For example, the *China Economic Review* article cited above pointed out that there was evidence against the claim that small backyard farms were the source of disease epidemics, although consumers seemed to believe the claim [42]. The article warned that “key features of industrial farming—including antibiotics overuse, large-scale farms, and breeding practices—could prime the pump for drug-resistant disease” to kill the country’s pig population [42]. A Reuters article noted that the disposal of 16,000 pig carcasses in the Huangpu river in 2013 could be attributed to “an unsustainable level of overcrowding—a key factor in the spread of disease and death rates” [58].

There was also some media interest in Chinese companies going overseas to acquire other companies, or to access land, water, and feed resources. A recurring theme in this media coverage was that China, by itself, did not have sufficient natural resources to meet rising demand for meat, and that its actions were having international repercussions. For example, an Earth Policy Institute press release noted that acquisitions of foreign companies by Chinese companies made sense because there was too little land in China to produce enough meat [87]. A *Global Meat News* article noted that China was importing corn for pig feed, which was affecting the world’s supply [88]. Another article from this source reported that a joint venture undertaken by a Chinese company with a Ukrainian partner for production of pork and corn in Ukraine generated controversy when the media reported that the former bought the land and would implement the project by itself [89]. The CEO of the Ukrainian counterpart had to defend the project by saying that the venture would employ Ukrainian citizens, generate pork mostly for Ukraine (not for export to China), and that there was “no intention to sell the land and the rights to foreigners, including the Chinese.”

4) *NGO or community campaigns, advocacy, and other efforts targeting IFAP*

Our landscape assessment found some information on legal actions surrounding Chinese industrial livestock production activities overseas. A recent report by the Center for Investigative Reporting described 25 nuisance lawsuits filed against Smithfield for its pig farms in North Carolina, in which the plaintiffs argued that the Chinese owners who owned Smithfield were expanding operations, and the pig manure stored in lagoons near their residences was harmful to their health and property values

[90]. The plaintiffs also claimed that the defendant took more care to manage manure in China than in North Carolina. The defendant company asked that it not be mentioned in court that the company was Chinese-owned and that there were plans to expand exports to China. At the same time, the North Carolina General Assembly was reportedly considering legal reforms to prevent nuisance suits and to force unsuccessful plaintiffs to bear the defendant's legal costs.

Although the nature of the "cases" was not specified, a 2014 IATP report on the Chinese feed industry noted that Greenpeace China had documented four unresolved cases of land acquisitions in Brazil for soy production [47]. The cases were pending because the Brazilian government was "pushing back on foreign land acquisitions" [47, p. 25].

From our landscape assessment, it appeared that many NGOs were interested in the topic of Chinese industrial livestock production. One of the earlier efforts we found was an investigation sponsored by Compassion in World Farming and Humane Society International, entailing visits to 55 intensive livestock farms in mainland China across nine provinces, and which resulted in a 2005 report on the current and projected direction of animal agriculture in China [61]. The report advised that campaigns to reform intensive farming in China should take a "phased and incremental approach," whereby the most serious welfare problems were targeted by leveraging public outcry and then making specific recommendations on how to improve the situation [61, p. 53]. A gradual and incremental approach was recommended because civil society in China was perceived to be weak [61]. Moreover, the report pointed out that Chinese authorities were more responsive when pressure came from outside; it advised that Chinese NGOs should "never forget to inform the Chinese authorities and industry of worldwide reactions to Chinese farming conditions" [61, p. 54].

Another effort, undertaken by a partnership between Western Kentucky University and the China Environment Forum at the Woodrow Wilson International Center for Scholars, consists of a USAID-funded program called the China Environmental Health Project, which examines animal agriculture, organic foods, pesticides, and other non-

food industrial activities.²¹ One of the project's research reports focused on Chinese CAFOs and their environmental impacts [79].

There is also a Forum on Health, Environment and Development (FORHEAD), an interdisciplinary network founded in 2008, which researches issues related to environmental degradation's impacts on health in China.²² FORHEAD's Working Group on Food Safety, funded by the Rockefeller Brothers Fund, sponsored a report that reviewed academic and grey literature on food safety in China and provided recommendations on research gaps [45]. The report recommended, among other tasks, "a systematic analysis of relevant data sets (including sampling frames and variables covered) in order to determine where there may be the potential for integrated analysis that could help to identify patterns of potential food safety risks" [45, p. 58]. It also suggested "[m]ore systematic linking of macro- and micro-level data," as "these levels of analysis [were] largely disconnected and [did] not fit well together" [45, p. 59].

For its part, the Food Climate Research Network is an international network of organizations based at the University of Oxford, and includes trade and industry organizations, NGOs, and government sector representatives across 70 countries.²³ It published a lengthy report in 2014 on China's food system, which contained a chapter focused on livestock [45]. One of the positions adopted by the report was that vertical integration improved quality management and increased profits.

Other reports include Brighter Green's 2011 report, which examined China's demand for meat and warned against the negative impacts of factory farming in China [9], as well as publications in the Institute for Agriculture and Trade Policy's "Global Meat Complex: The China Series" [15, 29, 47, 91]. These reports have contributed to putting China front and center as an example of industrialized food animal production.

There also appeared to be recent efforts to implement positive animal welfare practices. CIWF's 2013 report

21. Wilson Center—China Environment Forum—Environmental Governance and Health Research Briefs, available at <https://www.wilsoncenter.org/publication-series/environmental-governance-and-health-research-briefs>, last visited Feb. 13, 2016.

22. Forum on Health, Environment and Development, available at http://www.forhead.org/index_en.php, last visited Feb. 13, 2016.

23. Food Climate Research Network—About, available at <http://www.fcrn.org.uk/about>, last visited Feb. 13, 2016.

provided case studies of good examples of humane, sustainable livestock production, one of which consisted of organic eggs and chicken meat raised from a dual-purpose breed of chicken called “You Chicken” in China [92]. The males of these slower-growing breeds were raised for meat, while the females were raised for eggs and then used for meat at the end of their lives as layers. The birds were raised free-range, as well as with little antibiotic use and no mutilations. Eggs cost twice as much as conventional eggs. The demand for this type of meat was attributed to the perception that slower-growing breeds had more flavor. Further, according to a 2014 news article, CIWF was also working with the International Cooperation Committee of Animal Welfare to establish the “first official Code of Practice for Pigs in China” [93].

In its 2014 report, the FCRN noted that the World Society for the Protection of Animals (WSPA) and the Animal Health and Welfare Branch of the Chinese Veterinary Medical Association had signed an agreement whereby WSPA would help develop materials for animal welfare textbooks for Chinese veterinary students and practitioners, as well as help to establish a “comprehensive animal welfare education system” [3]. A “China Farm Animal” website had also been set up, which served as a communications platform for relevant institutions and provided companies with free advice and technical support on how to resolve issues in a way that respected animal welfare [3].²⁴

5) *Description of other civil society actors engaged in IFAP*

Research community

In our landscape assessment, we perceived the existence of an active community of researchers based both within China and outside China. Many viewed the abundance of independent, small-scale producers as a drawback for various reasons. For example, one researcher at the Jinnai Agribusiness Research Center noted that rural backyard production resulted in overweight, fatty pigs, and the fact that 75 to 80% of pigs were still produced in rural, backyard systems “cause[d] many difficulties in disease control, genetic improvement, carcass quality, uniformity control, pork safety control, and marketing channels establishment” [94].

Quite a few researchers supported greater integration, especially for the pork sector [5, 27, 33, 39]. Fragmentation was perceived as an obstacle to improving quality, safety, and product tracing, while integration could help processors cope with market uncertainties [33]. Some researchers also maintained that participation in integrated supply chains could help specialized household farms cope with market shocks [8]. At the same time, these researchers recognized that participation in *informal* producer associations actually dominated participation in formal ones, and were helpful for enabling small-scale producers to overcome disadvantages in technical capacity and bargaining power [8]. One historian advanced the idea that other forms of integration besides DHEs, such as co-ops, held more promise for building a “new rural society” [38].

One notable weakness consisted of empirical studies that only used productivity and output as metrics in their analysis, and then made recommendations based on how to increase those numbers without acknowledging potential negative consequences of increasing production [21]. In the literature, however, we observed the position among some academics that it was possible to move forward with intensification in a “good” way. For example, one article by a researcher at the Institute of Animal Nutrition at Sichuan Agricultural University noted that transition to intensive production was both necessary and possible to carry out in a way that was harmonious with social and environmental welfare [40]. Among other recommendations, the researcher provided ten concrete suggestions to pig producers on “nutrition management for environment protection,” six strategies for how pig feeding practices could improve pork quality and safety, and three future avenues of research for animal health scientists [40, p. 476].

Other researchers, based at the State Key Laboratory of Organic Geochemistry at the Guangzhou Institute of Geochemistry, advocated avoiding the use of antimicrobials [55]. They made the case that alternatives to antimicrobials exist and should be adopted, such as good veterinary care, vaccinations, check-ups, and probiotics to strengthen animal immune systems. According to these researchers, such measures would allow China to transition away from antimicrobials without detriment to food animal production.

In a similar vein, the 2014 FCRN report stated that large-scale livestock production was not incompatible *per se*

24. No link to the website was provided in the FCRN report.

with animal welfare [3]. The problem was the way in which expansion was occurring—e.g., with the use of high-yielding breeds, confined conditions, animal mutilations, and inappropriate feeding practices. By encouraging such practices, policies that supported scaling up were influencing—if at times unintentionally—animal welfare.

Other researchers have criticized the pursuit of growth in and of itself. For example, as the author of the CIWF and HSI reports noted in a related journal article, “the Chinese government’s obsession with growth explains the many growth ailments impacting environment and public health” [2, p. 218].

Other topics highlighted in the research literature include the lack of regulation (as cited above in the section on regulation), antibiotic resistance, and the importance of proper wastewater treatment (as cited above in the sections on inputs, waste management, and impacts).

Other investors in animal agriculture in China

According to the 2011 Brighter Green report, the International Finance Corporation has also invested in developing and expanding “factory farm operations” in China [9]. For example, it provided \$61 million dollars in 2003 for the expansion of a pork producer in Jilin Province.

More recent sources note the development of alternative markets and avenues for production besides industrial livestock systems. These alternatives, though a small part of the market, seek to link consumers more directly to producers and farmers [45]. In China, organic food (though mostly vegetables) amounts to 1% of the market of all food purchased [42]. In Beijing, there is an organic market with a growing free-range chicken CSA (community-supported agriculture); limited land, however, makes scaling up of this initiative a challenge [15]. In responding to concerns about the animal welfare of pigs raised in China, some pig producers have implemented and received recognition for practices that allow pigs to develop well both physically and mentally/emotionally [93]. According to a *China Economic Review* article, there is a growing organic pork industry in China [42].

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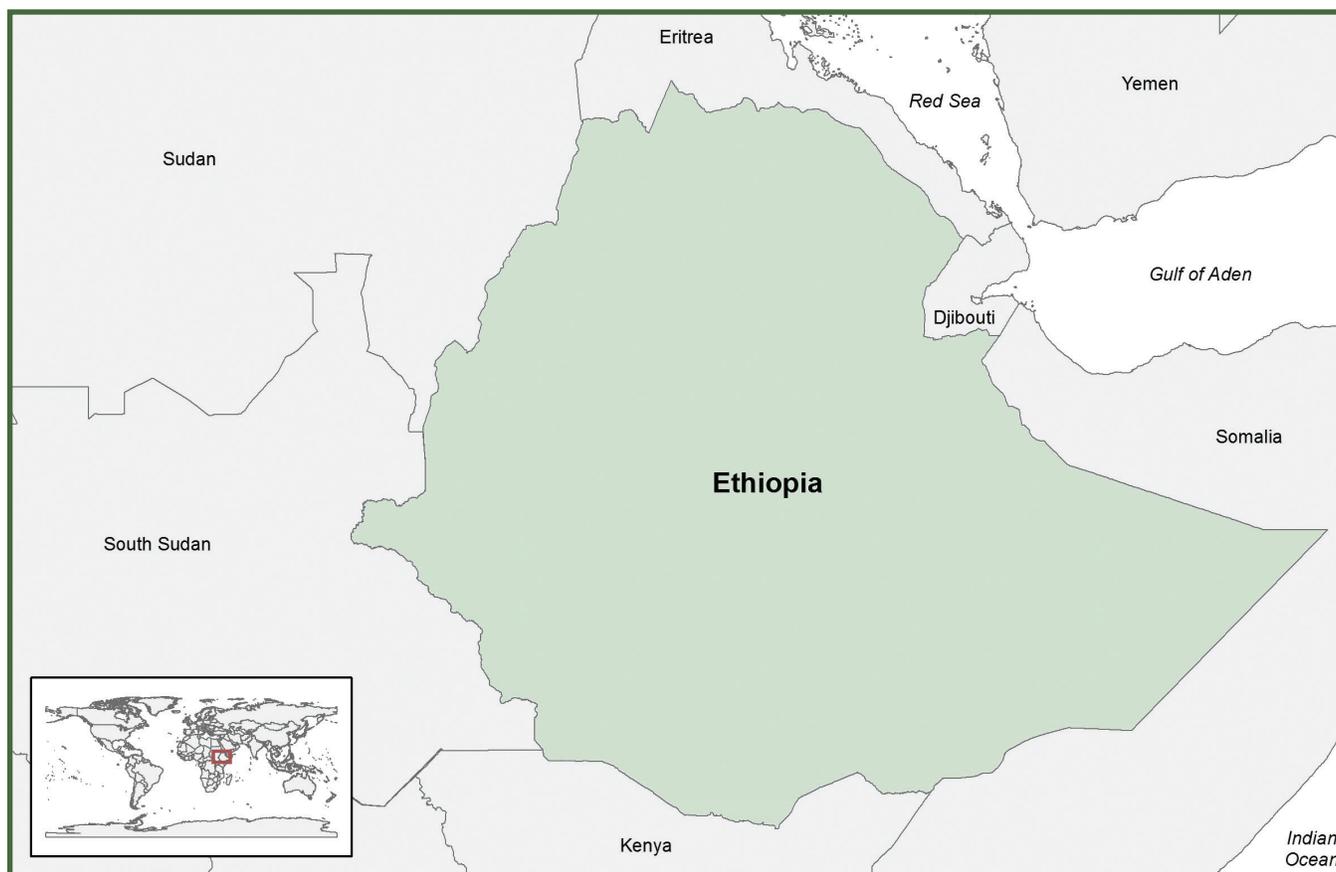
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Ethiopia



Overview

Ethiopia's livestock sector has historically been characterized by extremely low productivity and a mostly subsistence orientation. Traditional production is low input, based on pastoralism or mixed crop-livestock farming. Many barriers to growing the sector have been identified, with some of these relating directly to food animal production (such as a lack of animal health expertise, support for breeding, and other livestock extension services), with others stemming from the broader issue of rural underdevelopment (such as natural resource scarcity, weak incorporation of technology, and poor infrastructure in terms of transportation, energy, and marketing).

Improving livestock production is seen as a form of poverty alleviation and a way to increase national GDP. Rather than work toward increased output *per se*, the government's main effort —the National Livestock Development Project, the first cycle of which began in 1958— aimed to increase household income through improved livestock rearing. The Second (1973-1981) and Third (1975-1992) Livestock Development Projects included construction of slaughterhouses and a program for small-scale cattle fattening operations, respectively. Such public and other

private initiatives have contributed to some industrialization of livestock production, which could help improve nutrition and food security; however, the externalities and consequences of this development, as well as the need for more resources as inputs, are important considerations that have received limited attention to date in the Ethiopian context.

Food and Agriculture Organization of the United Nations (FAO) statistics on food animal production

Ethiopia had a total of 55,553,700 animal units (AUs) in 2013, resulting in an overall livestock density of 1.53 AU per hectare (ha) of agricultural area. The numbers of live animals raised in 2013 were 33,000 pigs, 51,350,000 chickens, and 54,000,000 cattle. FAO 2011 estimates of livestock densities, by specific animal class, were less than 0.01 pigs per ha, 1.38 poultry birds per ha, and 1.50 cattle and buffalo per ha.

However, it is important to note that there is uncertainty in the total number of cattle and poultry because there are no official statistics on the livestock kept in pastoral

Production, imports, exports, and net balance by livestock product

	Production (mt)			Imports (mt)	Exports (mt)	Net (mt)
	2002	2007	2012	2012	2012	2012
Pig meat	1,495	1,665	1,875	2	0	1,877
Chicken meat	54,064	46,240	60,480	1	0	60,481
Cattle meat	352,500	363,000	338,150	3	4	338,149
Milk, whole fresh cow	2,478,969	2,629,521	3,804,991	103	n.d.	n.d.

areas. In this regard, there are inconsistencies between FAO estimates and data from the Central Statistical Agency of Ethiopia, the official Ethiopian source of statistics [1]. Estimates on the number of cattle in Ethiopia, in particular, can vary widely depending on the source [2].

In 2012, production was 1,875 tonnes of pork, 60,480 tonnes of chicken, 338,150 tonnes of cattle meat, and 3,804,991 tonnes of cow's milk. Over the 2002 to 2012 period, pork, chicken, and cow's milk production increased by 25%, 12%, 53%, respectively, while cattle meat production decreased by 4%. The five-year period of 2007 to 2012 saw a decrease of 7% in cattle meat production, and increases of 13%, 31%, and 45% for pork, chicken, and cow's milk, respectively.

Industry characteristics

1) Scale

Those who support intensification and commercialization of Ethiopia's livestock sector, following the same path as Western industrialized countries, view the sector as an important, underdeveloped source of national income, export market share, and funds for poverty alleviation [3]. The government aims for annual meat production to grow from 613,000 tonnes (according to an official 2010 source) to 836,000 tonnes by 2025 [4]. The target for annual meat exports is 30,000 tonnes [3]. Efforts to increase productivity, intensity, and marketability of animal production usually address cattle or poultry production, as swine production is considered negligible in Ethiopia.

Scale of cattle production

It is projected that by 2024-2025, Ethiopia's total cattle herd will reach 75 million head in sedentary areas,¹ up

1. Sedentary areas are settled with non-pastoral, non-nomadic populations, and exclude the large pastoral areas of the Afar and Somali regions. See Leta S, Mesele F. Spatial analysis of cattle and shoat population in Ethiopia: growth trend, distribution and market access. Springerplus. 2014;3:310.

from 54 million head in 2012-2013 [5]. Cattle are typically raised for work power, milk, and breeding purposes; they are rarely raised for beef [6]. Cattle owners prefer to keep animals for domestic use, rather than sell them [2]. According to 2012 statistics from the Ministry of Agriculture, a quarter of the 52 million heads of cattle in the country were being used for work power [7].

As described in a report commissioned by the Bill & Melinda Gates Foundation at the request of the Ethiopian government and elaborated by consultants at the International Livestock Research Institute (ILRI) and the International Food Policy Research Institute (IFPRI), there are two main traditional systems under which most cattle are raised [2]. In the agro-pastoral system of the highlands, there are an estimated 55 million cattle, amounting to 80% of the country's total herd. Herds have approximately two to four heads, and cattle are mostly used for work power and dairy. The average distance to a market is 30 km. The remaining 20% of the country's total herd can be found in the pastoral systems of the lowlands. On average, there are 10 to 15 cattle per herd, and their main purpose is usually dairy production. The average distance to the nearest market is 90 km. Cattle move between the two systems when male calves from the lowlands are sold to highlanders for work purposes (providing animal power) and, thereafter, fattening for meat purposes [2]. Cattle density is higher in the highlands compared to the lowlands; however, it is uncertain how the densities compare to the carrying capacities of the regions [5].

There have been several site-specific studies in the Oromia region that reflect these general characteristics, although average herd sizes seemed to vary. One study that incorporated 2003 data from a sample of 60 pastoralists in the Oromia and Somali regions found an average herd size of 21.1 heads, with a standard deviation of 15.5 heads [8]. Most of those cattle were kept for milk production; they were rarely sold, usually only when a large amount of cash was needed [8]. A more recent study that sur-

veyed 180 smallholder cattle producers across three districts in Oromia revealed an average herd size of 11 heads [9]. Another survey of 78 households in a single district of Oromia documented an even smaller average herd size of 4.5 cattle [10]. Those cattle were kept primarily for work power, and secondarily for milk and meat [10].

Meat production is low compared to other African countries, as the national figure is only 8.5 kg per head of cattle per year [2]. When used for beef meat, yields are also extremely low, even relative to other countries in the region [6]. Average live weight of cattle is estimated to be 250 kg, with a carcass weight of 110 kg [7]. These figures are still much lower than those found in the United States, where in 2014, the average live cattle weight was reported by the US Department of Agriculture to be approximately 600 kg, giving an estimated average carcass weight of around 360 kg [11].

Past government interventions have focused on cattle, and have often promoted dairy production rather than beef. These interventions have entailed promoting urban-rural linkages, extension services, the National Livestock Development Project,² and slaughterhouses that are publicly operated [6]. As a result, although beef production is still predominantly traditional, there are now emerging intensive and semi-intensive production systems [6]. For example, the 2010 Gates-commissioned report states that there are large private feedlots, which have around 350 to 400 head, small private feedlots with around 100 head, and cooperatives, whose members raise around ten head each [2]. An even more recent US-AID report from 2013 mentions the existence of feedlots with as many as 5,000 head located in certain corridors of the country [12]. Feedlots, which will be described in further detail in the forthcoming section on inputs, are a step toward large-scale commercial cattle production for meat.

Marketing for cattle

In Ethiopia, approximately three-quarters of the geographic area lies more than 30 km from existing market infrastructure [5]. Thus, a key factor relevant to scaling up and commercializing cattle production is access to

markets. A 2011 study analyzing beef cattle value chains in the country reported that there are both legal and illegal cattle markets, with large- or medium-scale exporters in the former type and small-scale traders in the latter [13]. Illegal cross-border trade of cattle is significant, with estimates of around 320,000 cattle per year being traded through this channel as of the mid-2000s. It creates a challenge for beef cattle production and value chains by creating a shortage in live animals and processed meat for legal export.

The study describes a four-tier marketing system that differs between the livestock farming regions and the pastoral regions [13]. For the livestock farming regions, the first tier consists of small farmers and rural traders who make transactions with only one to two animals per exchange for all types of livestock. The second tier consists of the local markets, where small traders bring their animals and other traders then purchase a higher quantity of animals to bring to the third tier, known as secondary markets. At the secondary markets, animals are sold to butchers and other traders. At the fourth tier, called terminal markets, larger traders and butchers transact an even greater quantity of animals for slaughter. Finally, the animals are slaughtered and meat is sold to consumers through yet a different group of traders and businesses.

In the pastoralist regions, the first tier is known as the “bush” tier, consisting of bush markets where pastoralists and small traders have weekly exchanges [13]. The small traders and other pastoralists bring animals to the second tier, known as primary markets, which operate at the district level. These markets generally trade fewer than 500 animals weekly. From there, agents and medium-scale traders purchase animals and bring them to the third tier, which are secondary markets based in major towns. At these markets, between 500 to 1000 animals are traded weekly. Tertiary/terminal markets based in Ethiopia’s major cities make up the fourth tier. Large-scale traders and butchers buy animals there.

The panorama outlined above reveals that in both pastoral and livestock farming regions, beef value chains can often be long, relying on the participation of various middlemen to transport products from outlying regions to major population hubs.

Scale of poultry production

Poultry production is dominated by traditional and small-scale systems, and across the country the average house-

2. The National Livestock Development Project was started in 1999, and aimed to improve household income from livestock. Covering regional states and two cities, the project had four components: livestock production, animal health, forage production, and program management. See Addis Abba Chamber of Commerce and Sectoral Associations. Livestock resources: Potentials, constraints, and prospects for private-sector development. 2006.

hold flock size is between six to ten birds [14]. However, there are now large-scale industrial production activities developing in urban areas for the purpose of exploiting those markets [15]. These larger-scale farms may be run by the government or by private enterprises [16].

Several studies offer typologies of poultry production systems in Ethiopia [17-19]. Analyzed together, the following landscape emerges: at the smallest scale is traditional village or backyard production, involving flock sizes of up to 50 birds, raised based on free-range scavenging and usually for subsistence. Next is small-scale intensive or semi-intensive production, involving flocks of 50 to 500 birds. This type of production is commercial, located in peri-urban or urban-based settings or towns zoned for this purpose, and involves exotic breeds, a moderate level of feed typically sourced from large-scale commercial farms, and some amount of veterinary services. Finally, at the high end of the scale are large commercial farms, where over 10,000 birds can be raised in highly intensive, indoor conditions, utilizing many inputs related to feed, housing, and veterinary care. This type of production, based around and east of the nation's capital, accounts for about 1 to 2% of the country's total poultry meat [18-20].

The government has played a role in promoting commercial poultry production, including both broilers and layers, though practical support has been criticized as limited [14]. In 1996, the Ministry of Agriculture established a poultry extension package that helped establish "poultry multiplication and distribution centers" to encourage urban and peri-urban households to increase their flock sizes to 50 to 1,000 birds and manage them intensively [21]. As of 2008, there were seven such centers [18]. However, small- and medium-scale intensive poultry production accounts for a minority percentage of the output; what does exist is not specialized or vertically integrated. This has been described as an area that "should be supported by policy and regulation," by a researcher at the Ethiopian Institute of Agricultural Research and the Debre Zeit Agricultural Research Center [20].

Our landscape assessment found several studies characterizing traditional village/backyard poultry production at different sites in the Amhara, Oromia, Somalia, and Southern Nations, Nationalities and Peoples Region (SN-NPR) regions [8, 22-24], and fewer studies on commercial poultry production. One of the latter was a 2009 study on three commercial poultry farms—two considered "large"

and one deemed "small"—located near Addis Ababa [25]. One large-scale farm housed 10,000 broilers in the space of 780 square meters, resulting in a density of 12.8 chickens per square meter. Such a high density was said to facilitate infections and diseases, which in turn may have been one of the causes of high mortality observed at the farm [25]. Densities at the other two farms were lower, with 7,684 broilers housed in 800 square meters (9.6 birds per m²) and 6,034 broilers housed in 500 square meters (12.1 birds per m²) for the other large farm and the small farm, respectively [25].

A 2008 report by the FAO, ILRI, IFPRI, and others named three large-scale poultry companies operating in Debre Zeit, a hub for commercial poultry production located near Addis Ababa: ELFORA, Alema, and Genesis. ELFORA and Alema produced 420,000 and 500,000 chickens annually, respectively, while Genesis focused on egg production [18].

Marketing for poultry

There was little information about marketing infrastructure for poultry production, particularly commercialized production. Marketing is described as a constraint for village poultry production [24], and there is essentially no formal industry, rather only informal open markets that serve as outlets for indigenous chickens [26]. As is the case with cattle marketing, the animals or animal products may pass through several intermediate traders before reaching the consumers [26]. Even when families sell chickens and eggs at the market, the primary focus of their production may be on subsistence [27].

Expansion in other areas of the livestock sector

Pig production is much less common in Ethiopia. We found only one study characterizing pig raising, using a survey of 90 households, in one district of the Amhara region [28]. Most respondents had been raising pigs for less than one year, and the authors cited emerging smallholder pig farming in the northwestern region of Ethiopia [28].

In addition, another livestock trend is that sheep and goat populations are increasing relative to cattle in most areas of the country, similar to the rest of East Africa [29]. Ethiopia's ratio of sheep and goat population to cattle population increased from 0.80 to 1.07 between 2001 and 2008, according to official agricultural census data. One reason behind this trend is that sheep and goats require less feed and water compared to cattle, increasing

their popularity in both drought-prone pastoralist areas and densely populated highland areas. In the East African region, Ethiopia has the largest land area and the second highest livestock density when density is calculated using tropical livestock units that incorporate cattle, sheep, and goats [29].

2) *Industry consolidation or concentration*

In our landscape assessment, we did not find any information about livestock industry consolidation or concentration in Ethiopia.

3) *Vertical integration*

To improve livestock productivity, one official document from 2006 recommends “forging economic ties between large commercial farms and smallholder farmers for their mutual economic benefits” [6, p. xi]. However, from the recommendation it is unclear whether these ties would take the form of contract farming or some other kind of relationship. Our landscape assessment found a few references to vertical integration of poultry and cattle production (or lack thereof), described below.

Integration in the poultry sector

A representative of the Ethiopian Institute of Agricultural Research and the Debre Zeit Agricultural Research Center characterized the poultry sector as having “poor performance, insufficient levels of industry coordination, specialization, vertical integration and efficiency” [20, p. 299]. As a result, large producers compete with small producers, shedding doubt on whether small- and medium-scale production systems can survive in the market [20]. The solution proposed was to have small- and medium-scale intensive poultry production become more specialized and integrated [20].

Another source described one vertically integrated poultry production chain at Debre Zeit, approximately 50 km from Addis Ababa [14]. The article did not refer to the company by name. The integrator ran a modern hatchery, supplied chicks for its own operations and other farmers based on demand, maintained broiler and layer facilities, manufactured its own compound feed, and slaughtered and dressed birds at its own abattoir [14]. Birds were marketed both in Ethiopia and abroad [14].

Forms of vertical coordination for cattle production

Our landscape assessment did not find reference to existing vertically integrated cattle production. On the contrary, one 2012 value chain assessment of smallholder beef value chains in two sites near Addis Ababa showed that despite intensifying production and increased market orientation, beef fattening was “simply a business based on tradition” [30, p. 20]. The opposite of modernized, integrated production, actors in the value chain were only loosely linked to one another, and the technology used was outdated [30]. The authors recommended that farmers organize themselves into co-ops and bargain together [30].

Other entities have also recommended some form of vertical coordination as a means to improve the sector’s productivity. For example, an official government document suggests that some vertical linkages or supply chain development could be necessary and useful because animals raised by smallholders and pastoralists for feedlot operators who finish the animals do not always meet the required standards [6]. Moreover, it is not efficient for feedlot operators to deal with many dispersed producers [6]. It was recommended that producers organize themselves into cooperatives to have a strong, direct link with either feedlot or export-trade operators [6].

Several reports commissioned by the Ministry of Agriculture and elaborated by the International Livestock Research Institute (ILRI) also address this topic [4, 7]. For highland areas, ILRI advocates for organizing farmers into cooperatives and supporting private feedlots by linking them to producers and public extension services. The type of linkages recommended, however, are not as close as integration; rather, they recommend using memoranda of understanding [4]. Improving livestock productivity in the lowland areas would require a range of measures, including organizing pastoralists into cooperatives, supporting private feedlots, improving water availability and market access, and rehabilitating rangelands [4]. Moreover, ILRI has recommended that pastoralists be integrated into activities of domestic investors who undertake fattening, slaughtering, and trading, “in order to solve their marketing problems in an organized way” [4, p. 11]. At the same time, ILRI has also urged beef producers and feedlot operators to “incorporate inputs and services provisions such as veterinary drugs, feeds, mineral licks to organized/cooperatives and primary livestock producers” [7, p. 7]. In other words, a model resembling

vertical integration, whereby an integrator-producer provides inputs and services to farmers-primary producers is suggested. The sector should “[p]opularize vertical[ly] integrated large-scale beef industry development by incorporating commercial feed production, processing, ranching, transporting, beef fabrication and marketing operations” [7, p. 8].

USAID has weighed in on the situation and made similar recommendations. A 2013 report states that slaughterhouses should form ‘backward linkages’ with feedlots and farmers, and that the Ethiopian government can provide tax incentives for slaughterhouses to connect with or invest in feedlots and commercial farms [12]. In addition, more commercial feedlots need to be established, especially in the highlands, in order to advance production [12].

4) *Inputs*

Inputs are a key concern for livestock production in Ethiopia, as current practices use minimal, low-technology inputs, and this is perceived to hamper productivity. A 2006 official document recommends improving productivity by “increasing the use of modern inputs such as improved breeds, feeds and health care” [6]. Each of these areas will be discussed below.

a) *Breeding stock*

Poultry breeds

The Central Statistics Agency (CSA) reports that in 2013, 96.9%, 0.54%, and 2.56% of the country’s poultry population were indigenous breeds, hybrid breeds, and exotic breeds, respectively [31]. In comparing indigenous chicken breeds to imported or hybrid breeds, the former are described as hardier, broodier, more adaptive to the environment, commanding a higher price in light of better perceived flavor, and more diverse in terms of plumage, color, size, shape, and weight [20]. However, indigenous chicken breeds have also been characterized as being less productive due to slow growth and high mortality [26].

Exotic, higher-yielding poultry breeds were imported and the first “modern” poultry farms established in Ethiopia in 1959 [3]. Presently, exotic breeds are used mostly by large-scale commercial farms and, to a lesser extent, by small-scale intensive farms [16]. Commercial poultry farms also use hybrid breeds [20]. Alema, the second largest poultry company in Ethiopia, has its own hatchery and imports parent stock from Holland [18], while all

three commercial poultry farms from the Debre Zeit area surveyed in one 2009 study imported day-old chicks from Egypt [25].

For poultry, as well as other livestock, using improved breeds is considered part of the strategy to increase productivity and meat yields [6]. The government has attempted to increase poultry productivity since the 1990s by introducing a genetic improvement program that distributes exotic breeds and provides advice and services [32]. These are done through the public poultry multiplication and distribution centers (PMDCs), as well as Urban and Rural Agricultural Departments (URADs) [32]. For example, the regional livestock agency in the highland Oromia region took steps to initiate mass artificial insemination in 2013 [33]. For their part, the PMDCs deliver exotic breeds to small poultry farms throughout the country [18]. Some of the centers are being privatized, while new ones are also being established [32]. Besides PMDCs, there are also several medium- and large-scale importers [32].

Although backyard/village poultry production has historically relied on indigenous chicken breeds, advanced breeding practices have emerged to some extent in this context. A 2013 study characterizing indigenous chicken production among a sample of 306 respondents at one site in Amhara state found that 17% of respondents tried to improve productivity by using breeding techniques like crossbreeding (80%) and line breeding³ (20%) [27]. In addition, 11% of the respondents reported controlling mating in their flock [27]. The researchers interpreted these rates as reflecting more systematic practices than previously observed [34]. The most important traits that farmers selected for were egg yield and plumage color, followed by meat yield [34].

Cattle breeds

Less information was available about cattle breeds compared to poultry breeds. According to CSA data from 2011-2012, there are 52 million cattle, of which 99% are indigenous breeds [35]. The poor quality of these cattle is considered a barrier to commercialization [2]. At the same time, one official document from 2003 recognizes that high-yielding exotic breeds require more inputs,

3. Line breeding is a type of inbreeding in which desired traits are selected for by mating animals with a closely related lines, while not allowing any individual animal to contribute more than 50% of the DNA of any descendant. See On Pasture - Breeding Matters III, available at <http://onpasture.com/2014/10/20/breeding-matters-iii-inbreeding-vs-line-breeding/>, last visited Feb. 19, 2016.

and therefore recommends that they be raised mainly in modern farms around urban areas, while indigenous breeds from Ethiopia and neighboring countries that have higher yields should be selected, multiplied, and raised in drought-prone areas, as these breeds may be better adapted to climatic conditions [35].

b) Feed

Feed availability and quality are key issues in producing livestock in Ethiopia. Natural pastures and stubble after crop harvest are the main sources of animal feed [6]. The latter, however, is considered to have low nutritional value [6] and high fiber content [36]. As for the former, pastureland, which is typically communally owned, is being degraded, over-grazed, or privatized [36]. Land conservation practices are poor in Ethiopia [6]. In addition, droughts or water scarcity, especially in the lowland areas, may cause seasonal feed shortages [6]. As a complement to natural pastures, there is increasing use of crop residues (the parts of the plant that are left over from what is typically used by humans, like bran, broken rice, rice husks, etc.) and agro-industrial byproducts (from milling, brewing and food processing, such as wheat bran, molasses, corn gluten meal, bakery waste, citrus pulp, etc.) [36].

At the same time, cultivation of fodder crops (e.g., oats, alfalfa, Rhodes grass, fodder beets, and certain types of trees) is not common due to competing pressure for farmland [6]. Currently, most grain produced in the country is not used for feeding livestock, as small producers cannot afford grain-based feed and only the large-scale commercial operations located around the capital use grain-based feed regularly [3]. Rather, most domestically-produced grain is used for domestic human consumption.⁴ The US-based non-profit Brighter Green⁵ warns that using domestically-produced grain to feed livestock could further threaten food security in Ethiopia. Similarly, using land and water to raise feed crops that are fed to animals which are subsequently exported may be contro-

versial, given the country's water and land scarcity [3]. The NGO concludes that "Ethiopia's environment cannot sustain the current population of domestic animals, let alone significant increases in their numbers, or the intensity of production practices, in the future" [3, p. 16].

As for manufactured feed, animal feed processing plants face an "acute shortage" of raw materials, according to an official government document from 2006 [6]. Although the reasons for the shortage were not mentioned, the document stated that as raw materials become more expensive, the demand for concentrate feed⁶ decreases [6].

Nevertheless, the government has established an ambitious target of increasing annual domestic feed production from 5,000,000 kg in the early 2010s to 14,500,000 kg by 2025 [4]. In a government-commissioned report, ILRI states that commercially-processed feed has an important role to play in increasing livestock productivity, particularly in the highlands, and recommends that the government facilitate access to land and credit for investors to produce and process animal feed, including undertaking large-scale soybean and maize production [4]. However, we note that while increasing livestock production could have some positive impacts on human nutrition and food security, it requires significant natural resources that might be more efficiently used for cultivating crops directly for human consumption; in this regard, our landscape assessment did not produce any studies aimed at elucidating this tradeoff. The official 2003 Rural Development Policies and Strategies document claims that more feed can be produced in drought-prone areas if efforts are integrated with environmental protection, that farmers should focus on growing grasses for animal feed instead of allowing animals to graze openly, and that investors should be encouraged to set up animal feed factories [35].

Cattle feeding practices and rise of feedlots

In traditional cattle production, grazing is the most common source of feed in the agro-pastoral systems of the lowlands, while crop residues are more typically used as feed in the mixed crop-livestock systems of the highlands [13]. Various studies in the Oromia region characterize smallholder cattle production, providing more details about specific feeding practices. For example, a study of

4. According to a 2011 Brighter Green report, the country had been exporting some grain, but the government banned grain exports in January 2006 to counter increasing domestic grain prices. See Brighter Green. Climate, food security, and growth: Ethiopia's complex relationship with livestock. International Livestock Research Institute, 2011.

5. Brighter Green describes itself as a "public policy action tank," with work in the US and abroad, focusing on countries in the Global South. It addresses issues related to sustainability, environment, and animals. See Brighter Green—Our Mission, available at <http://brighter-green.org/mission/>, last visited Feb. 19, 2016.

6. Concentrates are high-energy ingredients that include fats, cereal grains, high-protein oil meals/cakes, and agro-industrial byproducts (such as those resulting from sugarcane, animal, and fish processing). They are distinguished from roughages, which include pasture grasses, hay, silage, and straw.

180 smallholder cattle producers in three districts found that three-quarters of producers relied on communal grazing land where conflicts were common; lack of grazing pasture was identified as a challenge [9]. For fattening beef cattle, 98-100% of the households in two of the districts used a free-grazing system, while in the third district 98% of the households used a zero-grazing system [9]. Another survey of 78 households in just one district of the same region found that in addition to natural pasture and crop residues, a few farmers practiced supplementation with oil seed products and linseed cakes, though most did not because of the cost [10]. Again, shortage of feed was identified as a constraint to production [10]. A 2013 study on one district in the region revealed some dry season supplementation using fodder trees [37]. At that site, farmers also practiced slightly more intensive feeding during the fattening period, whereby cattle were tethered near cropland and fed sorghum, maize, grasses and weeds, and sometimes supplemented with molasses, salt, or sorghum seeds, as well as vegetable residues [37]. Again, lack of feed was identified as a challenge, and cattle productivity was considered low [37]. It was reported that cattle could reach slaughter age at four to five years using traditional forms of feeding and rearing, or even at three to four years when cattle were “well fed” [37, p. 125]. An older study using 2003 data from a sample of 60 pastoralists in the Oromia and Somali regions found that there was also mineral supplementation with salt [8].

Against this backdrop of traditional cattle feeding, feedlots have become increasingly common in Ethiopia, with large-scale feedlots supplying domestic urban markets and export markets and small-scale backyard feedlots supplying local markets [1]. Large feedlots usually have herd sizes of 350 to 5,000, are located in areas known as the country’s “growth corridors,” and export animals around 2 to 3 years old, which are sourced from lowland pastoralists [12]. These types of feedlots are considered a recent development [7]. Smaller feedlots procure cattle for domestic sale from the highlands, which tend to be older animals (at least 4 years old) [12].

Feedlots rely on purchased hay or straw, agro-industrial byproducts that are more nutritious but increasingly expensive (e.g., oilseed cakes, wheat bran, brewer’s grain), and occasionally purchased formulated concentrate feed [6]. As of 2006, there were over 15 animal feed processing operators and 200 feedlots for fattening cattle in Ethiopia [6]. Expanding feedlots has been difficult, however, due to increasing feed prices, natural resource depletion,

and challenges in accessing export markets [2]. Although feedlot-raised beef is perceived as higher quality, it is much more expensive and therefore not competitive when sold at local butcher shops [2]. The Gates-commissioned study conducted by ILRI and IFPRI consultants found that backyard fattening might be cheaper than feedlots because feed is produced or available onsite [2]. Existing feedlots were also described as congested and unclean in an official 2006 report [6].

Nevertheless, feedlots are still being promoted. For example, the ILRI and IFPRI report recommends developing feedlots in the highland regions, among other measures, to help add value to beef products (by “converting weaker animals to quality products”), generate greater feed productivity, and create consistent demand for young male calves [2, p. 2]. However, the authors qualify the recommendation and incorporate flexibility as follows: “The form taken by feedlots should not be pre-supposed, but rather let develop according to apparent success stories” [2, p. 2]. Other researchers maintain that commercial feedlots not only add value, but also can improve animal health, and that Ethiopia can look to the experiences of neighboring countries like Djibouti and Yemen as examples [1].

Poultry feeding practices

A number of studies on indigenous chicken farming focus on characterizing feeding practices at a given site and describe the problem of feed shortage as a constraint to productivity [22-24, 26, 27, 31, 34, 38, 39]. Feeding primarily consists of chickens scavenging crops, grass, and household leftovers; depending on the site and the household, supplementation (using, for example, maize, barley, wheat, millet, sorghum, or household scraps) is provided on a daily, occasional, or seasonal basis. Supplementation may be done to help maintain chicken health as well as increase egg production and meat yield [27]. In general, commercially-produced feed and supplements were not used. One study by ILRI and the Ethiopian Farmers Project conducted in the Amhara and Southern Nations, Nationalities and Peoples Regional (SNNPR) states documented that households had little knowledge about the quality and quantity of supplementary feeds to provide [39]. A study based in the Oromia region found that baby chicks and layers were prioritized for supplementation given to poultry [26].

For other systems of production, such as semi-intensive production with flock sizes of 50 to 200 birds, lo-

cally-available commercial feed may be used [17]. Feed availability, due to lack of natural resources and competition with human food supply, is still a challenge for medium- and large-scale intensive production systems [15, 20, 21]. The largest producers may have their own feed processing plants; in fact ELFORA, Alema Farms, and Genesis all operate their own feed mills, generating grain-based (wheat bran and maize) chicken feed [3].

We found few recommendations about how to improve feed availability for poultry specifically. However, one article suggested that developing the poultry sector the same way as in developed countries might not be appropriate, and advocated for using feeds based on locally available ingredients, rather than importing feed [16].

Feeding practices in swine production

Only one study in our landscape assessment addressed swine production, finding that in one district of the Amhara region the most important feed sources for pigs were free-range, extensive grazing, crop residues (maize and straw), and household offal [28]. As in poultry and cattle production, feed shortage in swine production was also a commonly reported problem [28].

c) Antimicrobials, growth hormones, and other additives

Animal disease is identified as a major problem in various studies of livestock production in Ethiopia [9, 14, 21-23, 26, 37]. At the same time, animal health services are insufficient in Ethiopia and accessing veterinary advice and inputs (such as vaccines) can be a challenge for both traditional backyard and commercial livestock producers [9, 14, 17, 21-23, 28, 38]. An ILRI study commissioned by the Ethiopian Ministry of Agriculture found that only 45% of the country has access to animal health services [40]. One recent case study documented that access was a challenge even for farmers located in the Debre Zeit production hub, where several veterinary schools and the Ethiopian Institute of Agricultural Research are based [21]. Although one official report from 2006 maintained that the number of people with animal health expertise in Ethiopia had increased significantly [6], an ILRI study from 2013 found that the government had not promoted private sector development of animal health services, and that the public clinics that existed were improving but still inadequate in terms of coverage and quality [40].

Regarding the use of veterinary drugs and other growth-promoting substances, there are different perspectives. The 2010 ILRI and IFPRI report maintained that veterinary drugs were not widely available in Ethiopia [2]. A 2010 study on antibiotic resistance in poultry found that over 80% of *Enterococci* and *Salmonella* isolates from cattle and poultry feces were resistant to multiple drugs, including antibiotics used in human medicine [41]. However, the authors maintained that antibiotic use in Ethiopia was not widespread, and therefore hypothesized that the resistant genes may have been imported from abroad through live chicks produced where antibiotics were used [41].

A government-commissioned ILRI study from 2013 stated that veterinary drugs are produced or imported, and used in ways that are not regulated or controlled [40]. The NGO Brighter Green reported that animals housed in crowded, commercial systems are given feed that is “often laced antibiotics and hormones” [3, p. 8]. Surveys in two districts near Addis Ababa, completed in 2011 and 2012, documented the use of oxy-tetracycline as a prophylactic measure in village poultry production, which was used by 56% of respondents [31]. Though not specifically focused on prophylactic antibiotic use, a study based on a sample of 71 poultry producers in a city also near Addis Ababa found that there was “widespread and potentially inappropriate” tetracycline use, with no user awareness of the appropriate dosages and many adjusting the dosage according to their perceptions of disease severity [21, p. 124]. Usage of amoxicillin, another antibiotic used in human medicine, was also reported [21].

d) Facilities for housing, slaughtering, and processing

Animal housing facilities

A number of site-specific studies on backyard livestock production documented a lack of specialized housing, with animals (poultry, cattle, and—in one site—pigs) housed most during the nighttime, in basic structures with earthen floors, without roofs, or in the same living spaces as the families [9, 10, 22-24, 26-28, 37, 38]. In the case of village chickens, exposure to predators was a commonly reported problem [23, 24, 27, 38]. Slightly greater use of improved housing in village poultry production was documented in two districts near Addis Ababa, where 93% of the 180 respondent households employed a separate housing structure for the birds, and

82% had adequate ventilation; only 16%, however, used material for litter [31].

Improved housing is used to a greater extent in commercial livestock production; the intensive nature of production, however, is a major concern, with overcrowding observed in caged poultry systems, cattle feedlots, and confined dairy cow facilities [3]. One study documented a density as high as 13 birds per square meter in a commercial broiler operation located in the Debre Zeit area [25]. Given the overcrowded conditions, animals are unable to express their natural behaviors [3]. In the study mentioned above, biosecurity and sanitation were also found to be inadequate, resulting from poor hygiene practices, a lack of disinfection, improper litter disposal, and failure to isolate sick animals [25].

Slaughtering and processing facilities

The Addis Ababa Chamber of Commerce report from 2006 describes processing infrastructure as weak, with little involvement from the private sector [6]. As meat processing is underdeveloped in Ethiopia, most export is based on live animals [6]. Only five exporting slaughterhouses were operational as of 2013, and none of them were exporting beef [12].

Even with the small amount of processing infrastructure, slaughtering facilities were only operating at 57% capacity in 2006 [6]. As one 2011 analysis of beef value chains found, there were not enough (quality) animals being produced, so beef cattle processing facilities were only operating at half capacity [13]. Some slaughterhouses are owned and operated directly by large-scale poultry producers, such as the ones located in the Debre Zeit hub [18].

e) Land use and land acquisitions

Land use for livestock production takes three forms: extensive (pastoral or ranching), semi-intensive (integrated crop-livestock production), and intensive [36]. According to a 2013 ILRI study, integrated crop-livestock production in the highlands regions accounts for 70% of the country's livestock resources, while pastoralism accounts for 30% [7]. Natural resource degradation poses a problem for both types of production, however. For example, a 2013 study of mixed crop-livestock production in the Oromia region documented cattle feeding primarily based on natural pastures, heavy reliance on communal pasture for grazing land, and scarcity of both pastures and water

[9]. Another 2013 study on mixed crop-livestock farming in the Ethiopian Rift Valley also found water scarcity and feed shortage to be problems, and respondents coped by harvesting rainwater, prioritizing the most important animals, and reducing herd sizes [42]. A 2007 study on pastoralists in the Oromia region identified the encroachment of rangelands by different plant species and crop cultivation to be a major challenge [8].

According to the 2011 Brighter Green report, proponents of zero-grazing systems, whereby animals are confined and administered feed in feedlots or "production sheds," have emerged, claiming that these systems can prevent further environmental degradation and overgrazing [3]. The debate is whether pastoralism or agro-pastoralism can survive as production models given that the ratio of livestock to humans is declining, or whether there should be policies to expedite modernization of livestock production [1]. Along the lines of the latter strategy, investors and multinational companies are reported to have taken over land in the Gambela region and Lower Omo valley to establish industrialized agricultural enterprises, resulting in claims that rural communities are being displaced and unable to continue their traditional ways of life [43]. These "land-grabbing" deals are facilitated and authorized by the government, which maintains that all land belongs to the state [43]. More broadly, the NGO Brighter Green questions whether Ethiopia's land resources can sustain current levels of food animal production, let alone increased production [3].

There was no information about Ethiopian companies acquiring land outside of the country for the purposes of animal or feed production.

5) Waste management

There was limited information on waste management practices associated with livestock production in Ethiopia. A 2013 USAID report described the country's animal waste management practices and disposal systems as undeveloped, leading in most cases to liquid and solid waste being discharged into the environment without regard for impacts [12]. A 2008 report elaborated by the FAO, IFPRI and other organizations states that the poultry multiplication and distribution centers sell the poultry waste they generate to surrounding dairy farms as animal feed [18].

6) *Transnational corporations*

There were few references to transnational corporations based in other countries conducting livestock production activities within Ethiopia. The news source, *The InterContinental Cry* (a publication of the Center for World Indigenous Studies⁷), referred to foreign investors and multinational enterprises that had taken over land, especially in the Gambela region and Lower Omo valley, for industrialized agricultural production [43]. However, the report did not name who these entities were, and only made a reference to “a Saudi Arabian tycoon Al-Moudi” who had close ties to the Ethiopian government and received 10,000 hectares for rice cultivation [43].

7) *Regulation of livestock production*

Several policy documents guide livestock development in Ethiopia. These include the Agriculture Development Led Industrialization policy (which was the first comprehensive agricultural policy and influenced subsequent plans and policies) and the Rural Development Policy and Strategies document (which promoted labor-intensive livestock production rather the capital-intensive production) [35]. Through various policies, the government is seeking to improve veterinary services, develop a certification system to prevent future export bans,⁸ promote access to credit, and improve feed availability [1]. The task of regulating veterinary drugs and feed additives was transferred from the Ministry of Health to the Ministry of Agriculture; however, as of 2013, the responsible entity within the Ministry of Agriculture had not yet been established [40].

Impacts of industrial food animal production

1) *Impacts on worker health*

Our review did not yield any information on worker health in the large-scale animal production or processing facilities. An official 2006 report did mention, however, that cattle feedlot operators normally have to work in con-

gested and unclean conditions, given the difficulties in obtaining a space that is large enough to hold the animals [6]. However, the occupational health implications of this situation were not discussed.

2) *Impacts on surrounding communities and others*

There were very few studies documenting community impacts that had already been experienced as a result of industrialized livestock production. A media report described impacts consisting of forced displacement, human rights abuses, and destruction of traditional ways of life, which had been suffered by pastoralists, indigenous peoples, and small-scale farmers as a result of private investors’ land-grabbing in the Lower Omo valley and Gambela region [43]. While investment reportedly benefited migrants who arrived in the region looking for job opportunities, local communities themselves were becoming impoverished and confined to specially established areas along with their cattle herds [43].

On the other hand, we found more references anticipating future impacts from industrializing livestock production. Those who support industrialization view it as a way to increase national income and exports, alleviate poverty, and increase food security [3]. However, various sources caution against categorical industrialization. The government’s Rural Development Policies and Strategies document promotes labor-intensive production rather than capital-intensive production, meaning that even though advanced technology and farming methods are promoted, these should not displace labor [35].

For poultry specifically, one researcher at the Ethiopian Institute of Agricultural Research and the Debre Zeit Agricultural Research Center recommended against turning chicken production into a high-input endeavor, stating that “interventions requiring more than minimal purchased inputs or other cash outlays should be avoided as this may increase poverty and food insecurity” [20, p. 302]. Rather, “simple changes in the management of village chicken production” could improve production and household wellbeing significantly [20, p. 302]. The same researcher later warned that intensification, if not properly managed and not tailored to the socio-economic characteristics of the country, could lead to negative environmental and health impacts [16]. ILRI has also cautioned that increasing intensity of livestock production, especially in peri-urban areas where animals and humans live close together, will increase the risk of zoonoses [40].

7. Founded in 1984, the Center for World Indigenous Studies is a US-based non-profit research and education organization that works on the social, economic, and political situation of indigenous people around the world. See Center for World Indigenous Studies – Who We Are, available at <http://cwis.org/WhoWeAre/>, last visited Feb. 19, 2016.

8. Although the government has established a goal of 30,000 tonnes of meat exported per year, the international demand has been unstable due to short-term and long-term bans imposed by other countries on Ethiopian meat. Key importers, such as Saudi Arabia, have enacted bans due to concerns about possible diseases and slaughtering/processing hygiene. See Brighter Green. Climate, food security, and growth: Ethiopia’s complex relationship with livestock. International Livestock Research Institute, 2011.

3) *Impacts on natural resources*

We did not find any studies on the impacts of industrialized food animal production on the natural environment, which is already considered degraded to a significant extent, as described above. The media source on the Lower Omo valley and Gambela region states that commercial livestock farming would have the effect of restricting extensive cattle grazing and rotational agricultural farming, which reportedly help preserve the land and natural environment [43].

Public engagement with industrial food animal production

1) *Transparency and access to information*

Our search methodology did not produce any results related to this topic.

2) *Public awareness and attitudes*

Our landscape assessment yielded very little information related to public opinion on animal agriculture. There was one reference to consumer preference for local, rather than imported, poultry breeds [14]. The NGO Brighter Green stated that animal welfare was not a widespread concept in Ethiopia, but that there were some groups and individuals trying to promote the idea; the welfare of factory-farmed animals is not an issue that generates a lot of advocacy within the country [3].

3) *Media interest in IFAP*

Our search methodology for the landscape assessment generated very few news sources on industrial livestock production, suggesting that the topic—with the exception of the “land-grabbing” situation described above—has not attracted much media attention.

4) *NGO or community campaigns, advocacy, and other efforts targeting IFAP*

Brighter Green, a US-based NGO, has advocated against industrialization of food animal production in Ethiopia, citing negative impacts ranging from food security to environment/climate to equity [3]. Around the “land-grabbing” situation in the Lower Omo valley and Gambela region, the Anywaa Survival Organisation (a local grassroots group supporting the Anywaa people in the Gambela region), Human Rights Watch, and other domestic

and international NGOs and activists have conducted advocacy in support of the affected communities [43].

However, ILRI has promoted industrialization of animal agriculture, recommending measures like commercial feed production, large-scale soybean and maize production for feed, commercialization of livestock production, greater use of inputs, vertical integration, and expansion of feedlots [4, 7]. At the same time, ILRI also recommends promoting animal welfare through legislation, guidelines, communications, and organizations; however, the motivation behind that recommendation is to improve productivity, food safety, economic returns, and access to international markets [40].

5) *Description of other civil society actors engaged in IFAP*

The Brighter Green report mentions that international donors and development organizations have facilitated intensification of animal agriculture in Ethiopia, with some focusing on helping small farmers and others focusing on developing the commercial sector [3]. USAID, for example, has supported the idea of creating linkages among slaughterhouses, feedlots, and farmers, as well as the establishment of more commercial feedlots [12]. International donors, like USAID, the government of Scotland, and the UK Department for International Development (DFID), have also funded some of the studies on livestock production referenced in this landscape assessment [12, 18, 21]. Finally, it is also important to consider the community of researchers cited above, who, for the most part, recommend forming farmer cooperatives and providing greater support (for example, through extension services) to village-level producers, rather than wholeheartedly endorsing factory farming practices or vertical integration.

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India



Overview

India is a country with an expanding livestock sector, with decade-specific growth rates ranging from three to five percentage points during the 1980s, 1990s, and 2000s. Increased government investment in the sector coincided with its expansion early on, but private spending, which has risen since the 1990s, has now taken on a greater role. The consumption of animal products has increased with rising consumer purchasing power [1]. Chicken is the most widely consumed meat, while eggs are increasingly used to supplement vegetarian diets in urban households [2]. However, the level of livestock production varies substantially among India's 29 states. Mixed crop-livestock production still constitutes an important part of animal production, though commercialization of livestock production, especially poultry, has advanced significantly due to private sector initiatives. Besides these poultry operations and some dairy production, animal husbandry is still characterized in policy documents and the literature as being low input and low productivity. Productivity and efficiency remain key concerns for the government and livestock farmers, along with the challenges of feed shortage and animal disease.

Food and Agriculture Organization of the United Nations (FAO) statistics on food animal production

India had a total of 214,322,000 animal units (AUs) in 2013, resulting in an overall livestock density of 1.19 AU per hectare (ha) of agricultural area. The numbers of live animals raised in 2013 were 10,130,000 pigs, 709,000,000 chickens, and 189,000,000 cattle. FAO 2011 estimates of livestock densities, by specific animal class, were 0.05 pigs per ha, 5.39 poultry birds per ha, and 1.80 cattle and buffalo per ha.

In 2012, production was 357,000 tonnes of pork, 2,278,000 tonnes of chicken, 975,800 tonnes of cattle meat, and 59,805,250 tonnes of cow's milk. From 2002 to 2012, pork production decreased by 24%, while chicken¹, cattle meat, and cow's milk production increased by

1. It was only from 2007-2008 onward that data on poultry meat production included commercial poultry production. See Ministry of Agriculture. State of Indian Agriculture 2011-2012. Government of India, Ministry of Agriculture, Department of Agriculture and Cooperation, 2012. The FAOSTAT estimate for chicken production in 2002, which we used to calculate the 10-year (2002-2012) percent change, is an unofficial figure.

Production, imports, exports, and net balance by livestock product

	Production (mt)			Imports (mt)	Exports (mt)	Net (mt)
	2002	2007	2012	2012	2012	2012
Pig meat	468,580	385,000	357,000	219	116	357,103
Chicken meat	1,088,000	1,755,000	2,278,000	0	4,015	2,273,985
Cattle meat	958,375	1,018,092	975,800	0	433	975,367
Milk, whole fresh cow	34,612,000	46,822,000	59,805,250	0	9,544	59,795,706

109%, 2%, and 73%, respectively. The five-year period of 2007 to 2012 saw a decrease of 7% and 4% in pork and cattle meat production, respectively, and increases of 30% and 28% for chicken and cow's milk, respectively.

Industry characteristics

1) Scale

Expansion of poultry production

Within the livestock sector, poultry production has expanded the most dramatically and rapidly, with notable increases in size and intensity of operations [3, 4]. The government describes the industry as experiencing a “paradigm shift,” achieving a “quantum leap in the last three decades evolving from a near backyard practice to a venture of industrial promotion” [5]. Farms are raising more birds, and poultry density has increased throughout the country [3, 6-8]. One 2010 study characterizes small, medium, and large poultry farms as having up to 2,000 birds, between 2,000 and 4,800 birds, and more than 4,800 birds, respectively [9], but other studies have found broiler and layer farms housing 10,000 to 15,000 birds and farms with less than 5,000 birds becoming scarcer [3, 6]. Although the 2006 National Sample Survey on Livestock Ownership found that small-scale farmers raised 85% of the country's poultry [10], units with 5,000 to 50,000 birds per cycle were reported as common as early as 2007 [3]. At the same time, broiler companies have grown in size and feed mills are expanding [11]. Continued growth of poultry production is an ambition outlined in the government's 2012-2017 Five-Year Plan, with a target growth rate of 11% for commercial broilers and 7% for layers.

Growth in the poultry sector is attributed to private sector initiatives, and private production accounts for 80% of total poultry production [5]. Some of these private actors serve as integrators, using mostly fixed-fee formal contracts with large-scale farmers who produce at least 10,000 birds per cycle [12]. A recent news article reported that the largest broiler integrator has over one million

parent stock producing over 100,000 chicks daily, and that broiler companies are also establishing large feed processing plants as well as absorbing smaller farms [1]. Other integrators may contract with farmers operating on a slightly smaller scale, however. For example, Amrit, a Kolkata-based company, is contracting with farmers in Jharkhand who raise 1,000 to 1,700 birds per farm [13, 14]. In any case, the shift from backyard poultry production to large-scale poultry farming has reportedly facilitated the production of higher-value poultry products, namely chilled or frozen processed poultry products [2].

In addition to commercial farms, there are village-level “developmental poultry farms” that are relatively unorganized, utilize less capital, and have access to less technology [15]. This type of production is considered important for rural livelihoods, namely for increasing household income. The government provides support through programs such as the Integrated Rural Development Program and Special Livestock Production Program, but funding for these programs has been described as “minimal” and the programs have not been very successful [15].

Although one 2008 source reports that poultry density has increased substantially in every region of India [7], another study that same year describes Indian poultry production as not very intensive when compared to Western countries [16]. Further, there is regional variation. In the state of Jharkhand, for example, “common” flock sizes for broiler farms ranged from 200 to 500 birds, according to 2003 survey data [14].

Commercial poultry farms are reportedly confined to certain geographic areas [15]. The state of Andhra Pradesh in the Southern region produces the most poultry, accounting for 20% of national production [10]. Other areas with significant output are Tamil Nadu (Southern region), West Bengal and Bihar (Eastern region), Maharashtra (Western region), and Punjab (Northern region) [15]. In May 2013, the government of Uttar Pradesh state implemented a new subsidy of up to \$830,000 (USD) for farms with a

minimum of 10,000 parent units of broiler chickens and at least 70% bank financing [17]. It also offered rebates and exemption from a 4% feed tax. The state government is aiming to stimulate establishment of 410 new units with capacity for 12.3 million more birds within 5 years.

A few studies have compared small and large producers to ascertain whether the shift to large-scale, and sometimes integrated, commercial production results in higher productivity, efficiency, and better outcomes for farmers. A joint International Food Policy Research Institute (IFPRI) and FAO study from 2008 found that independent small-scale broiler producers in India made more profits per animal than independent large-scale broiler producers [4]. However, large-scale independent broiler producers were more efficient at securing profits for a given amount of resources than were small-scale independent producers. Moreover, small-scale contract growers also made less profit per unit than large-scale contractors. The researchers hypothesized that such differences might be attributed to the fact that smaller farms were farther from market outlets and larger farms were relatively more experienced. In order to remain competitive, smallholders might spend less on overhead, have lower labor costs per unit, and possibly engage in more intensive supervision [4].

A site-specific study conducted in 2010 with 140 randomly selected broiler farms in Punjab state had similar conclusions after examining several metrics, including feed conversion ratios, benefit-to-cost ratio, total fixed investments per bird, total variable costs per bird, total production costs per bird, net returns per bird, and production efficiency [9]. Researchers found that larger farms were both more efficient and more profitable, although all farms were profitable. Net returns were highest on large farms—those with over 4,800 birds. Total variable cost per bird was found to be the highest on small farms (up to 2,000 birds), followed by medium (2,001-4,800 birds) and large farms. The feed conversion ratios decreased from 1.69 for small farms, to 1.66 for medium farms, to 1.63 for large farms. The study concluded that “viewed from all angles, the production efficiency of broiler farms increased with the size due to better utilization of inputs” [9, p. 323]. However, the researchers did not report testing for statistical significance of differences or trends, nor did the study discuss alternative explanations besides economies of scale as to why large farms might be the more efficient or profitable. For example, there might be distortion from policies favoring larger-sized farms

over smallholders [4]. As described in the joint FAO-IFPRI study, policy distortions could arise from scale-specific subsidies (e.g., only larger farms receive access to subsidized credit) or scale-specific differences in “uncompensated negative environmental externalities” (e.g., larger farms “get away with” polluting more and/or compensate their neighbors less for polluted water, odors, etc.) [4, p. 3]. Further, as with other studies focusing only on productivity, the Punjab study did not consider factors like environmental impacts or the specific types of inputs used in the different sized production systems.

In fact, a study using 2002 survey data from 320 poultry farms located in a northern state and southern state of India suggested that policies such as subsidies and taxes, among others, could play a role in favoring larger producers or have a disproportionate negative effect on smaller-scale producers [16]. The researchers found that smaller operations spent more resources on pollution abatement, among other costs, and that policy subsidies worked to the disadvantage of small farmers’ efficiency relative to that of large farmers. The study concluded that profitability did not differ significantly based on scale of operation [16].

Expansion in other areas of the livestock sector

Relative to other components of the livestock sector, poultry production is the most organized and modernized [18]. There has been much less up-to-date information on trends in production scale for pig and cattle production. One study, based in the state of Jammu and Kashmir, found that between 1992 to 2003, the state’s average livestock density increased from 86 to 96 animals per square kilometer, with poultry density increasing everywhere and cattle density increasing in Jammu and Ladakh regions, but not in Kashmir [19]. Cross-sectional survey data from 2003 in Jharkhand revealed that “common” household herd sizes were one to three pigs and two to five stall-fed cattle, while a few dairy farms had herd sizes greater than twenty [14].

2) *Industry consolidation or concentration*

We found limited information about trends in consolidation of agribusinesses. Researchers from the Indian Institute of Management in Calcutta (a public business school) recommended that the Indian poultry industry consolidate through mergers, acquisitions and alliances, because they believed more vertically-integrated poultry supply chains would allow producers to reap econ-

omies of scale and be competitive internationally [20]. Other researchers stated that the absorption of small-holders into supply chains would allow them to benefit from industrialization and rising demand for meat, since they would otherwise have difficulty accessing feed, fodder and other inputs [21]. One recent media source reported that smaller broiler farms were being absorbed into larger companies [1].

Absorption of small farmers into large vertical supply chains is not a foregone conclusion, however. As an alternative avenue, the 2013 National Livestock Policy suggested that farmers organize themselves into cooperatives or producers' organizations to get better access to inputs and markets [22]. As will be discussed later, there are some studies that evaluate the performance indicators of producers who operate independently to those who are informally linked to co-ops or formally linked to integrators.

3) *Vertical integration*

Integration in the poultry sector

The 2011-2012 State of Indian Agriculture report documents a shift in the livestock sector toward integrated ownership of input, production, and marketing operations. The rise of "vertically coordinated structures like cooperatives, producers' associations and contract farming" in the poultry industry is a key feature of India's livestock sector development [3]. In particular, contract farming in the broiler industry has "emerged in a big way" [3]. Contract farming began in the 1980s [23], and by 2004-2005 it accounted for 37% of broiler production in India [24]. In major poultry producing states, much of the poultry is produced under contract [3, 25]. This reflects a general trend in Asia, as large-scale poultry production on the continent has become increasingly vertically integrated and even small-scale producers have become more market oriented [26].

Spatial distribution

The extent of integration within India, however, varies geographically [24], with more integrated broiler production reported in the southern and western regions—especially the states of Karnataka, Tamil Nadu, Andhra Pradesh, and Maharashtra—relative to the northern and eastern regions [18]. As one FAO conference paper on poultry sector development between 1995 to 2004 warns, the shift toward more commercialized and integrated production has been accompanied by an increase

in farm concentration, contrary to the biosecurity principle that farms should not be located so close to each other [18]. To combat the threat that "the large-scale poultry operations . . . turn into the disease heavens of tomorrow" and to promote animal growth, producers have turned to antimicrobials, as is discussed below [18].

Integration's actors

There are several large players in integrated poultry production. Venkateshwar Hatcheries, which began integrated poultry production in the mid-1990s [18], is considered the largest vertical integrator in the poultry sector [20]. Suguna Group, India's largest poultry company [2], unofficially reported in 2007 that progress toward integration was 80% in the South, 70% in the West, 10% in the North, and 50% in the East [18]. The company operates one of the country's most modernized processing plants, which has capacity for processing 3,600 birds daily, and has launched a chain for selling its chicken [2]. Shanthi Poultry Farm, another leading poultry integrator, uses advanced Dutch-imported processing machinery and is setting up franchise outlets in South India [2]. In the western state of Chhattisgarh, the company raised one million birds through 1,200 peri-urban contract farmers in 2007 [3]. Godrej, which owns operations ranging from breeding to marketing and has a joint venture with Tyson Foods to sell processed poultry in India, began its integrated model of poultry production in 1999, and in 2007 had contracts with 1,000 farmers in the southern and western regions [2, 18]. Other major poultry integrators include Taffa, Arumbagh, Skylark, Bengal Hatcheries, and Sneha Farms [18, 20, 27].

Types of integration arrangements and other vertical coordination

The most formal vertical arrangement involves written integrator-farmer contracts. In India, these contracts tend to be fixed-fee or wage contracts, whereby integrators provide feed and chicks, stipulate input-output ratios, and specify standards for quality [12]. Farmers are paid a fixed fee, based on amount of animal output, for their labor and facilities. Integrators assume market risks (for example, when there are changes in the prices of inputs and outputs), while production risks are assumed by both integrators and producers [12]. Forward-price contracts, whereby the integrator provides growing stock, veterinary services, supplies, and feed on credit and bears market risk, are less common [12]. In these contracts, the input costs are charged to the farmers when they sell their output.

There are also less formal arrangements that involve some degree of vertical coordination. For example, farmers may have unwritten informal contracts with intermediaries for either obtaining inputs or selling outputs [28]. A 2009 study documented partially-integrated companies that had “vertical coordination” by providing feed and chicks to independent, non-contract producers [29].

Nevertheless, a large number of the country’s feed producers, hatcheries, and commercial farmers still operate independently [16]. Outside of vertically integrated structures, the “disorganized state of marketing of poultry products” has been identified as a “major concern” in the 2012-2017 Five-Year Plan.

Comparisons of contract and independent producers, especially smallholders

One IFPRI-FAO report describes contract farming as advantageous for smallholders, allowing them to make a “smoother transition” and survive livestock industrialization [4]. For example, contract farmers may receive better support and have access to veterinary services compared to independent farmers [4]. They may also be able to lower transaction costs and suffer from fewer “asymmetries in information” [4]. A 2009 study of contract poultry farming in Andhra Pradesh found that contract growers, compared to independent growers, were relatively inexperienced, unspecialized and unskilled, and lacked access to credit [29]. Through contract arrangements, they were able to lower production costs, reduce their risks, and increase their expected incomes. They also performed as well as independent farmers; their chickens reached the same weight with shorter production cycles and better feed conversion ratios [29]. Moreover, the feed, medicines, chicks, and health services supplied by the integrator accounted for 97% of the variable input costs, while the labor, electricity, and remaining variable costs assumed by the contract farmer were only 3% of the costs, which researchers interpreted as a low barrier for entering into contract farming [29].

A 2013 study of 40 poultry contract farmers working with Suguna Foods in the same state also found independent growers to be more experienced compared to contract growers, and the latter achieved production cycles that were two days shorter [10]. However, the study did not make any reference to the sample being randomly selected or to testing for whether the differences were statistically significant. Similar to the prior study, contract

farmers’ out-of-pocket expenditures were around 4% of the total input costs.

On the other hand, researchers with the Pro-Poor Livestock Policy Initiative at the FAO, who examined contract farming in four countries including India, found mixed evidence as to whether contract farmers or independent farmers achieved better returns per unit output and whether contracting benefited smallholder producers [12]. In India, independent broiler producers tended to have higher net returns per unit of output than contract broiler producers, which might be due to higher educational attainment, greater resources, and other characteristics of independent producers [12, 28]. Moreover, contract broiler producers in India perceived the terms of the arrangement to be inequitable, and after achieving a certain scale of operation and more experience, producers shifted back to being independent [12, 28].

In addition, the same study found that formal contracts tended to exclude small farms and favor large-scale farms; as an alternative, informal contracts with cooperatives and traders were more flexible in accommodating farms of all sizes [12, 28]. The researchers concluded with a warning against interventions “geared toward putting [...] rural smallholders onto the supermarket and formal contract farming bandwagons” and “policies that force[d] them to fit into input-intensive industrial-type production systems for high-end products destined for supermarkets or exports” [28, p. 9].

Integration of swine and cattle production

There were no reports on integrated pork or cattle meat production in India. A 2014 ILRI report found that pig farms in South Asia only raised 10 to 500 pigs, and, unlike Southeast Asia, there were no big integrators or contractors in the hog sector [30].

4) Inputs

Inputs are a major concern in India, because productivity is considered to be below what it should be. The 2012-2017 Five-Year Plan reports that dairy and meat yield of most animals in India is 20% to 60% lower than global averages. Poultry production, which utilizes inputs like high quality chicks, equipment, vaccines, and medication, is considered the most advanced [5, 18]; nevertheless, there are still concerns about obtaining inputs, particularly feed, and improving productivity.

a) Breeding stock

Gains in poultry productivity in India have been attributed in part to improved breeding and hatching practices, as well as a shift from indigenous breeds to internationally recognized hybrid breeds [4, 5]. In 1961, hybrid breeds accounted for 2% of the poultry population; they now dominate the market, accounting for 59% of the population [15]. As with other livestock trends, uptake of hybrid poultry breeds varies by region. In Jammu and Kashmir states, for example, the percentage of poultry crossbreeds increased from 26% to 33% between 1992 and 2003 [19]. In Jharkhand state, on the other hand, a separate study found that even in the districts with the most intensive poultry production, almost all birds were local breeds [14]. The researchers hypothesized that these districts could become “leaders in poultry production” if they adopted improved breeds [14].

Hybrid parent stock for poultry are found mostly in the Southern region [15]. There are 500 broiler breeding farms throughout India, and most use cages and artificial insemination technology [1]. Sneha Farms, a poultry integrator, plans to expand its hatcheries using energy-efficient technologies [27].

The use of improved breeds has been encouraged in the context of cattle and pig farming, too, as a way to improve yields and commercialize production [14, 22]. The National Project on Cattle and Buffalo Breeding was initiated in 2000 [31], but uptake of crossbreeds has varied across different agro-ecological regions [7]. For example, while cattle crossbreeds accounted for 14% of the national herd in 2003, the crossbreed percentage in the Jammu, Ladakh and Kashmir regions had started from 26% in 1992 and reached 42% by 2003 [19]. The rise of hybrid breeds for pigs was even more dramatic in that region, increasing from 0.07% to 37% over the same period [19].

b) Feed

Feed is a major challenge in Indian livestock production, as there is competition for resources for producing feed for different types of animals, as well as food grains for human consumption [31]. India has a policy that encourages (and possibly requires) the country to be self-sufficient in food grains and to export grains. Grain and oilseed prices are rising, though, putting pressure on livestock producers [32]. Despite increased availability of some feed resources from the mid-1980s to the mid-2000s, the 2012-

2017 Five-Year Plan predicts that there will be a growing gap between supply and demand. For example, the International Credit Rating Agency projected that if poultry production were to keep pace with growing demand for broiler meat, then maize production in the country would need to double over the next ten years [33]. In light of this situation, the Five-Year Plan states that it is necessary to increase feed and fodder production and shift toward semi-intensive or commercial operations.

Feed is the most significant cost in animal production, accounting for 60% to 70% of the total input costs [31]. Access to feed can even determine what kinds of animals are produced. Smallholders depend on common grazing land for fodder and feed, which have been degraded [21]. Thus, poultry are generally raised by poorer households who depend on common property resources, while those with access to green fodder are more likely to keep larger ruminants rather than poultry and small ruminants [7]. In areas like Punjab state, grain production cannot expand due to land fragmentation, so for this additional reason poultry farming is considered a good alternative [9].

Livestock productivity, as measured by indices such as meat yields, is limited by the shortage of feed and fodder [21]. Straws, crop residues² and other agricultural byproducts are the major ingredients of livestock feed [22]. However, agro-industrial byproducts—grains, brans, and oilcakes—are not used as frequently as crop residues, which have lower nutritional value and do not enhance animals’ productivity [34]. Some technologies can help improve their nutritional content, but uptake of these technologies has been unsuccessful because they did not appear to be cost-effective to farmers and were introduced into systems where they did not fit appropriately (for example, ignoring the nexus between crop and livestock in mixed production systems) [34]. Although more feed is currently being processed [11], the production and use of feed generally reflect the “low adoption of improved livestock farming practices” in the country [14]. Concentrates³ and supplements are rarely used in India and the rest of South Asia, even compared to rural Southeast Asia [30]. For example, a 2011 ILRI study

2. Crop residues consist of the parts of the plant that are left over from what is typically used by humans, like bran, broken rice, rice husks, etc.

3. Concentrates are high-energy ingredients that include fats, cereal grains, high-protein oil meals/cakes, and agro-industrial byproducts (such as those resulting from sugarcane, animal, and fish processing). They are distinguished from roughages, which include pasture grasses, hay, silage, and straw.

of four districts in Jharkhand found that less than 5% of livestock animals were given purchased, concentrate feed, and fodder cultivation was also rare [13]. Indigenous poultry were kept in backyard systems, pigs were kept in scavenging systems and fed kitchen waste, and only improved breeds of broilers and layers were fed purchased, balanced concentrate feed [14]. Similarly, a study in two northeastern states of India found that even in semi-intensive and intensive production systems, including intensive urban-based poultry farms, producers used poor quality feed with low nutritional value [35]. The challenge of inputs, in conjunction with lack of market access and technical advice, restricted farmers from scaling up and commercializing their enterprises [35].

Currently, broilers have a feed conversion ratio of 1.8 to 1.9 and reach a weight of 2 kg within 40 days [31]. The corresponding indicators in US broiler production are a feed conversion ratio of 1.91 and a weight of 2.8 kg reached within 48 days, according to the National Chicken Council, a US-based broiler chicken trade organization.⁴ Site-specific studies have found some differences based on size of operation and participation in contract farming. For example, for 50 randomly selected non-contract and contract poultry growers in Andhra Pradesh, feed conversion ratios were 1.88 and 2.15, respectively [29]. In a study of 140 randomly selected broiler farms in Punjab state, average feed conversion ratios for small (up to 2,000 birds), medium (2001 to 4800 birds), and large farms (greater than 4,800 birds) were 1.69, 1.66, and 1.63, respectively [9].⁵

For pig production, the State of Indian Agriculture 2011-2012 observed that the sector would need support to improve feed conversion efficiency, though no figures were provided. As for cattle production, there was less discussion about feed conversion ratios; rather, the main issue was whether cattle are raised under free-range or stall-fed systems. A study in Arunachal Pradesh state found that some crossbred cattle were raised in intensive stall-fed systems, but that even in those systems, commercial cattle feed was not used [35].

c) *Antimicrobials, growth hormones, and other additives*

Antibiotics and growth promoters

Animal disease is another priority topic in livestock production in India, as there are shortfalls in veterinary services and animal health centers around the country [5]. In this context, the use and abuse of veterinary drugs—which are of debatable and unchecked quality—have emerged as key concerns. The 2013 National Livestock Policy states that disease prevention should be undertaken through vaccines; that awareness of veterinary drug abuse should be fostered to control zoonosis and protect human health; that in order to protect biosecurity states should promote responsible use of antibiotics and other medicines; and that foods of animal origin should be free of antibiotic residues, pesticides, and other harmful additives. The present food safety scenario is worrisome, with the government admitting that “[m]icrobial contamination, antibiotic residues and adulteration in milk, meat and animal feed is [sic] rampant” [31].

The Indian Ministry of Agriculture banned the use of antibiotics for growth promotion in food animal production, and for antibiotics used to treat disease it mandated a withdrawal period of seven days for eggs and milk and 28 days for meat before those products could be used for human consumption [36]. The government notified poultry farms not to use antibiotics in animal feeds [32]. In spite of this, Indian researchers found that poultry producers were still using antibiotics for growth promotion [36]. Some companies were reportedly selling a feed premix with antibiotics as a growth promoter [37]. Antibiotics mixed with feed were also administered for prophylactic purposes [32]. The New Delhi-based Centre for Science and Environment (CSE) released a report in July 2014, documenting antibiotic residues in 40% of 70 chicken samples tested from Delhi and around the capital region; 23% of the samples were tainted with one antibiotic, and 17% with more than one antibiotic [32]. A March 2015 media interview showed an owner of a poultry operation with around 450,000 birds admitting to the use of artificial growth promoters (such as steroid-containing artificial growth promoters) and antibiotics (including levofloxacin and enrofloxacin) to prevent diseases and fungal and bacterial infections [8]. Hatcheries like Venky’s, Vetline India, and Skylark Hatcheries were also documented using antibiotics to help chickens grow faster and prevent infections during hatching [38]. In some cases, chickens are exposed to a low dose of antibiot-

4. National Chicken Council – US Broiler Performance: 1925 to Present, available at <http://www.nationalchickencouncil.org/about-the-industry/statistics/u-s-broiler-performance/>, last visited Feb. 16, 2016.

5. Neither study tested for statistical significance of the observed differences, however.

ics throughout their full lifespans [37]. Such reports run contrary to a claim made by an autonomous but government-supported think tank that Indian and western poultry production differ significantly in that the former does not use hormones or growth promoters [16].

The majority of large poultry farms in India use feed with antibiotics [39]. Indian producers defend antibiotic use by claiming that cutting down on antibiotics would reduce yields, affect their livelihoods, and impact nutrition in the country [36]. They further assert that antibiotic residue levels are still much lower than in other settings, namely in the US and the EU [37]. The Indian Medical Association has demanded measures to prevent medically important antibiotics from being used in food animal production [40].

There has been less attention to the use of antibiotics in swine and cattle production. One 2014 study on pork value chains in Nagaland, the state in India with the greatest amount of pork consumption, found that four out of 88 pork samples (4.5%) obtained from slaughterhouses and butchers tested positive for antibiotic residues, with one in 20 samples exhibiting “unacceptable” levels [41].

Finally, as a different perspective, a 2008 study of registered organic livestock farmers in Uttarkhand found that routine use of antibiotics was “very limited” and restricted to emergency treatment of disease when plant-based homeopathic treatment did not suffice [42].

Other additives

Information about other feed additives was limited to a few media reports on agri-business investments in India. Given high grain prices and the need for feed alternatives in India, BRI, a US-based company, is targeting poultry producers in marketing an enzyme to improve broiler digestion and uptake of corn-soy diets [43, 44]. Another multinational company, Cargill, is developing and aiming to market “natural” products to promote gut health, filling the gap left by the shift away from antibiotic growth promoters [40].

d) Facilities for housing, slaughtering, and processing

Animal housing facilities

The literature contained very little information about housing facilities used in animal husbandry in India. For poultry production, one 2007 report referenced immi-

nent legislative regulations requiring new cages added to farms after 2012 to have a minimum of 750 square centimeters of space [18]. A 2008 source stated that most of the country’s poultry flock was raised in open houses, and only in winter in a few regions were birds housed in heated shelters [16].

For cattle production, a Jharkhand-based study reported that, as of 2008, only 5% to 10% of cattle (predominantly dairy cattle) were raised in confined conditions both day and night and stall-fed, while 30% to 60% of pigs were raised in pens or tethered [13]. Another site-specific study, located in Arunachal Pradesh state, similarly found that most cattle were raised traditionally in free-range systems, with only some crossbred cattle raised in intensive, stall-fed systems [35]. For swine production, farmers with more resources based in urban or peri-urban areas raised pigs intensively, placing them in shelters with concrete floors [35].

Slaughtering and processing facilities

Slaughtering and processing infrastructure in India is generally underdeveloped. Studies from the mid-2000s reported that most meat produced was “not processed for value-addition or chilled” [21, p. 1] and that slaughterhouses did not have the capacity to handle the demand for meat [3]. As of 2007, there were 10,000 traditional slaughterhouses in the country, only 40% of which were registered [21]. Traditional slaughterhouses were characterized as having poor hygiene and sanitation, poor meat quality, and negative environmental and health impacts resulting from pollution and inadequate waste disposal [3, 21]. In addition, these facilities tended to be located in urban areas and have poor linkages with producers, resulting in meat supply chains that required many intermediaries [21]. Although some modernized processing facilities had been established in the prior decade, these tended to be export-oriented [21]. Moreover, a study utilizing Total Factor Productivity economic analysis found that increased output by the meat processing industry was attributed to increased inputs and capital, rather than greater efficiency or economies of scale, leading to the conclusion that productivity and efficiency should be improved [45].

More recent documents suggest that developing and improving slaughtering and processing facilities are priorities. A 2012 research report describes meat processing in India as unhygienic, with poor quality and food safety [24]. The 2012-2017 Five-Year Plan states that plans to

modernize slaughterhouses have not been “effectively implemented.” There are 77 registered meat processing plants and 30 registered export-oriented slaughterhouses, and their upgrading and modernization are deemed a “top priority” [31]. The State of Indian Agriculture 2011-2012 report indicates that some projects for modernizing abattoirs are undertaken by the government itself through one of its ministries (though it is not specified which ministry). For its part, the 2013 National Livestock Policy also emphasizes the need to develop better links in rural areas between producers and “integrated modern abattoirs.”

Against this backdrop, it appears that the most developed processing facilities by far are those owned by large poultry integrators. For example, Bengal Hatcheries Ltd., which owns breeding facilities, commercial farms, feed processing units, meat processing operations, and retail outlets, had the capacity to process 6,000 tons of chicken meat per month in the mid-2000s [20]. Another integrator, Suguna Group, operates one of India’s most modernized processing plants, which can process 3,600 birds daily, while Shanthi Poultry Farm, also a poultry integrator, uses advanced Dutch-imported processing machinery in its facilities [2]. Technology is said to have revolutionized the poultry sector, turning it into one of the most specialized [15]. Nevertheless, recent media reports continue to describe progress toward processed meat products as sluggish, with marketing still focused on live birds and the slow growth of processed food vendors like KFC and McDonalds [11]. Integrators are trying to stimulate consumer demand for processed poultry products by establishing integrator-owned or franchised chilled/frozen poultry stores, sales counters within supermarkets, and home delivery services [2].

e) Land use and land acquisitions

There were a few indirect references to scarcity of land as a resource for feed production and livestock farming. For example, one study cited land fragmentation (whereby the sizes of landholdings become smaller due to ownership being split up) in Punjab state as an obstacle to expanding grain production, though did not provide additional information beyond that claim [9]. A few other sources emphasized the importance of common property resources in raising livestock, and noted that these resources are insufficient, degraded, or being encroached upon [5, 19, 21].

We did not find information about land acquisitions being undertaken by Indian agri-businesses overseas or by foreign enterprises entering India for the purpose of feed crop cultivation or food animal production.

5) Waste management

There was little information on waste management practices in livestock operations. In the case of one integrated poultry producer, Shanthi Group, manure deriving from the activities of 1,200 contract farmers was being sold to nearby crop farmers [3]. The 2013 National Livestock Policy briefly mentioned that there should be more effort to improve management of manure through composting and biogas plants. Recently, the Maharashtra Pollution Control Board inspected one slaughter plant operated by the Brihanmumbai Municipal Corporation (BMC) in a Mumbai suburb, and found that it needed an environmentally friendly way to dispose of animal waste [46]. As a result, BMC made plans to upgrade the plant by installing a bio-methanation plant, which would use solid waste to produce biogas for electricity generation and slurry to produce manure [46].

6) Transnational corporations

Besides the feed and feed additive companies described above, we did not find information about foreign companies conducting animal husbandry-related activities within India. A 2007 study reported that there was essentially no foreign direct investment in the country’s broiler sector [18]. The US company Tyson Foods has more recently noted in that it established a jointly-owned poultry production venture in India called Godrej Tyson Foods, Ltd,⁶ and the US company Cargill has acquired the Provimi company in India, which is an animal nutrition business.⁷

7) Regulation of livestock production

We found brief references to the regulatory landscape for a few areas related to livestock production. On the issue of environmental impacts, a 2008 IFPRI-FAO report stated that India had “minimal rules” regarding these impacts and no regulations for the application of animal manure or disposal of dead animals [4]. Regarding veterinary drugs

6. Tyson Godrej India, available at <http://www.tysonfoods.com/Around-the-World/International-Operations/Tyson-Godrej-India.aspx>, last visited Feb. 16, 2016.

7. Cargill— Animal Nutrition, available at <http://www.cargill.co.in/en/products/animal-nutrition/index.jsp>, last visited Feb. 16, 2016.

and vaccines, the 2012-2017 Five-Year Plan characterized quality control as non-existent. According to one August 2014 media source, the Indian Ministry of Agriculture officially banned antibiotic use for growth promotion and mandated a withdrawal period for antibiotics used for disease treatment [36, 47]. However, poultry producers' violations of these regulations were observed.

With respect to animal welfare, the 2013 National Livestock Policy deemed animal welfare an "integral part" of livestock production and—without specifying content or mechanisms—asserted that compliance with norms on animal production, transportation, slaughter, care, and handling would be ensured. A 2007 report stated that "[t]he whole organized poultry sector use[d] hybrid varieties of poultry and ha[d] adopted cages," [18, p. 20]; however, this "cage-based system [was] being phased out" [18, p. 50]. Current regulations required poultry cages to have a minimum space of 500 square centimeters, and new regulations would require a minimum of 750 square centimeters for any cages added to farms after 2012 [18].

For organic livestock production, one 2011 study described organic poultry farming as unregulated at the national level [48]. A separate study referenced international standards, such as the IFOAM Basic Standards and EU regulations, as well as the Indian Ministry of Commerce's National Standards for Organic Production [42]. That study compared those standards to the practices of 180 registered organic livestock farmers in Uttarakhand, the first Indian state declared as organic, and found that they were mostly met, although the researchers could not verify whether 100% of the purchased feed used was organic [42].

Impacts of industrial food animal production

1) Impacts on worker health

Our review did not yield any information on worker health in the large-scale animal production or processing facilities.

2) Impacts on surrounding communities and others

Most research on the impacts of industrialized livestock production in India focused on analyzing the effects of this development on small-scale farmers, some of whom might opt to participate as contract farmers and others of whom might be excluded from the new, vertically integrated supply chains. A 2007 report that reviewed the lit-

erature on the impact of contract farming on smallholders in India reached the following conclusions: (1) industrial animal production is forcing small farmers to leave the business; (2) contract farming or supporting smallholders with physical infrastructure could help prevent this from happening; (3) not all of the fears that contract farming is discriminatory against small farmers are well-founded; (4) there is conflicting data on whether contract or non-contract farming is more profitable for farmers; and (5) there is limited evidence showing the vertical coordination in the poultry sector actually reduces smallholders' risk and transaction costs [18].

Results from other studies included in our landscape assessment have generally aligned with these conclusions, if not a more critical view. A 2009 study conducted as part of the Pro-Poor Livestock Policy Initiative at the FAO found that the integration of broiler production in India tended to exclude small farms, favor large-scale farms, and result in contract terms perceived as unfair by contract farmers [28]. For reasons that might be due to self-selection bias, independent producers achieved higher returns per unit of output than contract broiler producers, and contract farmers ultimately reverted to independent production after achieving a certain scale of operation and obtaining experience [28]. A think tank study on poultry farms in a northern and southern state of India reached similar conclusions, finding that both large and small independent farms were statistically significantly *more* profitable than their contracted counterparts [16].

Regarding the pressure experienced by smallholders as a result of livestock sector growth, a 2007 study conducted on integrated, peri-urban poultry production in Chhattisgarh state, where 75% of poultry is raised under commercial systems, found that smallholder farmers had been displaced and marginalized because they now had less access to grazing resources, had been exploited by the market, and had little means for obtaining credit and other services. They could not make investments of similar magnitude in food quality and safety as large, industrial producers, and therefore could not compete [3]. Similarly, a study from 2008 found that smallholders were disadvantaged because they had to spend more resources on pollution abatement (collecting, drying, and transporting manure) and transactions (getting access to credit, information, marketing, transportation, and storage facilities) [16]. The researchers also found that in some regions, there were policies and subsidies that had a disproportionate impact on small producers, such as a

processing tax on poultry products levied by the state of Andhra Pradesh [16].

One exception to these perspectives was a recent study looking at the level of knowledge of contract broiler farmers in one district of Tamil Nadu state [23]. The researchers conducted a structured interview with 75 respondent farmers to assess what they knew about various aspects of contract farming, such as features of contract farming, inputs supplied by the parties, monetary and non-monetary benefits of contract farming, and companies that engaged in contract farming. They concluded that farmers had a high level of knowledge about contract farming [23]. We noted, however, that only one respondent knew about different types of contract farming and only nine respondents could name other livestock and poultry companies that used contract farming—which suggests that although respondents knew about their own arrangements, they might not know about alternative options available to them.

Given the push for continued vertical integration and expanded livestock production, further research is needed on the implications this development has for farmers, particularly those that operate at small scales, are based in rural areas, and/or own less land. Moreover, this research should focus not only on outcomes related to animal output, but rather households' total agricultural output and overall livelihood. This is because many producers engage in mixed livestock-crop systems, and there is a research gap regarding whether livestock contract farming improves these households' welfare more holistically, not just in terms of livestock [12].

Finally, beyond the impact on farmers, there has been essentially no research on community health in areas surrounding industrialized livestock production in India [6]. As early as 2007, the bio-security implications of more concentrated livestock production were flagged as an area of concern [18]. In fact, large-scale commercial poultry production was recognized as entailing greater public health risk than village poultry production, given that the latter has more genetic diversity, natural disease resistance, and less cramped/confined conditions [26]. Yet research on public health impacts of industrialized production has been limited, and the popular view is that small-scale producers are responsible for disease outbreaks and other bio-security hazards [26]. The connection between veterinary drug abuse and emergence of antibiotic resistance in humans was suggested by one

2014 media source, which stated that studies between 2002 and 2013 on antibiotic resistance in the Indian population had found pathogens resistant to the same drugs—ciprofloxacin, doxycycline, and tetracyclines—as those discovered in poultry through investigations conducted by the Centre for Science and Environment [32].

3) *Impacts on natural resources*

Our landscape assessment found little research on the environmental impacts of industrial food animal production. The 2013 National Livestock Policy only briefly mentions that efforts should be undertaken to reduce greenhouse gas emissions by livestock, and that high fiber fodder should be converted into silage, chaffed, or chopped up. One report examining six case studies of livestock production in India warned that the trend of decoupling crop production from livestock production would mean less efficient water use and breaking the nutrient cycle so that manure is less utilized as fertilizer [3]. Dead animals are also an increasing concern, given the scaling up of livestock production, with groundwater contamination resulting from decomposing carcasses that are improperly disposed of or air pollution resulting from their incineration [4].

In terms of accountability for environmental impacts, the joint IFPRI-FAO study on Thailand, India, Brazil, and the Philippines found that in general small farms caused less environmental harm than large farms, but that in India smaller broiler producers paid more environmental expenditures per kg of output than their larger counterparts [4]. These expenditures covered such costs as compensating neighbors, collecting manure, building manure storage facilities (e.g., lagoons), disposing of manure, and other activities to mitigate environmental impacts. However, large and small contract farmers spent the same amount, which was more than what was spent by independent farmers [4]. Another study based on 2002 survey data from a northern and southern Indian state also found that smaller operations spent more on pollution abatement; for example, expending more resources to collect, dry, and transport manure so that the poultry sheds and their surroundings were kept clean [16].

Public engagement with industrial food animal production

1) *Transparency and access to information*

Our search methodology did not produce any results related to this topic.

2) *Public awareness and attitudes*

We did not find any studies focusing on public awareness and attitudes toward industrial food animal production. One study mentioned that the public believed slaughter should occur close to where the animals were raised; however, no citation was provided for this assertion [18]. Another study cited lack of consumer awareness about organic poultry farming as a limitation to its development in India, yet mentioned consumer preferences and increasing health concern as drivers of organic livestock farming [48]. No further information was provided about these claims.

3) *Media interest in IFAP*

As demonstrated in previous sections, media interest in food animal production often centered on the use of antibiotics and growth hormones, particularly by poultry farmers. Down to Earth, an environmental science journal based in India, has published articles on this topic and advocates for the regulation of antibiotic use in animal agriculture [38].

4) *NGO or community campaigns, advocacy and other efforts targeting IFAP*

Our landscape assessment found that the major advocacy effort emerging around industrial food animal production is the campaign against antibiotic use that arose last year. Following their finding of antibiotic residues in chicken samples tested, researchers at the New Delhi-based research and advocacy think tank Centre for Science and Environment called for a ban on antibiotic growth promoters in poultry production [32]. The Indian Medical Association similarly called for banning antibiotics for poultry growth promotion and disease prevention, demanding better monitoring and a national-level database to keep track of antibiotic use in humans, animals, and the food chain [49].

The poultry industry in India defended itself by saying that antibiotic residue levels were still much lower than

elsewhere, like the US and the EU [37]. CSE responded to this line of argument by criticizing the industry for misleading the public, as the EU does not allow antibiotics to be used as growth promoters and the thresholds it establishes for allowable antibiotic residues pertain to therapeutic use [37].

Poultry farmers and industry representatives have also argued that the medications are necessary for maintaining yields [36] and they do not remain in the animals for a long duration, so by the time they are consumed by humans the residues have a negligible effect [8]. Others maintain that antibiotics are only being used in small doses and for therapeutic purposes [8].

5) *Description of other civil society actors engaged in IFAP*

When it comes to other civil society engagement with industrial food animal production, it appears that researchers have mobilized around the issue of whether industry integration and growth benefit small-scale producers and what, if anything, should be done to get them incorporated into modernized supply chains. One 2007 report written by Indian-based consultants—four of whom were non-governmental researchers and one of whom was affiliated with a local Natural Resource Development Unit in Rajasthan—was funded by the Swiss Agency for Development and Cooperation (SDC). The report's authors support a "polluter pays" principle and removal of "policy distortions that artificially magnify economies of scale," such as subsidies, inappropriate environmental regulations, inadequate protection of smallholders' property rights, and concessions favoring large-scale operators [3].⁸

Research produced as part of the FAO's Pro-Poor Livestock Policy Initiative has also warned against forcing "rural smallholders onto the supermarket and formal contract farming bandwagons," instead supporting policies that can strengthen their position [28]. Other researchers, however, take the opposing view and recommend vertical integration as the way to get smallholders involved in supermarket supply chains [18].

8. The report did not provide more detail or name the specific policies that were favoring large-scale producers to the detriment of small-scale producers; however, it referred to other sources from the early 2000s, whose information may not be the most up-to-date.

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Kenya



Overview

In Kenya, economic liberalization in the mid-1990s was accompanied by restructuring of the Ministry of Agriculture, Livestock Marketing, and Development, which put greater emphasis on facilitating the private sector, providing extension services to farmers, and making production more efficient [1]. At present, there are signs of industrialized livestock production, like vertical integration and large-scale contract farms; many animals, however, are still raised in systems characterized by minimal inputs and low outputs. As efforts to scale up and expand the livestock sector continue, domestic meat consumption, especially pork and poultry, is expected to rise dramatically over the next decade and a half [2].

Food and Agriculture Organization of the United Nations (FAO) statistics on food animal production

Kenya had a total of 19,507,852 Animal Units (AUs) in 2013, resulting in an overall livestock density of 0.71 AU per hectare (ha) of agricultural area. The numbers of live animals raised in 2013 were 432,979 pigs, 39,872,000 chickens, and 18,138,500 cattle. FAO 2011 estimates of

livestock densities, by specific animal class, were 0.01 pigs per ha, 1.09 poultry birds per ha, and 0.66 cattle and buffalo per ha.

In 2012, production was 12,950 tonnes of pork, 23,654 tonnes of chicken, 410,600 tonnes of cattle meat, and 3,732,960 tonnes of cow's milk. From 2002 to 2012, chicken, cattle meat, and cow's milk production increased by 20%, 29%, and 29%, respectively, while pork production decreased by 10%. The five-year period of 2007 to 2012 saw decreases of 20% and 8% in pig and cattle meat production, respectively, and increases of 1% and 17% in chicken and cow's milk production.

Production, imports, exports, and net balance by livestock product

	Production (mt)			Imports (mt)	Exports (mt)	Net (mt)
	2002	2007	2012	2012	2012	2012
Pig meat	14,400	16,200	12,950	49	362	12,637
Chicken meat	19,689	23,460	23,654	1,827	50	25,431
Cattle meat	318,650	445,000	410,600	1	438	410,163
Milk, whole fresh cow	2,890,685	3,202,387	3,732,960	12,233	4,758	3,740,435

Industry characteristics

1) Scale

In 2012, the FAO reported that farm sizes in Kenya were decreasing due to fragmentation of landholdings, projecting that this could lead to favoring animals which can be farmed more intensively, such as pigs, over less intensively produced animals, such as cattle [3].

Scale of cattle production

According to a recent assessment by the Dutch government, cattle production occurs under three systems in Kenya: pastoral (80-90%), ranching (2-3%), and highland (7-18%) [2]. No details were provided about the characteristics of these systems, except that the second system—ranches—targeted high-value markets [2].

A 2006 study provided a more detailed typology, categorizing beef production into two main types: beef produced on large-scale ranches or mixed dairy-beef production on small-scale farms [1]. Large-scale production could further be classified into three sub-types: pastoral ranching, large commercial ranches, and intensive feedlot systems. Drawing on low inputs and using natural pastures to graze animals, pastoral ranching accounted for 50% of the beef produced in Kenya (as of 2006). Large commercial ranches rely on natural or cultivated pastures as the main feed component, and employ some disease control measures. Feedlot systems were originally introduced as finishing systems, but were not sustainable because supplying grain-based feed competed with grains used directly for human food. Moreover, infrastructure and labor made feedlot-raised beef more expensive, and therefore not competitive [1].

As for small-scale dairy-meat production, the real focus of these systems is milk production, and cattle are sold for meat when cash is needed for household expenses [1]. They use indigenous breeds and have minimal inputs and low outputs [1].

Scale of poultry production

A 2008 FAO report described a four-part classification system for poultry production in Kenya: sector one corresponds to industrial and integrated production; sector two consists of commercial production with a high or medium level of biosecurity; sector three consists of commercial production with a low level of biosecurity; and sector four represents village/backyard production [4]. As of 2008, only one company, Kenchic, was considered to be a sector one vertical integrator, and it had six breeding farms and a total flock capacity of 100,000 birds [4]. As an integrator, the company contracted with farmers within 50 km of Nairobi that had between one to four flock houses, each with capacity for 3,000 birds [4].

For sectors two and three, the information we found is not entirely consistent between sources. The 2008 FAO report stated that sector two and three broiler farms, primarily located near provincial urban centers and in peri-urban areas around Nairobi, keep between 300 and 2,000 birds per farm, and they are usually not integrated with hatcheries or slaughterhouses [4]. However, a subsequent FAO report from 2009 distinguished sector two as composed of commercial hatcheries raising layer breeders and broiler breeders, and sector three as corresponding to semi-commercial poultry farms producing 100 to 4,000 layers and 300 to 2,000 broilers per farm [5]. With this classification, there were 11,311 sector three layer farms and 23,661 sector three broiler farms in the mid-2000s [5]. A 2014 report financed by the Dutch government provided different information for these two sectors, reporting that the 10 to 15 farms that made up sector two raised between 20,000 and 50,000 broilers in confinement each, while the farms that comprised sector three raised between 2,000 and 50,000 animals in a range of housing and production styles, sometimes for the open market and other times serving as out-growers for sector one or sector two farms [2].

Finally, for sector four, village/backyard poultry production based in rural areas or informal urban settlements

generally involves indigenous chickens, which can be found in three-quarters of the country's households and of which there are an estimated 21 million in Kenya [4]. Several other site-specific studies examine sector four systems in greater depth, focusing on indigenous chicken production [6, 7]. One 2012 source described indigenous chicken farming as having three types—free-range, semi-intensive, and intensive, with a potential shift toward the last type as land becomes scarcer [8]. In free-range indigenous chicken production, undertaken mostly by rural households, few inputs are used to raise flocks of up to 30 birds [8]. Semi-intensive and intensive systems, found in urban and peri-urban areas, involve flocks from five to 50 birds or five to 500 birds, respectively [8]. A 2010 study describing indigenous chicken production cited various limitations on production, such as breeds, poor nutrition, animal disease, and improper management [9]. As described by the FAO, the Ministry of Livestock and Fisheries Development has undertaken an extensive program to help improve the productivity of indigenous chickens, and has encouraged smallholder farmers to raise chickens as a commercial endeavor [4].

Scale of pig production

According to a 2012 FAO source, there are both commercial farms and free-range traditional/scavenging systems for pig production in Kenya [3]. The former uses improved breeds and concentrates¹ for feed, while the latter is based on scavenging and some supplementation with kitchen wastes and agricultural byproducts [10]. Traditional/backyard systems predominate in the slum areas of Nairobi and in the Western and Nyanza regions, while commercial systems are the main systems found in the Coastal, North East, Eastern, and Central regions, as well as the outskirts of Nairobi [3]. More specifically, smaller scale commercial farms are found around Nairobi, Central Province, Central Rift Valley, North Rift Valley, Eastern Province, Western Province, and Nyanza Province; the most intensive of the small-scale farms are found in the Central Rift Valley, North Rift Valley, Central Province, Narok Province, and Eastern Province [3]. Large-scale intensive farms are found in Nairobi, Central Province, and the North Rift Valley [3].

Smaller-scale commercial farms raise as few as 100 and up to 2,000 exotic-local cross-breeds in confinement,

1. Concentrates are high-energy ingredients that include fats, cereal grains, high-protein oil meals/cakes, and agro-industrial byproducts (such as those resulting from sugarcane, animal, and fish processing). They are distinguished from roughages, which include pasture grasses, hay, silage, and straw.

while large-scale intensive farms keep between 5,000 and 30,000 pigs, and medium-scale farms fall somewhere in between [3]. As much as 70% of all pig farmers are considered small-scale pig farmers [3]. On the opposite end, Farmer's Choice operates the largest pig farm in Kenya, with 25,000 to 30,000 pigs, and the enterprise represents industrial, integrated production [3]. Intensive farms may be vertically integrated into Farmer's Choice's supply chain; medium-scale commercial farms may also sell fattened pigs to that company or to other pork processors [3]. As the major player in the pork industry, Farmer's Choice has urged farmers to scale up their production [3]. In 2012, its factory was slaughtering 400 pigs and processing 350 pig carcasses daily, with half of the carcasses coming from its own farms and the other half coming from one of its 120 contracted farms or some other pig farm [3].

Under traditional backyard systems, pigs are allowed to roam to varying degrees and are kept for different amounts of time, with some farmers selling the animals as piglets and others selling them closer to market weight [3]. Such systems are found in resource-poor areas, notwithstanding the government's ban on free-range pig-keeping since the 1970s, according to a 2012 article [11]. Though the article did not explicitly describe the motivation behind the government's ban on free-range pig keeping, it implied that animal disease may have been a consideration. It recounted that following the ban there was a decrease in prevalence of porcine cysticercosis in commercial farms that followed the regulations. The study went on to note that while most pigs raised in Central Kenya were raised intensively and commercially, free-range pig-keeping could be found in Western Kenya and Nyanza Province and was increasing in slum areas [11].

A recent study based on a survey of 102 pig farmers in Central and Western Kenya concurs with this characterization, with researchers finding mostly semi-intensive commercial pig farming at the Central Kenya site and smallholder free-range, extensive pig farming at the Western Kenya Site [10]. The average herd sizes for pigs being raised semi-intensively and extensively were 13.8 and 2.4 pigs, respectively. At both types of sites, pigs were kept as a source of cash income when major expenditures were made. They also served as insurance against emergencies, as livestock in general were a "financial buffer against crop and/or business fluctuations" [10, p. 372].

2) *Industry consolidation or concentration*

Our landscape assessment found limited information about industry concentration and consolidation. A small number of sources referred to the company Farmer's Choice maintaining control over the pig processing market. For example, a 2012 FAO report stated that the company handled 80% of the pigs processed in the country, while a 2014 report financed by the Dutch government pointed out that the other three pig slaughterhouses in the country only slaughtered between 15 and 50 animals per day [2]. The latter source even characterized Farmer's Choice's integrated processed pork value chain as a monopoly, and suggested that small pig slaughterhouses should develop an alternative avenue for pork processing [2].

3) *Vertical integration*

There are vertical integrators in Kenya's livestock sector, and these private entities offer extension services in the form of training and demonstrations, as well as veterinary services [2]. One recent study describes four types of contract farming found in Kenya: centralized, multipartite, intermediary, and informal [12]. In the centralized model, there is vertical integration, with a centralized processor/buyer sourcing from many small-scale farmers and usually providing inputs to the farmers. The intermediary model is similar to the centralized model, except that the burden of managing all of the contract growers is outsourced to an intermediary who acts on behalf of the central enterprise. In the informal model, there are repeated transactions, but no written contracts or other binding documents, as all agreements are oral. The last type, the multipartite model, involves two or more organizations, which can be governmental, private firms, NGOs, or international aid agencies, working together to coordinate between buyers and farmers.

Integration in the poultry sector

The FAO has reported a lack of information on the level of integration, types of integration, and number of integrated systems in Kenya's commercial poultry sector [5]. It found that in 2008, there was only one company that qualified as sector one poultry production (industrial and integrated poultry production) [4]. The company, Kenchic, operated six breeding farms and contracted farmers near Nairobi who had capacity to rear 3,000 to 12,000 birds [4]. Farmers received day-old chicks, and grown broilers were taken back to the slaughterhouse to

be slaughtered, processed, packaged and sold by Kenchic [4]. Kenchic did not manufacture its own feed, but contracted with feed producers (Kenya-based Unga Feed), while oversight of feed quality was done by the Kenya Bureau of Standards [4].

Later sources reported the presence of other poultry integrators, with Kim's Poultry Care Centre (KPCC) being the main emergent player [5]. A 2014 study on contract farming stated that Kenchic worked with medium- and large-scale farmers in Kiambu county, while KPCC worked with farmers of all scales in Nakuru county [12]. Both counties were the focus of commercial hatcheries engaging in vertical integration because of their proximity to urban centers [12]. According to another 2014 report, there were also other large- and medium-scale integrators that ran their own slaughterhouses and processing plants [2]. In that year, 30% of broilers were reportedly slaughtered in facilities that were part of a vertically integrated structure [2].

There have a small number of studies of factors related to participation in contract farming and the consequences of that participation. One investigation, using a sample of 180 households from Nakuru county (69 of which were contract farmers with KPCC and the rest independent), found that participation in contract farming was positively associated with being male, less educated, located closer to a main road, more risk averse, and not receiving advice from extension agents [12]. That study found that contracted farmers earned more per bird than independent farmers and concluded that contract farming was beneficial for small-scale poultry farmers in Kenya [12].

Another study based in four districts—Kiambu, Kilifi, Vihiga, and Nakuru—found that poultry farmers contracted by Kenchic had to raise at least 3,000 birds, be able to advance cash capital of approximately 1 USD per day-old chick, follow quality assurance and production protocols, and be located within 50 km of the company's breeding facility. Broiler production was more integrated than layer production, and farmers in the study districts only produced broilers if they had a contract because feed was expensive and indigenous chickens were preferred by most consumers anyway; broilers were usually sold to high-end markets (supermarkets, for example), tourist hotels, and the aviation industry [13]. According to that study, integrators enforced stricter biosecurity standards, meaning that contracted farmers had better biosecurity practices than independent farmers [13]. A 2009

FAO report on highly pathogenic avian influenza (HPAI) similarly stated that poultry farmers that were not industrial/integrated had poor biosecurity [5].

Although integration was portrayed positively, the 2014 report financed by the Dutch government recommended helping medium-scale chicken producers who were not part of a vertically integrated structure, especially in terms of animal health services, slaughtering, and marketing [2].

Integration in the pig sector

A 2012 FAO report referred to a single integrator in pork production, Farmer's Choice Limited, which operated the largest pig farms in Kenya [3]. According to this source, the company imported parent stock from Denmark, manufactured its own feed, raised piglets, fattened pigs on its own farms and also contracted other farms, slaughtered and processed pigs at its own factory, and exported some of the output [3]. Besides Farmer's Choice, there are also other structures for vertical coordination; some medium-scale commercial producers own slaughter slabs and butcheries, as well as produce or mix their own feed [3]. The Kenya National Pig Farmers Association, which represents some medium-scale commercial farms, has worked on getting farmers involved in the whole value chain [3].

Forms of vertical coordination for cattle production

We did not find information about integration in cattle production. One 2014 report financed by the Dutch government identified the opportunity of developing "deep" value chains to link pastoralists with cattle fatteners/feedlots and beef processors [2].

4) Inputs

a) Breeding stock

Poultry breeds

According to 2006 official statistics, there were 29 million chickens in Kenya, 22 million of which were indigenous chickens and four million of which were commercial broilers [8]. Indigenous-exotic crossbreeds are also used, especially in semi-intensive production systems [9]. One 2012 study, however, described crossbreeding as an unsuccessful and inappropriate technology, resulting in high mortality and a reduction of indigenous chicken genetic resources [7]. A more recent media source report-

ed, however, that in 2014 six million of the country's 32 million chickens were commercial hybrids [14].

Comparing industrial cross-breeds to indigenous chickens, the latter are perceived to have better taste and to be better adapted to the natural environment [6]. Indigenous chickens also command higher prices [15]. A new indigenous crossbreed, the Kari Kienyaji, is now being adopted by farmers because it commands a good price in terms of eggs and meat, is resistant to diseases, and can survive by foraging [14]. Even indigenous chickens can be raised intensively [8], and, in this regard, one 2015 media source reported that farmers are switching from extensive to semi-intensive production while adopting indigenous Kienyeji breeds [16].

Cattle breeds

We found limited information about cattle breeds in Kenya. A 2006 source reported that cattle are indigenous (mostly zebu or Boran), exotic, or crossbreeds of indigenous and exotic [1]. Large-scale beef production relies on Boran or exotic breeds and modern breeding methods, while small-scale dairy-meat production relies on indigenous breeds [1].

Pig breeds

The use of improved pig breeds is common across different types of pig production systems in Kenya [3]. In intensive industrial production, the major agribusiness, Farmer's Choice, provides imported breeding stock to its own contract farmers, which may then be resold to other commercial farmers [3]. In intermediate commercial production systems, breeding stock is sourced from government institutions as well as Farmer's Choice or neighboring commercial farms [3]. Even small-scale systems and extensive/scavenging-based systems use improved breeds, such as crossbreeds of exotic (Large White and Landrace breeds) with local breeds [3, 10]. According to one 2011 study, indigenous pigs accounted for only 13% of the overall pig population, and were more commonly found in Western Kenya [17].

b) Feed

According to a 2014 report, Kenyan livestock feed depends mostly on maize for the energy component [2]. Specific aspects of feed production and utilization are presented below by type of livestock.

Cattle feeding practices

A 2006 study reported that there were three types of large-scale beef production systems in the country: pastoral ranching, commercial ranching, and intensive feedlot systems [1]. In pastoral ranching, inputs are low and animals graze on natural pastures, while in commercial ranching, either natural or cultivated pastures are used as the main feed component [1]. The third type of production, intensive feedlots, were introduced as finishing systems, but they were not sustainable because use of grain-based feed competed with using grains as food for humans [1].

Poultry feeding practices

Poultry feeding practices have been examined in various studies. According to a 2008 FAO report that referenced the four-sector classification of poultry production systems, commercial feed is used in sectors one (industrial and integrated), two (commercial with high/medium biosecurity), and three (commercial with low biosecurity) [4]. The one company that qualified as sector one in 2008, Kenchic, did not manufacture its own feed but reportedly contracted feed producers that were known for producing high-quality feed [4]. According to another report jointly authored by the FAO, as of 2009, all of Kenchic's feed was obtained from one feed company—Kenya-based Unga Feed [5].

Farms in sectors two and three were reported to have purchased feeds from feed shops but also added growth-promoting ingredients to commercial feed themselves, such as maize, wheat bran, or fish meal [4]. As of 2009, few poultry farmers had the capacity to formulate or mill their own feeds because of lack of technical capacity to achieve adequate feed balance and a lack of economies of scale [5]. Commercial layers and broilers were raised almost exclusively on concentrates in the form of mashes, most of which were purchased from commercial feed mills throughout Kenya [5]. A recent news article reported that as feed is becoming more expensive, however, more poultry farmers are making their own feed [16].

In sector four, indigenous chickens raised in backyard/traditional systems mostly scavenge, though some birds receive supplementation in the form of kitchen scraps, maize, grains, cassava, sweet potatoes, or commercial feed [4]. When scavenging, chickens feed on insects, waste, grass, vegetables, and grains [9]. Supplementation may occur to a greater extent in wet season than in dry season, as cereals, the primary component of supple-

mentation, need to be reserved for human consumption in dry season [18]. Indigenous chickens usually have poor nutrition and low feed conversion efficiency, circumstances that limit their production [9]. For example, a 2012 study surveying 594 households located in the six districts with the largest indigenous chicken populations in Kenya found that 90% of chicken farmers practiced feed supplementation, but farmers identified lack of quality feeds as a major constraint on production [7]. Similarly, high feed costs were identified as a major constraint in a 2013 study using a sample of 120 farmers in two districts in Western Kenya [6]. Three-quarters of the sample provided feed supplementation using locally available feed that was homemade, gathered from around the area, or derived from kitchen scraps, while only 6.8% used commercial feed and 19% used both commercial and locally available feed [6]. Moreover, following the implementation of a management intervention package that included feed supplementation (among other practices), researchers found that feed expenditure among that sample was positively and significantly associated with output; specifically, a 1% increase in feed input was associated with a 29.8% increase in the value of the output [15]. Production assets, like feeding troughs, were also positively and significantly associated with output [15]. However, the study methods suggest that caution should be used when interpreting these results.²

Pig feeding practices

According to the FAO, in 2012, less than half of pig farmers used “modern pig farming” techniques, including “proper” feeding procedures (e.g., underfeeding was cited as a problem that led to pig infertility) [3, p. 41]. The authors of the report state that there is “no shortage of animal feed in Kenya” but recognize that feeds (especially concentrates) are expensive, quality is sometimes poor, and competition for maize exists between pig feed and human consumption [3]. Grain byproducts (e.g., bran from wheat, rice, wheat grain, and maize grain) are also used as sources of the energy component of feed [3]. They are produced domestically or, in famine years, imported [3]. Protein sources (e.g., soy-based feed premix, sunflower cake, cotton cake, and fish) are imported from Europe, India, or neighboring countries [3].

2. This study did not use a pre/post-design to evaluate the impact of the intervention package. The researchers only examined a cross-section of respondents, and assumed that correlations between different covariates and outputs implied causation.

Like poultry production, feeding practices vary among the different pig production systems. Both large- and small-scale commercial systems rely on commercial concentrates for feed [10]. Cereals are the primary feed component, and large-scale farmers mix their own feed, while small-scale farmers may form co-ops to operate feed mills [3]. Intermediate commercial farmers use commercial feeds for finishing, and some also own feed production factories or mix their own feed [3]. At the largest scale, integrator Farmer's Choice manufactures its own feed and supplies it to its contract growers [3]. At the opposite end of the spectrum, free-range pig production relies on scavenging and some supplementation with kitchen wastes or agricultural byproducts [10]. The extent to which pigs are allowed to roam and are provided with supplementation varies [3].

A few site-specific studies examining pig feeding practices confirm this general characterization and provide a few additional details [10, 17, 19]. For example, a 2015 study found that pigs farmed semi-intensively and commercially at a Central Kenya site were fed agro-industrial and market byproducts, with 33% of farmers feeding pigs mostly concentrates, 64% using both market wastes and concentrates, and 4% relying only on market wastes [10]. All of these pigs were stall-fed [10]. Concentrates were obtained mostly from local retailers, though about 22% used homemade mixes, and purchased cereal byproducts were mixed with a protein source, such as soybean meal, sunflower meal, cottonseed meal, or fish meal [10]. Moreover, 37% of the farmers administered mineral supplements [10]. At the Western Kenya site, on the other hand, the study found that most pig farming was done in extensive smallholder systems, which kept pigs tethered most of the time, but also allowed them to free-range/scavenge [10]. About 30% of these farmers gave small amounts of commercial concentrates to pigs, especially sows and piglets, and kitchen scraps and other wastes were also used to supplement pigs' diets [10].

c) Antimicrobials, growth hormones, and other additives

According to an article authored by a US-based extension veterinarian, livestock diseases in Kenya differ from those found in developed countries in that they are typically vector-borne or contagious, rather than provoked by stress and illness from abrupt weaning, long journeys to feedlots, and other practices associated with industrialized animal agriculture [20]. In our landscape assess-

ment, we found that most sources addressing the topic of livestock health did tend to focus on vector-borne or contagious diseases. We also found there were more references to poultry and swine health than to cattle health.

For poultry farming, diseases and parasites were mentioned as constraints on production, especially indigenous chicken production [7, 9]. A 2008 FAO report classified poultry production systems based on biosecurity levels [4], and a subsequent 2009 report stated that with the exception of industrial integrated producers, poultry farmers observed low biosecurity measures [5]. Non-integrated commercial poultry farms were reported to obtain drugs and other agricultural inputs from "Agrovet" shops [4]. Poultry disease control was carried out mainly by private actors, with some animal health service providers visiting farms themselves [5]. Drugs sold to farmers can be used for prophylactic purposes; farmers—especially commercial-scale ones—administer most of these drugs themselves, either in animal feed or drinking water [5].

A few site-specific studies provided additional details about the animal health situation in poultry production. For example, participatory research carried out from 1996 to 1999 with 200 smallholder chicken farmers across five regions found that nearly all farmers used traditional medicine to treat animal disease, that some farmers did not use any conventional medicine, and that there was inconsistent uptake of vaccinations and deworming practices [19]. More recently, among 120 indigenous chicken farmers in Western Kenya, diseases were identified as a major production constraint, and less than half of the farmers reported having access to extension and veterinary services [6]. Some farmers, however, had formed groups to mobilize resources jointly, carrying out activities like group-based vaccination and collective purchases of drugs, feeds, and equipment [21]. The researchers found that group purchases of drugs and collective vaccination efforts helped ensure timeliness and reduced costs [21].

Less information was found through our landscape assessment regarding swine production. A 2012 FAO report mentioned that less than half of pig farmers used industrial pig farming techniques or followed proper veterinary care procedures, and these factors hindered production [3]. A couple of studies examined cysticercosis in pigs at specific sites, with one 2011 study detecting the condition in 43 out of 288 households farming indigenous pigs

in Western Kenya and a pig-level prevalence of 4.5% [17]. A 2012 study based in one district in Nyanza province found that a third of the samples collected from 392 pigs tested positive for cysticercosis. The largest risk factor was being raised on a farm with no evidence of (human) latrine use [11].

We found few sources addressing animal health in cattle production. The one source we found that described the topic in some detail was a 2006 report by international and in-country researchers that listed a number of endemic tropical diseases affecting cattle in Kenya, such as foot-and-mouth disease, rinderpest, East Coast Fever, redwater, anaplasmosis, trypanosomosis, and heartwater [1]. According to the report, vaccination campaigns were a challenge, particularly in pastoral systems, because of climatic conditions that reduced vaccine efficacy, the lack of infrastructure, and the nature of production [1]. Moreover, the challenge of parasites and diseases was exacerbated by parasite resistance deriving from abuse of veterinary drugs by producers of various scales, as well as by ineffective quarantines that allowed diseases to spread [1]. The authors attributed veterinary drug abuse to a lack of knowledge and economic resources on the part of pastoralists, and recommended improving farmer knowledge and providing government subsidies for veterinary drugs, along with proper and early disease diagnosis [1].

d) Facilities for housing, slaughtering and processing

Animal housing facilities

Animal housing facilities for chicken production vary based on type of production system. According to a 2010 source, in systems where indigenous chickens were raised free-range, housing structures were not well developed, with only simple structures used as nighttime shelters [9]. In fact, a 2012 study surveying 594 households that raised indigenous chickens found that 59% of them housed chickens only at night and in the farmer's main house [7]. Predators were identified as a major challenge [7]. However, a different study noted that even birds raised in free-range systems might be confined during growing seasons [8]. A study on indigenous chicken production based in Western Kenya found that production assets, such as chicken houses, were positively and significantly associated with output, and extension services in the study area recommended that farmers

adopt a full management intervention package, which included housing, chick rearing, and brooding [15].

In semi-intensive chicken production, birds are fenced in or allowed to roam freely [8]. In general, they are sheltered only at nighttime [9], using basic structures [8]. A study examining uptake of improved management practices by 200 smallholder chicken farmers across five regions in the mid-to-late 1990s found that most farmers had adopted improved housing to shelter birds from the elements, thieves, and predators [19]. The housing included ventilation and lighting [19].

Intensive chicken production keeps birds fully confined, and the most common type of housing structure involves deep litter and slatted floors [8]. A 2008 FAO report observed that breeding stock and hatchery flock houses had cement floors and stone walls, while broiler flock houses usually had earth floors with wood shavings used for deep litter [4]. However, a subsequent FAO report provided slightly different information, distinguishing between large- and small-scale producers (rather than broiler versus layer producers) as follows: large-scale broiler/layer production mostly uses a deep litter system with sawdust, though a few large-scale producers use battery cages. Poultry houses have solid stone or timber rear walls, half-way-open front walls, and open wire mesh sides because of the heat [5]. Moreover, they usually have concrete floors and the premises are not generally fenced in [5]. In small-scale broiler/layer production, sawdust is also used as deep litter, but the walls are constructed with corrugated iron sheets and mud, and floors are earthen [5]. Again, the premises are usually not fenced [5].

Similarly, pig production uses different levels of confinement depending on the intensity of production. As mentioned above in the sub-section on the scale of pig production, free-range pig keeping was banned by the government in the 1970s but still occurs, especially in resource-poor areas and in Nyanza and Western Kenya [11]. For example, a 2012 study found that only 1.6% of 299 pig farming households in one district in Nyanza kept their pigs in total confinement [11]. A 2015 study of extensive pig farmers at a site in Western Kenya found that pigs were allowed to scavenge free-range, though they were kept tethered for most of the time [10]. Seasonal variation in level of confinement was noted by a 2011 study of 288 indigenous pig farmers in two districts of Western Kenya, with pigs being tethered more than half the time by 91% of the farmers during planting season,

90% during growing season, and 78% during harvesting season [17]. In general, pigs were confined at night and allowed to scavenge during the daytime [17].

Proper housing for pigs is a challenge, with the FAO noting in 2012 that fewer than half of the country's pig farmers had adopted proper housing, among other "modern" production techniques (FAO 2012). The 2011 study referenced above observed animal wounds from tethering, which constituted an animal welfare concern [17]. Only 27% of the 288 pig farmers provided a pig house, and shelters were made from locally available materials [17]. The 2015 study of pig farmers in Western Kenya found that a little over half of free-range/extensive pig farms provided no housing for pigs, a little less than half provided temporary sheds or stalls, and a very small percentage provided pens [10]. The same study found that the animals kept by semi-intensive pig farmers at the Central Kenya site were stall-fed and housed in shelters, mostly in special pens, though about 10% used semi-permanent stalls or sheds [10]. In addition, 73% of the structures had concrete floors, while 27% of them were wooden [10].

Slaughtering and processing facilities

Slaughtering and processing facilities vary based on the types of production system and livestock animal. According to one source, slaughtering used to be a government or quasi-governmental activity, which explains why private sector involvement is not high [2].

For poultry production, the FAO reported that in 2008, slaughtering at municipal slaughterhouses was common. For sector four (village/backyard) poultry production, there were a few slaughterhouses located in rural areas for slaughtering indigenous chickens [4]. Subsequent reports indicate that, in response to consumer preferences, there is now some tendency for farmers to add value to indigenous chickens by processing and packaging them [8, 9]; however, chickens raised free-range don't usually benefit from that [18]. For sectors two and three commercial broiler production, broilers were slaughtered and processed "at home" (i.e., on the broiler farms themselves), sometimes with the help of other persons or traders from the city market. Birds were then packaged and sent to market [4]. Sector two and three production were not integrated with slaughterhouses, at least not according to the 2008 FAO report. For sector one production, Kenchic's vertically integrated broiler farms send broilers back to the company's slaughtering facilities and the company processes, packages, and sells the birds [4].

A more recent report from 2014 did not describe slaughtering and processing capacities by sector, but stated that 30% of broilers were slaughtered in slaughterhouses and processing plants owned by large- and medium-scale integrators, while the rest were slaughtered in rudimentary, on-farm facilities [2].

For pig production, the FAO reported in 2012 that the Kenyan government was interested in promoting the market for "value-added [animal] products," and had therefore encouraged the establishment of small slaughterhouses and meat-processing facilities [3, p. 22]. The extent to which slaughtering and processing capacity exists outside of the Farmer's Choice system, however, is unclear. The Farmer's Choice factory slaughtered 400 pigs and processed 350 pig carcasses daily in 2012, with half of the carcasses coming from its own farms and the other half from one of its 120 contracted pig farms [3]. The FAO also reported that small-scale commercial farms primarily sent their pigs to Farmer's Choice pork processing factories for processing, and that both large- and small-scale intensive pig farms tended to be integrated into the Farmer's Choice value chain, which included slaughtering and processing [3]. The same FAO source stated that some medium-sized pig farms sold their pigs to other pork processing entities, or may own slaughter slabs and butcheries in town [3]. According to a 2014 Dutch-government financed report, there were three other main pig slaughterhouses in Kenya besides Farmer's Choice's factory, and these only slaughtered 15 to 50 animals daily [2]. The report described Farmer's Choice as having a monopoly and highlighted the need for small pig slaughterhouses [2].

Finally, regarding cattle, as of 2014 there were eight slaughterhouses meeting the standards for export; no cattle, however, were being exported [2], although the government had plans to build four export slaughterhouses and 18 local slaughterhouses for ruminants [2].

e) Land use and land acquisitions

There was limited information on land as a resource for food animal production. One 2006 source stated that at least half of the country's livestock population was raised on arid or semi-arid lands [1]. A 2012 FAO report noted that farm sizes were decreasing due to an increase in population and fragmentation of landholdings [3].

Our landscape assessment also did not yield information about land acquired outside of the country by Kenyan enterprises for the purposes of producing animals or animal feed.

5) *Waste management*

Limited information was found regarding waste management in animal production systems. According to a 2009 report written jointly by the FAO and several NGOs, there is little documentation of how manure from commercial poultry systems is being used [5]. A 2008 report by the FAO found that waste from sector one poultry farms was being buried, burned, or sold, typically to other farmers; manure, however, was not typically composted before being sold, and thus could be a source of disease for other farms where it is applied to the land [4].

Waste and manure disposal was also identified as a major challenge for commercial pig farms, especially those not integrated with crop production [3]. According to a 2012 FAO source, some of these farms dump manure on the roadside, on uncultivated land, or into sewage and storm water drains, causing both air and water pollution [3]. Moreover, waste disposal is also a problem for slabs and small slaughterhouses that have no treatment facilities [3]. On the other hand, larger slaughterhouses have treatment plants, allowing them to sell or give sludge and compost to farmers for growing fodder, presumably as fertilizer (the source did not specify the precise way the sludge and compost were used) [3].

Regarding cattle production, a 2014 report found that a few cattle slaughterhouses had biogas systems to digest waste. Even in these systems, however, effluent was allowed to “run[] freely into the open” [2, p. 46].

6) *Transnational corporations*

We did not find any information about the presence of transnational corporations or other foreign agribusinesses in Kenya.

7) *Regulation of livestock production*

Our landscape assessment yielded more sources discussing the government’s promotion of livestock production as opposed to its regulation of the sector. During economic liberalization in Kenya in the mid-1990s, the Ministry of Agriculture, Livestock Marketing and Development

was restructured to become more focused on facilitating the private sector, providing extension services to farmers, and making production more efficient [1]. For example, rangeland research was geared toward increasing productivity and beef output [1]. In poultry production, the Ministry has implemented an extensive poultry program over several decades that has sought to improve the productivity of indigenous chickens and has encouraged smallholder farmers to raise poultry as a business [4]. Poultry production projects, such as the Smallholder Poultry Commercialization Development Project and the National Agriculture and Livestock Extension Programme, have aimed to increase production as a means to reduce poverty and unemployment in areas like Nakuru district in the Rift Valley [13]. Government agents, along with other actors (e.g., NGOs, private companies, and community organizations), have offered extension services as well [2]. Furthermore, the Kenyan government seeks to promote value-added animal products, and therefore has encouraged the establishment of small slaughterhouses and meat processing facilities [3].

In terms of regulation, a 2008 FAO report mentioned that the Kenya Bureau of Standards conducted some monitoring of feed quality, specifically of feed produced for Kenchic’s integrated broiler operations [4]. On the other hand, a 2009 FAO background paper on Highly Pathogenic Avian Influenza (HPAI) in Kenya stated that the country’s poultry industry was “poorly regulated all along the value chain” [5, p. 91]. Moreover, according to that source, there were no regulations on the use of poultry waste as animal feed or its treatment before such use, nor guidelines on transporting poultry waste beyond the farms [5].

For swine production, one source referenced a ban on free-range pig keeping since the 1970s (although the practice was described as still existent, especially in resource-poor areas) [11], while another source stated that Kenyan legislation “recommend[ed] pig confinement in pig-proof houses” [17]. For swine waste, the Animal Diseases Act requires that pig manure be composted for one month before being applied to crops or fodder cultivation as fertilizer [3].

Impacts of industrial food animal production

1) Impacts on worker health

We did not find any information about the occupational health impacts of industrialized food animal production in Kenya.

2) Impacts on surrounding communities and others

Information on the social and health impacts of industrial food animal production was limited. In terms of health impacts, a 2008 FAO report alluded to possible disease transmission risk resulting from the sale of poultry manure to other farms without first being composted [4]. Regarding the social impacts of contract farming, a 2014 study using a sample of 180 poultry farming households in Nakuru county concluded that contract farming improved the welfare of small-scale poultry farmers, based on applying the method of propensity score matching to find that participation as a contract farmer was associated with a significant, positive gain in net revenue per bird [12]. The authors thus maintained that contract farming could reduce rural poverty, rather than reinforce it, as had been suggested by some previous studies [12].

3) Impacts on natural resources

There was extremely limited information found on the topic of environmental impacts of animal agriculture. A 2012 FAO report on pig production stated only that waste and manure disposal were major challenges for commercial pig farms, especially those that did not integrate with crop production [3]. Some farms dumped manure on the roadside, on uncultivated land or into sewage and storm water drains, and the waste caused both air and water pollution [3].

Public engagement with industrial food animal production

1) Transparency and access to information

One FAO paper from 2009 identified two research gaps: the first related to how manure from commercial poultry systems was being used, while the second concerned integration—including type of integration, level of integration, and the number of integrated operations—in commercial poultry production [5]. A recent study financed by the Dutch government reached the more general conclusion that livestock production data were difficult to come by and existing data were not always reliable due to

the significant amount of informal slaughtering, processing, and marketing that occurs in the sector [2].

2) Public awareness and attitudes

There were only a few mentions of public attitudes toward animal agriculture in Kenya. A 2011 source noted an increasing consumer preference for traditionally produced animals, resulting in indigenous chickens costing more than industrially produced hybrids [15]. Indigenous chickens are perceived as being tastier compared to the commercial hybrids [6]. At the same time, a consumer preference for value-added meat products has also been noted, leading to more processing facilities [8].

3) Media interest in IFAP

The methods used for our landscape assessment yielded very few media articles addressing meat production in Kenya. Therefore, it was not possible to draw general conclusions about media interest on this topic.

4) NGO or community campaigns, advocacy and other efforts targeting IFAP

The landscape assessment did not yield information on these issues.

5) Description of other civil society actors engaged in IFAP

A few sources have pointed to various civil society and other actors involved in promoting livestock development in Kenya. The Dutch government-financed report stated that the Dutch government had financed feedlot development programs in the 1970s (though these were considered not successful) [2]. Although the report portrayed integration and developing “deep” value chains as positive developments, it also advocated for helping medium-sized chicken producers and for building alternatives to the “current monopoly position of the highly integrated Farmer’s Choice processed pork value chain” [2, p. 12]. The source also stated that Dutch agribusinesses could help producers in Kenya reduce antibiotic use; however, it did not say more about the use of antibiotics [2].

The same report additionally referred to extension services offered not only by the government and private producers, but also by NGOs and community organizations [2]. In this regard, a site-specific study based in Western

Kenya observed that government extension services and NGOs had a longstanding history in two districts where they had disseminated a management intervention package designed to improve productivity of indigenous chicken farming [15]. The package included components such as feed supplementation, housing, chick rearing, brooding, and vaccination [15].

Lastly, some researchers based at ILRI and academic institutions have recommended greater confinement of livestock animals as a way to promote public health and reduce disease [17]. The study in which they made this suggestion addressed the topic of indigenous pig farming and the control of porcine cysticercosis [17].

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Mexico



Overview

Vertical integration and other characteristics of industrialized animal agriculture are present in Mexico, although the extent varies depending on the type of livestock. One defining characteristic of the sector, however, has been the country's trade relationship with the United States. Competition from cheaper imports from the United States has significantly shaped trends in meat production, especially following the North American Free Trade Agreement (NAFTA). Along with this development, multinational agribusinesses have inserted themselves into Mexico's agricultural sector and become major industry players there.

Food and Agriculture Organization of the United Nations (FAO) statistics on food animal production

Mexico had a total of 54,611,241 Animal Units (AUs) in 2013, resulting in an overall livestock density of 0.51 AU per hectare (ha) of agricultural area. The numbers of live animals raised in 2013 were 16,201,625 pigs, 524,271,000 chickens, and 32,402,461 cattle. FAO 2011 estimates of livestock densities, by specific animal class, were 0.15

pigs per ha, 5.07 poultry birds per ha, and 0.32 cattle and buffalo per ha.

In 2012, production was 1,238,625 tonnes of pork, 2,791,639 tonnes of chicken, 1,820,547 tonnes of cattle meat, and 10,880,870 tonnes of cow's milk. From 2002 to 2012, pork, chicken, cattle meat, and cow's milk production increased by 16%, 34%, 24%, and 13%, respectively. The five-year period of 2007 to 2012 saw increases of 8%, 10%, 11%, and 5% for pork, chicken, cattle meat, and cow's milk, respectively.

Production, imports, exports, and net balance by livestock product

	Production (mt)			Imports (mt)	Exports (mt)	Net (mt)
	2002	2007	2012	2012	2012	2012
Pig meat	1,070,246	1,152,003	1,238,625	385,266	461	1,623,430
Chicken meat	2,075,758	2,542,493	2,791,639	603,525	4,317	3,390,847
Cattle meat	1,467,574	1,635,040	1,820,547	2,974	35,977	1,787,544
Milk, whole fresh cow	9,658,282	10,345,982	10,880,870	28,464	7,426	10,901,908

Industry characteristics

1) Scale

Scale of swine production

According to a 2006 paper by the Midwest Agribusiness Trade Research and Information Center, swine production in Mexico falls under three types: technologically advanced, small commercial or “semi-technologically” advanced, and traditional backyard production [1]. Comprising 57% of national pork production (in the mid-2000s), technologically advanced production had herd sizes from 300 to 1,000 sows, animal slaughter weights ranging from 95 to 105 kg, and days to market lasting between 150 and 170 days [1]. For the semi-technologically advanced production, herd sizes were 150 to 500 sows, slaughter weights ranged from 90 to 100 kg, and days to market ranged between 170 and 180 days [1]. For the same time period, this type of production accounted for 15% of the country’s pork production. Finally, for backyard production, herd sizes were 10 to 50 sows, slaughter weights ranged from 80 to 90 kg, and production required more than 180 days [1]. Most of this production occurred in rural or semi-urban areas, and could be for used for subsistence or sale in places with fewer pork consumer options [1]. A more recent USDA source reported that current practice is to hold hogs until they reach higher weights—around 120 kg—before slaughtering [2].

The 2006 paper described trends in the sector, such as industrialization of production, slaughtering, and processing [1]. The phasing in of NAFTA, beginning in 1994, drove structural changes in the sector, including increasing scale and productivity [1]. According to one media report, hundreds of industrial-scale hog production facilities were built in the 2000s [3]. Although it did not define the term, a 2010 journal article reported that swine concentrated animal feeding operations (CAFOs) had expanded over the past four decades, and were now found in various states, including Sonora, Jalisco, Tamaulipas, Nuevo León, and Veracruz [4]. A single company, Granjas

Carroll de México (GCM), raised over 950,000 hogs in the Perote Valley [4].

Backyard pig production has also continued in Mexico [1]. According to one UN report from 2013, there were one million registered producers, and small- and medium-sized enterprises accounted for 83% of pigs produced [5]. However, a recent media source forecasted that medium and large hog producers would continue to merge over the medium- and long-term to increase scale and productivity [6].

Scale of poultry production

Compared to swine production, distinct poultry production systems were less well characterized in the literature found by our landscape assessment. In general, poultry production has experienced “dynamic growth” over the past couple of decades [7, p. 259]. With state support, average flock sizes expanded from 3,000 birds in the 1950s to 50,000 birds [8]. As an example of the influence of foreign, multinational agribusinesses on the country’s livestock development, US-based Purina brought the US model of poultry production to Mexico, providing technical assistance and credit, and promoting industrialization and the contract farming model [8]. As vertical integration and consolidation occurred, production became more industrial and smaller producers left the sector [8].

As another example, in the mid-1990s, Pilgrim’s Pride contracted agreements with chicken farmers in a type of association known as a “maquila” [9]. The scale of the farmers’ operations could be small (28,000 to 50,000 chickens grown per six to seven week growing cycle), medium (200,000 to 450,000 chickens per growing cycle), or large (over one million chickens per growing cycle) [9]. More details are provided below in the sub-section on integration.

A recent media source reports a heavy concentration of poultry production in the southern part of the country, and less dense production in the north [10].

Scale of cattle production

There are both small-scale, pasture-based cattle ranching and concentrated feedlot production of cattle in Mexico [5]. An increasing amount of cattle in Mexico is being produced under semi-intensive or intensive “feeder cattle production systems,” where cattle are raised for some time in feedlots, rather than spending their entire lives grazing extensively on pastures [11, p. 11]. In extensive systems, cattle require two to three grazing seasons and are three to four years old when slaughtered [11]. In semi-intensive systems, cattle are either finished for 70 to 110 days in confined feeding operations or finished using high-quality forage and/or supplemental grazing [11]. In the most intensive operations, cattle may be placed in feedlots at a younger age and finished at 13 to 18 months of age, or they may be given high quality forage or supplementation after weaning, followed by feedlot finishing [11]. Such intensively produced cattle result in beef of similar quality to that produced in the United States [11].

According to a 2012 USDA report, eight million beef cattle were calved per year, with 1.5 million exported, 2.7 million going to pens for intensive feeding and slaughtering at federally-inspected slaughter plants (TIFs), and 3.8 million for grazing and then slaughtering at a TIF facility or municipal slaughterhouse [2]. In 2010, feedlot production amounted to 1.75 million metric tons [5]. Around nine million heads of dual-purpose cattle (milk and meat) were produced under traditional/extensive, semi-intensive, and intensive types of systems [12].

There is some geographic variation in the distribution of semi-intensive and intensive production systems. In the northern regions, most cattle are either exported or fed in feedlots, and in the northwest irrigated pastures allow cattle to move to feedlots earlier [11]. Operations in the Mexicali region in Baja are the most technically advanced, and the region has the highest average intensity in stocker and feedlot production [11]. However, more cattle from the south are going to feedlots or finished semi-intensively [11]. One of the most rapidly developing areas in terms of cattle feeding consists of southern Tamaulipas and the Huasteca regions, where only a decade ago most cattle were finished on grass or sent to other areas for finishing. According to the 2011 USDA report, the feeding industry in this area had capacity for 30,000 to 40,000 heads, and appeared to be growing quickly [11].

The 2011 USDA report also observed that reduced cattle supplies and increased competition from the United

States had slowed the growth of feeding in areas like Monterrey, Torreon, and Sonora in northern Mexico [11]. In some of these areas the development of other agricultural sectors, like dairy, pork, and poultry, had also created additional competition [11].

2) Industry consolidation or concentration

Various sources mentioned the trend of livestock sector concentration. According to one law review article, transformation of the livestock sector in Mexico was led primarily by foreign-owned multinational corporations—usually with ties to the United States—resulting in increased meat production by fewer producers [13]. Facilitators of this development included Mexico’s proximity to the United States, which enabled early adoption of the US model of industrial poultry production, the Mexican government’s policies favoring major poultry companies, and agrifood globalization [8]. These “global agrifood linkages” took such forms as contract farming and “North-South food relationships” [8, p. 495]. In this regard, neoliberalism associated with free trade agreements and international institutions based in the global North (e.g., the World Trade Organization, the International Monetary Fund, and the World Bank) caused a restructuring of agriculture in the global South, favoring the accumulation of capital and, thus, greater market consolidation and concentration.

As reported by one study on the Mexican poultry industry, Tyson de Mexico had expanded its contract farming model to cover breeding along with 70% of poultry meat production and 50% of egg production by 2008 [8]. Consolidation of the poultry industry had occurred following NAFTA’s implementation in 1994, and increased due to disease outbreaks and a financial crisis [8]. The Mexican poultry industry’s level of consolidation had surpassed that of the United States [8]. In 2005, the top three broiler companies in Mexico—Bachoco, Pilgrim’s Pride, and Tyson—accounted for 60% of the market, amounting to greater economic concentration than in the United States [14]. According to a 2014 news source, outbreaks of highly pathogenic avian influenza (HPAI) in 2012 and 2013 also prompted further consolidation of the broiler industry [15].

For the cattle sector, a UN report stated that three companies in Mexico had 27% of the country’s feedlot processing capacity in 2010. An earlier source from 2005

described cattle processing facilities as growing, but less concentrated compared to those in the United States [16].

The 2013 UN report described hog production as still being carried out by many separate producers [5]. There were approximately one million registered producers, and two companies, GCM and Kenken (also known as Grupo Porcicola Mexicano), accounted for 17% of pigs produced, while the remainder were produced by small- and medium-sized companies [5].

3) *Vertical integration*

Integration and other forms of vertical coordination in the poultry sector

In the literature, the development of vertical integration in Mexico's poultry industry is attributed to the influence of foreign companies. One 2013 study stated that the US model of poultry production had proliferated in Mexico over the past several decades, and critically deemed contract farming a "central tenet of neoliberalism," since it provided the company with control, flexibility, and limited liability [8, p. 496]. Purina, an early integrator, brought the US model of poultry production to Mexico, providing technical assistance and credit, and promoting "modernization" and the *aparcería* (contract farming) model (though it later divested its interests to regional firms, such as Tyson and Pilgrim's Pride) [8]. The presence of integrators increased during the 1960s, with national and transnational companies working toward a "modern," integrated poultry production system [8]. There were acquisitions, consolidation, and departure of smaller producers from the sector [8]. A few vertically integrated poultry companies achieved success during this time [8].

In the next period, from 1984 to 1994, structural readjustment imposed by the IMF and economic liberalization coincided with 27% of poultry producers leaving the business between 1980 and 1990 [8]. Larger producers became even more vertically and horizontally integrated during this period [8]. Pilgrim's Pride, which began operating in Mexico in 1988, also started "shared risk" agreements with contract farmers, whereby the farmers became *aparceros*, owned and operated facilities for growing out chickens, received inputs from the company, and received payment from the company based on their productivity [9]. According to one source, this type of association, called a *maquila*, was beneficial for farmers of all scales; large producers were able to survive financial crises, and small and medium growers were also loy-

al participants in the arrangement [9]. Trasgo de Mexico also took similar initiatives around this time, receiving help from government subsidies to engage in contract farming, and was later acquired by Tyson [14].

After 1994, more consolidation of the market occurred due to disease outbreaks and a financial crisis [8]. In addition, NAFTA also allowed US corn to be imported into Mexico without tariffs, and this helped support vertically integrated poultry production; it also contributed to impoverishment of Mexican farmers [14]. Between 1997 and 2008, the number of contract growers with Trasgo-Tyson increased from 138 to 730 [14]. By 2008, the company's contract farming model covered breeding, 70% of the country's poultry meat production, and 50% of the country's egg production [8]. It is now targeting emerging economies such as Brazil, China, and India [8]. Mexican agribusiness, Bachoco, another vertical integrator and one of the ten largest poultry producers in the world, has nine vertically-integrated complexes with over 700 farms, 14 processing plants, 16 feed plants, and 60 distribution centers [8].

Integration of swine production

Structural changes in the swine industry began in 1994 with NAFTA's phase-in. Domestic producers had to adapt to increase productivity and competitiveness [1]. As smaller producers who failed to be competitive exited the industry, the sector became more highly integrated [1], while the swine "CAFOs" referenced above often formed part of a larger, vertically-integrated structure [4]. As described by one trade research center, Mexican pork production, slaughtering, and processing have become "modernized," with large, vertically-integrated production systems that resemble those of the United States [1].

Similar to the poultry sector, foreign policies and multinational companies have also been influential in integrating the swine industry. Following NAFTA, multinational companies engaged in joint ventures with, or purchased, Mexican companies [13]. US companies in particular had a competitive advantage over Mexican companies because they could obtain large volumes of feed much cheaper in the United States and could import them tariff-free into Mexico due to NAFTA [13]. An example was Smithfield, which introduced its first vertically-integrated operation in Mexico in 1999 [13]. As one law review article recounted, these companies were able to minimize feed and labor costs and form vertically-integrated business arrangements, enabling them to price their pork

products so low that Mexican producers were forced out of the domestic market unless they also operated on an industrial scale [13].

In terms of slaughtering and processing, vertically-integrated slaughterhouses are usually federally inspected [1]. These facilities, known as TIF plants, obtain pigs from integrated producers and their pork is usually sold in urban markets (and also meets standards for export) [1]. Smaller commercial slaughtering and processing operations do not typically meet the standards of federal inspection, and therefore are limited in terms of where their products could be exported [1]. Vertically integrated pork processor Norson Holding, a joint venture by Smithfield and local investors, received a \$40 million investment from the International Finance Corporation (IFC) to expand production, “modernize” farms, and take measures to control environmental impacts of waste [17].

4) *Inputs*

One source described the Mexican poultry industry as traditionally depending on foreign technology, and this dependence has increased with new technologies that have reportedly led to greater efficiency and automatization [9]. The technology used by the poultry industry is similar to that of the United States, a development described as necessary and inevitable given the intense competition that ensued following implementation of NAFTA [9].

In the swine industry, one study using survey data from 2005 examined technology uptake among a sample of 61 swine farms in four Mexican states (Guanajuato, Jalisco, Sonora, and Yucatan), and found that pork producers were very efficient and benefitted from a high level of support from the government [18].

More detailed information on inputs is provided below, based on the type of input. Overall, our landscape assessment methods produced little or no specific information on breeding stock, animal housing facilities, or agricultural land use, and left us with limited information on feeding practices for swine and poultry.

a) Breeding stock

Our landscape assessment did not provide specific information on the use of breeding stock.

b) Feed

Demand for sorghum and wheat as feed grains has increased, according to a recent media source [6].

Swine feed and feeding practices

Feed efficiencies for swine in the early 2000s were as follows: 2.8 to 3.2 for the most technologically advanced production systems, 3.2 to 4.0 for semi-technologically advanced or small-scale commercial systems, and unknown for traditional backyard production [1].

Poultry feed and feeding practices

We found limited information about poultry feeding practices; one source, however, did mention that similar feeds were used by the US and Mexican poultry industries [9]. InVivo, a French-based company, announced plans to target the Mexican broiler market (among others) with a new pre-starter feed for chicks that combines corn, wheat, and soybean, and supposedly promotes better feed intake, immunity, and viability [10]. According to a company representative, the use of pre-starter broiler feed is common in Mexico, notwithstanding the labor intensive nature of administering such feed to chicks [10].

Cattle feed and feeding practices

In terms of cattle feed, the sector relied in large part on domestically-produced feed and agro-industrial byproducts; in the mid-2000s, use of concentrate¹ feed by the beef industry was a relatively new development [16]. Fewer cattle are now finished exclusively on grass; rather, cattle are raised in pasture-based supplementation systems and finished younger than traditionally grass-fed cattle [16], either semi-intensively or intensively in feedlots, requiring the use of some concentrate feed to replace forage [11].

Thus, the number of cattle feedlots has increased in Mexico, especially in certain geographic areas (as highlighted earlier). Most feedlot operators started as meat companies and then entered the business of cattle feeding [16]. However, one article maintained that these feedlots would not reach the intensity of those found in the US, and that they would not be as competitive if they did [16]. According to the author, “subtle but significant differences in consumer preferences” between the US and Mexico

1. Concentrates are high-energy ingredients that include fats, cereal grains, high-protein oil meals/cakes, and agro-industrial byproducts (such as those resulting from sugarcane, animal, and fish processing). They are distinguished from roughages, which include pasture grasses, hay, silage, and straw

meant that Mexican producers should aim to supply less intensively produced and less finished beef [16, p. 18].

A 2011 USDA report characterized feedlots as follows: turnover rates varied from 2.5 times per year for feedlots with longer feeding periods of 130 to 150 days to three times per year for feedlots with shorter feeding periods of 90 to 120 days [11]. While the total productive capacity of the industry was unknown, it was estimated that production of two million heads of cattle annually would be possible if facilities operated at full capacity [11]. In 2011, the industry was operating at approximately 65 to 75% capacity, and thus producing around 1.25 to 1.5 million heads of cattle per year [11].

As reported by the USDA, most feedlots used feeding regimes that increased in feeding intensity, and under these regimes cattle gained 2.2 to 3.3 pounds per day, and even up to four pounds daily under optimal genetics, management, and feed quality conditions [11]. Feedlot rations were made up of the following components: 60 to 70% energy (historically sorghum, but also corn, wheat, silage, or industrial byproducts); 8 to 20% forage (grasses or hay); protein (most often cottonseed meal, but also soybean meal, fish meal, poultry meal, canola, and sesame meal); 3 to 5% fat (some mixture of animal and vegetable fat); 7 to 12% molasses; and premix (containing vitamins, minerals, and ionophores²) [11]. In 2011, feedlot-finished cattle typically weighed around 880 to 990 pounds [11].

Historically, there has been less stocker/backgrounding production in Mexico³ [11]. According to a 2011 USDA report, the stocker production that exists usually entails pasture grazing; however, some stocker production also occurs in more intensive systems that combine pasture grazing with supplementation, the use of improved pastures, or some measure of confinement [11]. The report predicted that stocker programs would increase as feedlots increased, such that stocker production would emerge as a distinct, more important production activity in Mexico [11].

In spite of these developments, many cattle are exported to be finished in the United States, typically after weaning, due to higher costs of grain in Mexico [11].

2. Ionophores are a feed additive that increases feed efficiency and rate of weight gain.

3. Stocker production is production that emphasizes animal growth and weight gain over fat deposition, before they are sent to feedlots for finishing.

A 2012 USDA report forecasted that Mexico would continue to export live cattle in the next few years because of the lack of grazing lands and feed resources to finish them domestically [2].

c) Antimicrobials, growth hormones, and other additives

Several sources referred to the use of veterinary drugs and growth promoters in meat production in Mexico. According to one 2012 report by the USDA, unapproved or greater than permitted levels of veterinary drugs continue to be found in beef carcasses and products, but the occurrences were decreasing due to authorities shutting down operations that used unapproved drugs, extensively reviewing the events leading to incidents, and even prosecuting the responsible parties [2]. The report stated that following the detection of unapproved beta-agonists (the specific types were not named) in beef products, the government had intensified scrutiny at beef slaughterhouses in 2011 and 2012 [2].

A 2014 news report portrayed a less optimistic picture. According to that report, the beta-agonist growth enhancer clenbuterol had been banned from cattle production 14 years prior, but cattle ranchers, especially in states surrounding Mexico City, continued to use it [19]. Federal authorities had tested for the substance, which in cattle reduces fat and increases muscle (which retains water and adds weight), and in humans causes heart palpitations, tremors, dizziness, nausea, and increased anxiety [19]. Authorities found that 30% of 175 samples in Guanajuato state contained clenbuterol, while nationwide testing between January and May 2014 found that 10% of 943 samples were tainted with the substance [19]. In addition, seven out of 20 municipal slaughterhouses had animals that tested positive for clenbuterol contamination [19].

According to the National Service of Health, Food Safety and Food Quality, municipal slaughterhouses are where problems with inadequate safety procedures and toxic substance control intensify [19]. Since 2011, 52 of 164 municipal slaughterhouses visited had beef containing clenbuterol, according to the head of the Federal Commission for Sanitary Risk Protection [19]. Thus, the report stated that clenbuterol contamination was more of a problem with the smaller municipal slaughterhouses, street food vendors, and mom-and-pop restaurants, as most major supermarkets sourced beef from large, private slaughterhouses with testing by on-site federal in-

spectors [19]. One butcher cited in the article, however, mentioned that clenbuterol was prevalent in feedlots, reducing fattening periods from 100 to 90 days [19].

Another news article from 2014 reported that given the shift away from using antibiotic growth promoters, InVivo had conducted trials in Mexico of a pre-starter feed known as Genesa, which used an activated copper additive that was thought to safely support the immune system due to antimicrobial properties [10].

d) Facilities for housing, slaughtering, and processing

Animal housing facilities

One source mentioned that US and Mexican poultry industries had similar facilities, but we did not find more specific information about the facilities [9].

Slaughtering and processing facilities

As early as the mid-2000s, slaughtering and processing facilities for pork production were described as being “modernized,” integrated, and comparable to systems found in the United States [1]. There are three types of slaughterhouses: federally-inspected (TIF) plants, municipal plants, and traditional on-site slaughtering [1]. The number of TIF plants increased from 33 in 1999 to 160 in 2005 [1]. In 2003, 4.7 million heads were slaughtered in TIF plants, amounting to 36% of all hogs in the country [1]. However, TIF plants were only operating at 55 to 60% capacity in 2000 [1].

As mentioned earlier, for cattle production, a 2005 source described processing facilities as still smaller in scale and less concentrated when compared to the United States [16]. A 2013 report noted that supermarkets were gaining importance, especially in urban areas, although there were still small butcher shops in markets.

e) Land use and land acquisitions

Our landscape assessment did not identify specific information regarding the use of land within Mexico or land acquired abroad by Mexican agribusinesses for food animal production.

5) Waste management

There was little information on the issue of waste management relating to industrial production and processing of food animals in Mexico. One undated source from the Humane Society International reported that in 2006, the National Commission for Water (CONAGUA) estimated that only a fifth of wastewater from pork production was treated, and that a congressional commission’s visit to pig farms in the Perote Valley that year had observed waste and manure disposal areas located too close to sources of water [20]. Prior studies by CONAGUA found fecal bacteria contamination of aquifers in the valley [20]. A 2010 journal article analyzing secondary data on the situation of swine CAFOs in one area of Veracruz noted that producers found it cheaper to pay fines instead of investing in expensive wastewater treatment infrastructure [4].

6) Transnational corporations

The influential presence of transnational corporations in Mexico has been a subject of concern for several researchers. For example, one law review article commented that it was primarily foreign-owned multinational agribusinesses with ties to the United States that had transformed livestock production in Mexico, both through joint ventures with and acquisitions of Mexican companies [13]. Moreover, this NAFTA-driven industrialization process had occurred very rapidly, increasing meat production and decreasing the number of farmers [13]. Free trade policies had given US companies in Mexico a competitive advantage over Mexican companies, as described earlier. At the same time, pork imports from the United States were on the rise [13].

Several key agribusinesses were mentioned in the literature. Tyson, for example, began its international expansion in 1988, engaging in a joint venture with Trasgo de Mexico and acquiring an 18% share in that company [14]. In 1994, Tyson acquired a majority share of Trasgo de Mexico, and in 2001 bought out 95% of the remaining interest [14]. It also purchased the vertically integrated broiler production of another company [14].

Pilgrim’s Pride, Inc. began operating in Mexico in 1987, acquiring four integrated broiler operations from Purina [14]. Like Tyson, it made more acquisitions throughout the 1990s [14]. However, it faced debt and high feed costs, which led to its bankruptcy, and it was subsequently purchased by Brazil-based JBS [14].

US-based Smithfield joined with Agro-industriales Unidas de México to produce meat in the Perote Valley in 1993, forming the company Granjas Carroll de México (GCM) [20]. In 1999, it initiated its first vertically-integrated operation in Mexico [13]. Smithfield and local investors also started the joint venture, Norson Holding, a vertically integrated pork processor that received a \$40 million investment from the International Finance Corporation to expand and modernize its facilities [17].

French feed company InVivo has also promoted premixes, vaccines, and complete feed in Mexico [21]. In 2014, its subsidiary in Mexico already had ten production facilities and a national distribution network [21].

7) *Regulation of livestock production*

Support for industrialized food animal production

Aside from NAFTA, the government has also promoted industrialization through domestic livestock policies. As one 2009 study reported, pork producers in Mexico benefit from a high level of support through both direct and indirect subsidies [18]. In addition, the government has provided financial assistance and implemented other programs to encourage pork producers to have their hogs slaughtered and processed at TIF plants [1]. For example, in 2003 and 2004, the government paid producers the price differential between using TIF slaughtering facilities and municipal plants [1]. The government has also helped plants become registered as TIFs and assisted retail by matching one-for-one the money spent on promoting TIF-slaughtered meat (for instance, through supermarket displays and promotional materials attempting to convince consumers that TIF-slaughtered meat was more sanitary) [1].

However, according to a 2013 article published in a Spanish-language journal, most government support during the period of 1986 to 2011 was focused on dairy and poultry meat production and much less so on beef [7]. The article maintained that pork received the least government support of all, reflected in significantly reduced production, while cattle ranching also experienced a continual decrease in support. The author concluded that the government should prioritize support for public goods such as infrastructure, research, extension work, training, livestock corrals, and cold chains.

Supports for “modernizing” the poultry industry date back to programs begun in the 1950s, which promoted land reform, industrialization, provision of credit and financing, and technical assistance [8]. Government subsidies supported the development of poultry contract farming [14], while NAFTA indirectly facilitated vertical integration by allowing US corn to be imported into Mexico without tariffs [13]. The 2011 law review article referenced above stated that industrial animal farms would be unsustainable without government support [13].

Regulation or lack thereof

Several sources have criticized the insufficient regulation of industrialized food animal production in Mexico, with some invoking the term CAFO⁴ to refer to operations engaging in this mode of production. A 2012 study noted the rise of CAFOs in developing countries such as Mexico and working under minimal federal regulations. Specifically, there was no standardized definition of a CAFO or regulations on minimum distances that CAFOs need to be located from human settlements or on ways to mitigate health risks from these operations [22]. Existing regulations focused on discharge into waterways, but environmental standards were considered relatively lenient, making it inexpensive to operate CAFOs in Mexico [22]. In this regard, as mentioned above, one 2010 study found that some swine producers found it cheaper to pay fines than to build infrastructure to treat wastewater [4]. That study stated that swine CAFO regulations were lacking at all levels—federal, regional, and municipal—with no restrictions on size, concentration, or geographic location, and typically no requirements to notify the public living around and downstream of the activities (for example, about potential impacts of the operations) [4].

At the same time, a few sources did recognize actions (sometimes tardy or insufficiently effective) undertaken by authorities to inspect, monitor, or sanction identified food production activities and practices. As discussed previously in the sub-section on waste management, authorities such as the congressional Commission on the Environment and Natural Resources and CONAGUA

4. “CAFO” refers to “concentrated animal feeding operations,” and has been used in the United States by entities like the US Environmental Protection Agency to refer to animal feeding operations that exceed a certain threshold of production (1,000 pounds of live weight, confined on site for more than 45 days during the year) or that discharge waste into a ditch, stream, or other waterway. See United States Department of Agriculture Natural Resources Conservation Service - Animal Feeding Operations, available at <http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/plantsanimals/livestock/afo/>, last visited April 19, 2016.

have conducted visits to animal production facilities and reported on environmental contamination deriving from them. We do not know, however, whether actions are taken following such inspection reports [20]. In the case of Perote Valley residents affected by GCM's CAFOs, they had to wait two years for inspectors to visit and respond to the complaints they had filed [4]. They did not have the option of bringing a private lawsuit, as civil tort options are limited in Mexico [13]. Moreover, even after authorities inspected GCM-operated farms in 2006 and reported some issues of concern, no formal penalties were imposed [4].

There have also been inspections targeting the use of growth promoting substances, such as clenbuterol [19], and some operations that used unapproved veterinary drugs have been shut down [2]. According to a 2012 USDA report to promote transparency and accuracy, the Secretariat of Agriculture, Livestock, Rural Development, Fishery and Food and the National Confederation of Livestock Organizations were working on a program that would identify and track all animals and animal products in the country [2].

Impacts of industrial food animal production

1) Impacts on worker health

We found minimal information about this topic through our landscape assessment. One 2010 study drawing on secondary data on swine CAFOs in the Perote Valley stated that although there were no specific statistics on occupational health outcomes, farm workers had reported respiratory health problems and it was "certainly possible" that these were linked to hog waste pollution [4, p. 1109].

2) Impacts on surrounding communities and others

The 2010 study mentioned above also noted that residents of the Perote Valley area had reported respiratory health problems, and complaints about hog pollution dated back at least as far as 2004 [4]. However, the situation persisted in spite of the complaints [4].

A 2012 study examining fungal samples, bacterial samples, and antibiotic-resistant pathogens (*Staphylococcus aureus*) near an urban-based dairy CAFO in northern Mexico found that over half of the organisms collected onsite were antibiotic-resistant [22]. There was also a high concentration of antibiotic-resistant *S. aureus* at and around (upwind and downwind) the site, with 65%

resistant to ampicillin and 34% resistant to the two classes of antibiotics evaluated, penicillins and cephalosporin. There were also high concentrations of bacterial and fungal bio-aerosols, most of them fine particles, which are considered worse for human health because the particles enter the body's upper airways and are not filtered [22]. Throughout the course of the study, the distance between the CAFO and the nearest house continually decreased due to people constructing homes closer and closer to the CAFO [22].

1) Impacts on natural resources

Little information was found about the environmental impacts of industrial food animal production, aside from the example of swine farms in the Perote Valley. Visiting that region, the congressional Commission on the Environment and Natural Resources reported decreased aquifer levels, fetid odors, and questionable air quality deriving from pig factory farms in Puebla and Veracruz [20]. CONAGUA had also found the area's aquifers contaminated by fecal bacteria [20]. However, the National Water Commission and GCM claimed the Perote-Zalayeta aquifer had *not* been affected by swine production [4].

Public engagement with industrial food animal production

1) Transparency and access to information

Our search methodology did not produce much information related to this topic. A USDA report cited the government's initiative to create a program that would identify and track all animals and animal products in the country— an effort that was estimated to be halfway complete in 2012 [2].

2) Public awareness and attitudes

Sources reporting on public awareness and attitudes toward meat production in Mexico focused on consumers' preferences for certain types of pork or beef. For example, a 2006 trade research center paper stated that there was a perception that pork produced via traditional backyard systems might be better because it was fresher and not processed [1].

For beef, an article from 2005 stated that Mexican consumers preferred beef that was raised semi-intensively and finished to a lesser degree (for a shorter number of days), compared to US practices [16]. The author recom-

mended that Mexican cattle feeders continue to produce less intensive and finished products, rather than mimic the US system [16]. However, a later USDA source reported that consumer preferences for fed beef appeared to be increasing in many areas of Mexico, leading to expansion of feeding facilities [11]. According to the USDA, Mexican consumer tastes were shifting toward feed-lot-raised beef that is smoother and leaner with white fat, qualities that result from earlier slaughter age and more intensive feeding [11].

3) *Media interest in IFAP*

We did not find many media sources on industrialized food animal production in Mexico; however, one article referred to a possible link between the swine flu of 2009 and industrial-scale hog production facilities. It stated that CAFOs are *not* biosecure and that they serve as “mixing bowls” for viruses and other pathogens [3]. The article’s stance contrasts with another media source from 2014, which stated that the merger of medium and large hog producers over the medium- and long-term would not only increase scale and productivity, but also mitigate the effects of animal disease [6].

4) *NGO or community campaigns, advocacy, and other efforts targeting IFAP*

Our search methodology did not produce any results related to this topic.

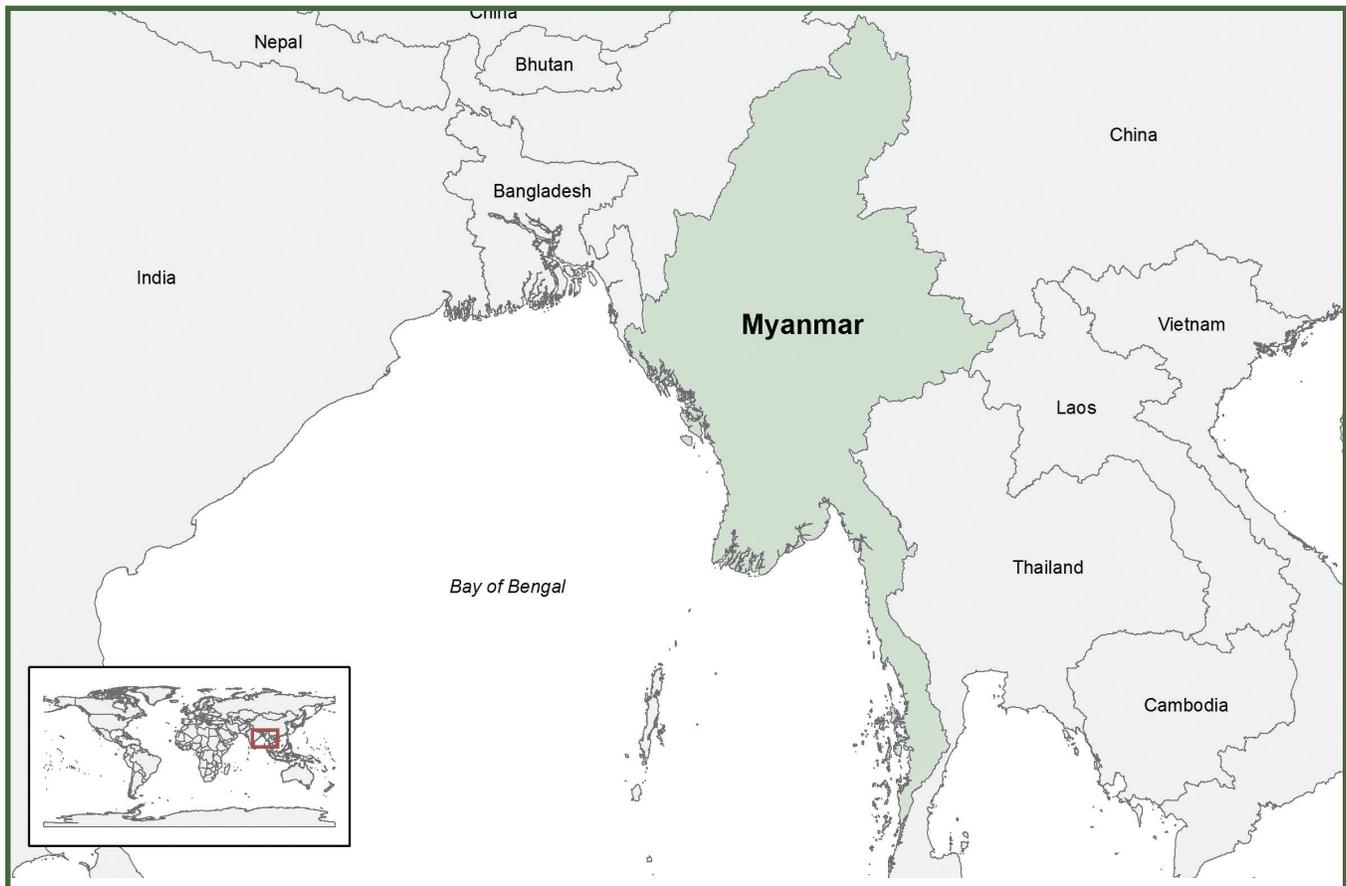
5) *Description of other civil society actors engaged in IFAP*

In support of the vertically integrated Mexican pork processor, Norson Holding, the IFC was investing \$40 million to enable it to expand production, “modernize” farms, and take measures to control the environmental impacts of waste [17]. The IFC CEO claimed that the partnership with the vertical integrator would help support food security, jobs for rural areas, and environmental and social standards [17].

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Myanmar



Overview

Myanmar, located in the Southeast Asian region, is a country with relatively recent growth in its livestock sector, beginning with its 1988 transition to a market economy and the government's promotion of the sector. As is characteristic of the region, factors like urbanization, increased purchasing power, changing food habits, and liberalization are driving a "livestock revolution" [1]. Nevertheless, smallholder farming remains the predominant form of animal agriculture. Farming systems are small in scale, and integrated livestock-crop production for subsistence is the dominant profile of rural households [2]. Information about Myanmar's adoption of industrial methods for producing food animals is limited.

Food and Agriculture Organization of the United Nations (FAO) statistics on food animal production

Myanmar had a total of 26,717,310 animal units (AUs) in 2013, resulting in an overall livestock density of 2.12 AU per hectare (ha) of agricultural area. The numbers of live animals raised in 2013 were 12,725,000 pigs, 219,377,000 chickens, and 15,046,000 cattle. FAO 2011 estimates of

livestock densities, by specific animal class, were 0.75 pigs per ha, 13.81 poultry birds per ha, and 1.32 cattle and buffalo per ha.

In 2012, production was 620,000 tonnes of pork, 1,080,000 tonnes of chicken, 215,000 tonnes of cattle meat, and 1,300,000 tonnes of cow's milk. From 2002 to 2012, pork, chicken, cattle meat, and cow's milk production increased by 221%, 259%, 165%, and 148%, respectively. The five-year period of 2007 to 2012 saw increases of 51%, 49%, 65%, and 33% for pork, chicken, cattle meat, and cow's milk, respectively.

Production, imports, exports, and net balance by livestock product

	Production (mt)			Imports (mt)	Exports (mt)	Net (mt)
	2002	2007	2012	2012	2012	2012
Pig meat	193,020	410,736	620,000	21	n.d.	n.d.
Chicken meat	300,790	726,497	1,080,000	97	n.d.	n.d.
Cattle meat	81,000	130,196	215,000	314	0	215,314
Milk, whole fresh cow	525,114	980,314	1,300,000	369	n.d.	n.d.

Industry characteristics

1) Scale

The pig and poultry sectors in Myanmar can both be described as having three different types of production—small, medium, and large—with intensity, amount of inputs, and the degree to which production is market oriented roughly increasing with scale. Most livestock are raised in small-scale systems. Despite the fact that Myanmar has one of the largest cattle populations in the Southeast Asian region, beef cattle farming for meat production is essentially non-existent in the country, with cattle primarily for draught purposes¹ and secondarily for dairy production [2].

There are three types of poultry production: traditional, small-scale extensive backyard production has up to 50 birds; semi-intensive market-oriented production has 50 to 1,000 birds per flock; and intensive large-scale integrated production has 1,000 to 5,000 birds [3]. According to 2006 data from the Ministry of Livestock and Fisheries, production is 88.0% extensive, 10.0% semi-intensive, and 2.0% intensive [3].

There are also small, medium and large swine farms. On small farms, where about 95% of the country's pigs are raised, around two to four pigs are fattened at a time for eight to twelve months [4]. Medium farms have ten to 500 fattener pigs and five to 50 sows, and there is reportedly intense competition at this level [4]. There are only a few large farms raising 500 or more pigs, and some of these are owned and operated by the government [4].

1. Draught animals are used for work purposes, such as pulling loads and other agricultural labor.

2) Industry consolidation or concentration

Our literature review did not produce any information about industry consolidation or the degree of market concentration. However, given the dominance of small-scale livestock farms and the competitive nature of medium-scale production [4], it can be assumed that production is not very concentrated. It is unclear the extent to which slaughtering and processing facilities are concentrated.

3) Vertical integration

The FAO describes the third type of chicken production system as “integrated” production, though it does not specify whether this term is used to mean *vertical* integration, as is common in poultry production practiced in the United States [3]. It notes that since the mid-1990s, Thailand-based Charoen Pokphand (CP) has made substantial investments in the sector, instigating contract-growing systems for broiler production [4]. One academic article described a CP “integrated” poultry production facility, where 1,500 broilers are raised, fed company-manufactured feed, and housed alongside 3,000 layers and 350 village chickens [5]. It is not clear, however, whether slaughtering, processing, and marketing also occur within company-owned infrastructure. In general, our literature review did not yield information about vertically integrated value chains or activities of companies other than CP, so the degree of vertical integration in Myanmar is uncertain.

4) Inputs

a) Breeding stock

Large companies produce chicken and pig breeding stock [4]. Indigenous village chickens are considered very different than the poultry breeds used for commercial production, with the former described as poorly adaptive to

intensive farming, formulated feeds, and confinement [6]. Similarly, native pig breeds are considered slow-growing, and these and native-exotic crossbreeds are farmed on small farms [4]. Some of the larger farms are actually government-operated commercial farms that import pigs and distribute improved breeds to small- and medium-scale farms [2, 4].

Productivity of the livestock sector has increased over the past decade due to artificial insemination (AI) and improved breeding [4]. There are concerns, however, about preservation of animal genetic resources. For example, in 2003 the government set up a chicken breeding farm for the purposes of saving and spreading indigenous chicken breeds [2].

b) Feed

The country is thus far self-sufficient in terms of livestock feed, which is manufactured by large companies, and only feed supplements and additives are imported [4]. There are around twenty feed mills in the country, mostly located in Yangon and Mandalay, with capacity to produce fifty to sixty tons of feed per day [4]. Feed for pig farming comes from agricultural and fish byproducts [4]. However, recent news reported that one company, a supplier of soy-based feed, is starting feeding trials in the region to capitalize on the industrialization of pig farming, and is also trying to make a broiler-targeted starter feed [7].

Most small-scale farms do not use commercial feed, and feeding is mostly based on scavenging with supplementation using household food scraps and cultivation byproducts, such as broken rice, rice bran, groundnut meal, and sesame meal [3, 8]. In medium-scale pig and poultry farms, animals may be fed commercial feed or homemade concentrate,² or allowed to graze freely [3, 4]. Intensive, large-scale poultry farming uses automated feeding systems with commercial feed, and broiler fattening occurs over a period of approximately 42 days (or six weeks) so that birds reach a weight of 1.75 to 2.0 kg [3]. (As of 2015, the typical US commercial broiler reaches a weight of ap-

proximately 2.8 kg over 48 days, according to the National Chicken Council.³)

c) Antimicrobials, growth hormones, and other additives

In Myanmar, antimicrobials have been widely used for a long time in livestock production for treating disease, preventing disease, and promoting growth [9]. Imported from China, Thailand, Korea, India, Bangladesh, and the EU, the classes of antimicrobials used are beta-lactams, tetracycline, fluoroquinolone, aminoglycoside, macrolides, and sulphonamides [9]. Antimicrobials are purchased freely, usually mixed into livestock feed or water, and administered without adequate veterinary supervision [4, 9]. Most poultry farmers, for example, give antimicrobials for prophylactic purposes through drinking water and often use chlortetracycline in feed as a growth promoter, leading to residues in the meat because producers do not wait for the substances to leave the animals' bodies [9]. Pig and cattle producers use antimicrobials in similar ways [9].

A 2012 conference paper summarizing studies on antimicrobial resistance related to livestock, all of which were Masters theses conducted at the University of Veterinary Science in Yezin, Myanmar, reported *Salmonella* resistant to tetracycline, ampicillin, chloramphenicol, ciprofloxacin, and cotrimoxazole, as well as *E. coli* resistant to chloramphenicol, ciprofloxacin, neomycin, tetracycline, ampicillin, and oxytetracycline in poultry; *E. coli* resistant to ciprofloxacin, gentamycin, and trimethoprim-sulfamethoazole, in cattle; and *E. coli* resistant to ampicillin, oxytetracycline, chloramphenicol, ciprofloxacin, gentamycin, and sulfamethoxazole/trimethoprim in pigs [9]. Notable for all of these studies was that the percentage of resistant samples was often quite high, especially for tetracycline resistance [9].

It is not clear at what production scale abuse of antimicrobials is more likely to occur. However, one FAO document referred generally to this practice as leading to the development of drug resistance on smallholder farms [4].

2. Concentrates are high-energy ingredients that include fats, cereal grains, high-protein oil meals/cakes, and agro-industrial byproducts (such as those resulting from sugarcane, animal, and fish processing). They are distinguished from roughages, which include pasture grasses, hay, silage, and straw.

3. National Chicken Council—U.S. Broiler Performance: 1925 to Present, available at <http://www.nationalchickencouncil.org/about-the-industry/statistics/u-s-broiler-performance>, last visited Dec. 20, 2015.

d) Facilities for housing, slaughtering, and processing

As most livestock production occurs at the small scale, the majority of housing infrastructure for raising animals is quite basic. For example, on small chicken farms, some birds have shelters while others are kept underneath the homes, in cowsheds, or trees and other natural housing; on medium-sized chicken farms, more confinement may occur and attention to sanitation may be found [3]. For small- and medium-scale pig farms, the animals may be completely unconfined, confined within a large area, tethered, or confined to a pen [4, 8].

Large-scale commercial poultry farms use automated housing, feeding, and watering systems [3]. The construction of modern, industrialized poultry farms by domestic companies is a relatively recent phenomenon [10]. There are also a few large pig production facilities, mostly based in Yangon, that are reported to be well-equipped and managed [4].

In terms of slaughtering facilities, most of which are private, there are three types: abattoirs selling wholesale and retail, abattoirs selling only wholesale, and abattoirs only for retail [4]. These were described generally as using “simple equipment” [4, p. 32].

e) Land use and land acquisitions

We did not find information about land use or about companies from Myanmar acquiring land overseas for the purposes of livestock farming. As mentioned earlier, the country is considered self-sufficient in terms of producing animal feed. Both confined and free-range poultry production are concentrated in the rice-growing regions because of feed availability there [3].

The main foreign actor producing in Myanmar is the Thai company CP, a major player in both commercial poultry and pig production [4]. It is unclear whether “CP feed” is produced in-country or imported from abroad.

5) Waste management

There were only a few general references to sanitation-related issues on pig and poultry farms, and those reported inadequate sanitation on smaller scale pig and poultry farms [3, 8]. For example, a study on indigenous pig farming found that most pig farmers did not wash their hands

before feeding pigs, and dirty containers were used for collecting liquid kitchen waste (swill) from neighboring houses to be used as pig feed [8]. There was even less information about waste management. The only specific reference involved a description of a CP poultry facility where 1,500 broilers and 3,000 layers were housed in bamboo cages elevated 1.3 meters above the ground, 350 village chickens fed on scraps that fell through the broilers’ cages, and manure from underneath the broiler and layer cages was collected for fertilizer every two days [5].

6) Transnational corporations

The main transnational corporation mentioned in the documents we reviewed was Thailand-based CP, which operates poultry and swine production facilities and supplies feed and vaccines for Newcastle disease in poultry [3, 4]. A Danish company, Hamlet Protein, is looking to expand its market share by supplying more soy-based feed to the Southeast Asia region’s pig and poultry farms, including piglet farms in Myanmar [7].

7) Regulation of livestock production

The Livestock Breeding and Veterinary Department (LBVD), under the Ministry of Livestock and Fisheries, is in charge of livestock industry development, animal health, breeding and livestock extension services, and the 1993 Animal Health and Development Law regulates the prevention and control of contagious animal diseases [3]. However, existing domestic regulations insufficiently addresses topics such as animal feed, food safety, import/export, and quarantine operations [4]. Although the government is trying to increase monitoring of food safety issues, which include the use of banned drugs and chemicals [4], there is no legal framework or institution that regulates and enforces control over the use of antimicrobials in food animal production [9].

Impacts of industrial food animal production

1) Impacts on worker health

Our review did not yield any information on worker health in the large-scale animal production or processing facilities.

2) Impacts on surrounding communities and others

In reference to livestock development in the Southeast Asian region, one study commented, but did not provide or cite supporting data, that vertical integra-

tion and increasing scale were detrimental to smallholders who could not compete with high-technology and large-scale production [1].

Although antimicrobial abuse was cited as a problem that could lead to drug resistance and affect public health, there was no information to indicate whether this was a practice tied to industrialized livestock production. In fact, as mentioned earlier, an FAO document stated briefly that drug resistance was developing on smallholder pig farms [4].

3) *Impacts on natural resources*

Without providing primary data or citations to previous studies, one study referred to various environmental costs of the livestock revolution such as air pollution, water contamination, and water depletion [1].

Public engagement with industrial food animal production

There was little information on this topic, perhaps because large-scale commercial livestock production is a relatively new development. One indication about how the public might view industrial food animal production is contained in the statement that consumers in Myanmar prefer the taste of village chickens to commercial broilers, which they consider too soft [5]. A couple of documents suggest that researchers and NGOs working on food animal production in Myanmar may view certain characteristics of industrialized production positively. One study recommends using confined housing systems to raise pigs to decrease prevalence of cysticercosis,⁴ which they found to be associated with free-range production [8]. A World Vision value chain analysis suggested that semi-broiler breeds should be introduced to help commercialization of native chickens, and recommended forming vertical linkages between township wholesalers

and farmers, who were encouraged to shift from extensive to semi-intensive production [6].

We found no documents suggesting that antimicrobial use for disease prevention or growth promotion should be banned, though the importance of, and need for, proper veterinary supervision was emphasized in an FAO summary [4]. In fact, some stated that antimicrobials are necessary for raising food animals in Myanmar [9].

Given the limited media reports that our search yielded, we cannot draw any conclusions regarding media awareness about industrial food animal production. We did not find any information about transparency or access to information about this topic, nor about specific campaigns or civil society actors targeting industrial animal agriculture practices in the country.

4. Porcine cysticercosis is a parasitic disease caused by infestation of the larvae of the tapeworm, *Taenia solium*. Pigs are often carriers without exhibiting symptoms, although if the infestation becomes severe enough they may show clinical signs, such as nervous system and muscle disorders, sensitivity of the muzzle, and heart failure. Lesions, in the form of cysts, are usually found in the muscles, and more rarely in the lymph nodes, liver, spleen, lungs, and brain. Pigs become infected usually through infected food or contact with human feces. Humans can get tapeworm infection by eating raw or undercooked pork contaminated with these cysts, which develop into adult tapeworms. See UN Food and Agriculture Organization—AHP Disease Manual—B252—Porcine Cysticercosis, available at https://www.spc.int/lrd/ext/Disease_Manual_Final/b252__porcine_cysticercosis.html, last visited Dec. 20, 2015.

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Turkey



Overview

In Turkey, there has been a shift from extensive farming to more intensive and capital-dependent types of farming, with the government's Five-Year Plans in the 1960s and 1970s stressing modernization and capitalization, and further market deregulation and liberalization occurring in the 1980s and thereafter [1]. However, while poultry, red meat, and dairy output have increased, it is only the poultry sector that has grown substantially in terms of number of birds and integration of the production chain; cattle numbers actually peaked in the 1980s, and production gains are attributed instead to improved breeds [2]. Thus, some still consider agricultural industrialization in Turkey to be "in its infancy" [1, p. 156]. As the country's demand for meat surpasses its supply, factors like animal disease, domestic policies, insufficient government investment, and rural-to-urban migration are viewed as challenges for increasing livestock numbers and continuing the sector's transformation [2, 3].

Food and Agriculture Organization of the United Nations (FAO) statistics on food animal production

Turkey had a total of 22,401,105 Animal Units (AUs) in 2013, resulting in an overall livestock density of 0.58 AU per hectare (ha) of agricultural area. The numbers of live animals raised in 2013 were 3,145 pigs, 266,153,000 chickens, and 14,415,257 cattle. FAO 2011 estimates of livestock densities, by specific animal class, were less than 0.01 pigs per ha, 6.25 poultry birds per ha, and 0.30 cattle and buffalo per ha.

In 2012, production was 1,723,917 tonnes of chicken, 799,344 tonnes of cattle meat, and 15,977,837 tonnes of cow's milk. From 2002 to 2012, chicken, cattle meat, and cow's milk production increased by 148%, 144%, and 113%, respectively. The five-year period of 2007 to 2012 saw increases of 61%, 85%, and 42% for chicken, cattle meat, and cow's milk, respectively. Data for pork production in Turkey was reported as 37 tonnes in 2002, not available for 2007, and reported as zero for 2012.

Production, imports, exports, and net balance by livestock product

	Production (mt)			Imports (mt)	Exports (mt)	Net (mt)
	2002	2007	2012	2012	2012	2012
Pig meat	37	n.d.	0	0	0	0
Chicken meat	696,160	1,068,453	1,723,917	385	300,596	1,423,706
Cattle meat	327,630	431,963	799,344	25,436	14	824,766
Milk, whole fresh cow	7,490,630	11,279,340	15,977,837	0	8,801	15,969,036

Industry characteristics

1) Scale

There are around 4 million agricultural enterprises in Turkey, 95% of which produce both crops and livestock [2]. Most of the enterprises are family farms with less than five hectares of land, producing mainly for subsistence and yielding only small surpluses, if any [2]. Most livestock are raised under traditional systems, with extensive, grazing-based production and little veterinary care [2]. However, the uptake and contribution to productivity of industrial breeding practices have been recognized [2, 4]. Notwithstanding these general features, trends in production scale and intensity vary greatly based on the type of livestock concerned.

Scale of cattle production

The cattle sector is distinguished by an increase in meat and dairy production output but a decrease in number of live animals over the past few decades. Cattle numbers have been decreasing for many years, although the decline slowed in 2007 when the government implemented supports for the meat and dairy sectors [5]. Between 1980 and 2009, red meat and milk output increased three-fold and by nearly a third, respectively [2]. This is due to increased productivity, defined as carcass and milk yields per animal [6]. In Turkey, meat yield per bovine was 261 kg per head in 2012 and is projected to reach 320 kg per head by 2023, as compared to 341 kg per head in 2012 in the United States [7]. Growth in production output, however, has been slower than poultry, fish, and eggs over the 1960 to 2002 period [6]. According to one 2013 article, beef prices in Turkey have increased significantly since 2001, because the increase in supply has been relatively small compared to the rise in demand [7]. However, a 2012 article stated that red meat consumption per capita had declined slightly between 1960 and the early 21st century, while total meat consumption per capita had increased because consumers were switching from red meat to poultry meat [2]. In

particular, large and small ruminant meat comprised 67% of total meat consumed in 1960, but only about 25% in the early 2000s. The Turkish Ministry of Food, Agriculture and Livestock forecasted in 2013 that demand for beef would increase from 1,046,000 tons in 2011 to 1,314,000 tons by 2018 [8].

Regarding the style and scale of production, a 2010 USDA report observed that small farm sizes, domestic breeds, and pasture/grazing-based systems characterize the sector, as the less productive breeds are able to adapt to the climate of eastern Turkey,¹ where over half of the animal population is located [5]. Average herd size according to a 2001 agricultural census was 5.2 cattle per farm, and 84% of all cattle farms had fewer than five heads of cattle [9]. Most cattle are raised on farms with mixed crop and livestock production, and traditionally there was no specialized beef production since meat was obtained from dairy animals [9]. The beef sector has not developed as much as the dairy sector [5]. As of 2013, there were 1,125 officially recognized organic producers of cattle, producing 51,003 tons of milk and 3,126 tons of meat organically [10].

Styles of production vary based on region. In the eastern region, traditional farming methods are still used, while in the western region (where there are large metropolitan centers), new technologies are employed and there is evidence of intensification [9]. Most private investment has focused on dairy and some feedlots in the western region of Turkey [5]. For example, a study in Edirne province in western Turkey examined a sample of 135 cattle farms (formed by randomly selecting three farms from each of 45 settlement areas chosen as representative) and found that 28% of the sample had more than 50 heads of cattle [11].² Cattle farming had also developed in the northern

1. The report did not define what was meant by "eastern" Turkey; presumably, it includes at least the Eastern Anatolia Region, but it was unclear whether the Southeastern Anatolia Region or parts of Black Sea Region were also included.

2. This study did not state when the survey was carried out.

areas, with one mid-2000s survey on cattle-fattening farms in Amasya province—a region in the northern Black Sea Region known for having the largest of such operations—documenting 1,500 cattle-fattening farms in the study area. Researchers found that 42% of the farms had more than 30 heads, while nationally 31% of cattle farms have over 30 cattle [12].

By 2010, intensive cattle fattening farms had been established in urban areas, with capacities of up to 1,000 animals [13]. The government also announced a new policy at the end of 2009 to promote dairy production and feedlots, consisting of support for new cattle stock farms containing over 50 animals in the East and South-east Anatolia regions. The government will cover 30% of the cost of construction and 40% of the cost of breeding equipment for these farms [5, 7].

Researchers and others have made comparisons between large- and small-scale cattle farms and anticipated what might happen to smallholder producers in the coming years. For example, one European Federation of Animal Science conference paper, whose authors included two representatives of the Cattle Breeders' Association of Turkey, forecasted that smaller farms would have difficulty staying in business due to competition from medium and large firms with improved efficiency [9]. In this regard, a study based on 2005 survey data on energy use by 100 beef cattle farms of different sizes in Afyon province found that as farm size increased, the amount of energy used (including transportation energy, feed energy, and energy used in operating the feedlot) decreased per kg of liveweight, as well as per Mcal of protein energy output [14]. The researchers concluded that large farms (those with 25 or more heads of cattle³) had better feed efficiency and higher growth and carcass weights than cattle raised on small farms (those with five to ten heads) [14].

The abovementioned study on cattle-fattening operations in Amasya province randomly selected 54 farms to perform Data Envelopment Analysis⁴, and found that economically efficient farms tended to have larger barns and more animals [12]. Although almost all of the sam-

3. Note that 25 heads of cattle would be considered a small herd in developed countries.

4. Data Envelopment Analysis is a quantitative method for estimating efficiency by breaking down total economic efficiency into two components: technical efficiency, which measures the ability of an entity to use minimum inputs to reach a given level of output, and allocative efficiency, which measures the ability of an entity to optimize proportions of inputs, given their corresponding prices and available technology.

pled farms were inefficient at allocating resources—that is, they did not use the optimal combination of inputs in light of input prices—technical efficiency was statistically significantly higher for large-scale farms than for medium- and small-scale farms [12]. A more recent study on 95 cattle-fattening farms in Aydin province reached similar conclusions, finding that technical efficiency was correlated with increasing farm size, although overall the farms in the sample were operating at 71% efficiency [15]. There was also a positive relation between efficiency scores of cattle fattening farms and attending training/extension events, farming experience, and cattle fattening experience [15]. The authors of that study concluded that in order to meet the growing demand for food products of animal origin, farms need to intensify and become more efficient [15].

Scale of poultry production

According to official statistics, in 2013 there were 80 hatcheries, 322 breeding enterprises, 9,444 commercial broiler enterprises, and 994 commercial laying enterprises in Turkey [16]. Both the number of birds and poultry meat produced have increased substantially since the 1950s [2]. As will be discussed below, the sector is now controlled by large-scale firms using contract farming [17]. With the implementation of contract farming in 1970s, the broiler sector transformed from traditional village production to industrial production with modern technology [18]. The country is self-sufficient in broiler production and exports its significant surplus of poultry meat to markets in the Middle East and North Africa [17, 19]. In fact, the share of the world market occupied by the Turkish broiler sector increased twenty-fold from the early 1990s to the mid-2000s [17].

One article noted that the Ministry of Food, Agriculture, and Livestock and Turkish Statistical Institute had reported that in 2013, 0.1% of broiler meat was produced “organically” [16]. The article noted that the country had organic standards and a registration system (though did not provide more detail about these). At a conference event organized by the Animal Husbandry Alliance of the Germany-headquartered International Federation of Organic Agriculture Movements, it was reported that poultry production in Turkey rose from 890 heads in 2005 to 516,375 heads in 2013. However, there were only 24 officially recognized organic poultry producers that year [10]. These data were attributed to the Ministry of Food's Organic Agriculture Information System.

Scale of pig production

We found very little information about swine production in Turkey. One 2011 review article found that the sector was not organized and there was no effort to maintain pig farming as a food production activity [20]. The researchers predicted that pig farming might disappear entirely, as there were few pig farms in Turkey and the population of pigs had declined since the 1970s [20].

2) *Industry consolidation or concentration*

We found some information on concentration and consolidation. One study described a trend of a decreasing number of livestock farms and increasing farm acreage, with the number of farms falling from 4.09 million to 3.08 million and average farm size rising from 56.8 to 59.9 acres between 1990 and 2001 [6]. This is seen as progress by many because Turkey's agricultural sector has been criticized as being fragmented and filled with small-scale enterprises, characteristics said to inhibit productivity and therefore competitiveness [21].

Similarly, a 2014 report by the Turkish Prime Ministry described the feed sector as fragmented [19]. The top five feed producers account for 23% of production, and there are many "small inefficient players" [19, p. 42].

Concentration has been most evident in terms of poultry production. Most broiler production in Turkey occurs within integrated enterprises using contract farming [17, 22]. Firms unable to adopt vertical integration were reported as inefficient in production and marketing, and this was provided as an explanation for their ultimate bankruptcy [17, 18]. According to a 2006 study, there were 66 integrated broiler companies, the top 20 of which accounted for 84% of total production and the top five of which held a 47% market share [18]. Researchers have described this level of concentration as dampening competition, and rendering the broiler sector a loose oligopoly [17]. Yet the same researchers have also maintained that there is enough competition to keep prices close to cost [17]. Others have reported that this concentration is beneficial "in terms of food quality, safety, and price for the consumer" [22, p. 2221]. The top five broiler producers between 1998 and 2004 enhanced their competitiveness by meeting certain technical standards on food safety and quality, and secured major export deals with other EU countries [18].

3) *Vertical integration*

Contract farming has been observed in feed production and, to an even greater extent, in poultry production. Regarding the former, a 2010 study reported that the multinational firm Cargill operated in Turkey by importing animal feed and implementing contract farming for maize production, among other activities [1]. Ata Group and Koç Holding also engaged in contract farming to produce maize and soy for animal feed [1].

In terms of integrating poultry production, the government has been instrumental in issuing regulations and legislation to encourage expansion of contract farming [1]. Among other supports, the state Agricultural Bank extended credits to the Turkish Development Trust and Mudurnu Poultry company to invest in contract farming [1]. By the mid-2000s, the sector was reported to be both concentrated and vertically integrated, with integration helping to reduce transaction costs, increase productivity, and improve competitiveness in the global arena [18]. Broiler firms that did not adopt vertical integration had difficulties surviving, and the market became controlled by large-scale firms using contract farming [17]. According to a 2010 USDA report, there were 66 industrial, integrated poultry slaughterhouses with a combined capacity of 220,000 heads per hour in Turkey, along with 13 other slaughterhouses with a combined capacity of processing 7,500 heads per hour [23]. For about a decade starting in the mid-1990s, some of these large integrators attempted free-range broiler production⁵ but stopped because they could not successfully market their products [24].

4) *Inputs*

a) Breeding stock

Use of improved animal breeds have contributed to productivity gains in Turkey, notwithstanding declines in livestock numbers for certain types of livestock [2, 4]. The government has offered support in the form of breeding policies and preservation of genetic resources, such as conservation of live animals and cryopreservation of genetic material [2, 4].

5. The author did not define what was meant by the term "free-range" in this context. In other parts of this source, he contrasted "free-range" from "extensive indoor" and "traditional free-range" production systems, but also did not define those terms.

Poultry breeds

Up through the 1990s, breeding was done by small enterprises, but starting in the mid-2000s, large-scale enterprises took over [18]. Traditional poultry breeds are still important in rural areas, but hybrid strains are now used in intensive production [2]. Organic poultry farming, however, which accounted for 0.1% of broiler meat produced in 2013, does not use genetically modified breeds [16]. Research is also being conducted on slow-growing broilers, which are slaughtered at 80 to 90 days of age and have higher production costs [25]. A 2012 study that surveyed 2,241 families across 61 provinces found that 36%, 40%, and 9% of the respondents were willing to pay 10%, 20%, and 50% higher prices for slow-growing broilers, respectively [25]. However, the reasons behind why respondents might prefer slow-growing to fast-growing broilers were not explored; the authors only mentioned that slow-growing broilers cost more to produce.

Cattle breeds

One 2010 study reported that 36% of the cattle population consisted of low-productivity domestic breeds [21]. Less productive breeds are better able to adapt to the harsher climate and topography of eastern Turkey, where over half of country's herds are located [5]. Because of regulations concerning Bovine Spongiform Encephalopathy (BSE), dairy and beef breeding stock were only permitted from certain countries—originally only Uruguay, Australia, and New Zealand, and thereafter Germany, Norway, Denmark and Sweden [5]. Cattle imports from the US were banned in 2003 due to BSE, but the US and Turkish officials negotiated and signed a health protocol in 2007 that permitted imports of US breeding cattle [5]. Nevertheless, specialized beef breeds are still considered rare in Turkey, according to a 2010 USDA report [5]. A study evaluating the efficiency of 54 cattle-fattening farms in Amasya province in the mid-2000s found that farms with more Holstein breeds, rather than indigenous breeds and their cross-breeds, were more efficient [12].

b) Feed

High feed prices and the state of the country's pastures constrain livestock production in Turkey [21]. The domestic feed industry is developing; there were 692 feed factories operating at 71% capacity in 2009 [5] and 6% of arable land was being used for fodder crop cultivation [21]. However, production has been insufficient to meet the internal demand [19, 21]. In 2008, the country imported 3.17 million metric tons of feed ingredients, of which 27%

was soybean, 13% was corn, and 11% was soybean meal [23]. In 2014, official sources stated that 95% of feed capacity production was being utilized, and therefore capacity needed to expand [19]. Moreover, the feed sector was criticized for being fragmented, because the top five producers account for 23% of feed production, and there are many small and inefficient players [19].

Much of the agricultural budget has been devoted to fodder crop cultivation [26], taking the form of government subsidies that support reclamation of agricultural land for this purpose [27]. Official sources reported an increase in cultivated area from 1.2 million ha in 2002 to 2.2 million ha in 2011, thereby meeting 75% of the country's demand for fodder [27].

The government has additionally supported pasture reclamation [4]. Pastures are an important component of feed production, as livestock are usually grazed on public lands with minimal supplementation [6]. Official sources reported an increase in area of "improved pastures" from 8,300 ha in 2002 to 446,000 ha in 2012 [27]. However, there was no explanation about what reclamation and improvement actually entailed.

As mentioned earlier, various companies, including the multinational enterprise Cargill, engage in contract farming of crops such as maize and soy for animal feed [1]. One 2010 journal article criticized feed producers for generating waste due to poorly stored and spoiled feed and fodder [13].

Cattle feeding practices

The USDA reported in 2010 that small-scale farms using pasture/grazing systems were still prevalent in Turkey, that fodder cultivation and pastures were not properly managed, and that most animals were fed straw, which did not promote growth [5]. Feedlots are a relatively recent development in Turkey. Some large firms have invested in feedlots in the western regions of Turkey, and the government enacted policies to pay for 30% of the costs of construction and 40% of the costs for breeding equipment for cattle stock farms with over 50 animals in the East and Southeast Anatolia regions to promote dairy production and feedlots [5].

One source from 2010 reported that beef productivity was 183 kg per animal in Turkey, compared to 278 kg per animal in the European Union [21]. Another source from the same year reported a national average carcass

weight of 169 kg per head [12]. This is less than weights found in the United States, where in 2014, the average live cattle weight reported by the US Department of Agriculture was approximately 600 kg, giving an estimated average carcass weight of around 360 kg [28]. However, an investigation in Amasya Province, the region of Turkey with the largest cattle-fattening operations, found that in the study area carcass weight had actually reached 292 kg per head [12]. Moreover, operations in the study area were more feed-efficient, using 11.80 kg feed per kg production compared to the national average ratio of 13.15. In the research area, cattle were sold after attaining 432 kg in size after nine months of fattening [12]. For the sample of 54 cattle-fattening farms that were surveyed in this study, the average farm size was 35 heads of cattle and pasture-grazing was not common. Most farmers fed the cattle with concentrate and forage over an average fattening period of 269 days, and an average of 0.2 ha were dedicated to fodder crop cultivation [12].

Another study based in Afyon province in western Turkey, which surveyed 100 beef cattle farms, found that cattle were fed 59% concentrate, 36% roughage, and 5% green chopped forage [14]. Compared to cattle on farms with up to 25 heads, cattle on farms with more than 25 heads were fed a statistically significantly higher proportion of green chopped forages, a feed component that promoted performance and entailed relatively little input [14].

Poultry feeding practices

The USDA reported that feed accounts for 70% of total poultry production cost in Turkey, and that lack of available feed ingredients constrained poultry production and exports [23]. One of the reasons cited was a “biotechnology” regulation from 2009 that restricted the importation of most raw feed materials and led to an increase in feed prices. Other biosafety laws being negotiated were anticipated to drive feed prices higher by reducing soy and corn supplies. As of 2010, poultry feed consisted of 40% corn, 20% soybean, 5% to 10% soybean oil, and 30% other feed material [23]. In organic poultry production, which is undertaken by 24 companies across nine cities, birds are fed organically grown feed [16].

Swine feeding practices

We found one study on pig production in Turkey, and the only information provided regarding feeding practices was that live weights attained by pigs at eight months were approximately 80 to 90 kg, leading to carcass weights around 55 to 60 kg. These figures can be com-

pared to those reported in a US pork industry analysis, which provided that finishing weight (i.e., live weight) in 2013 was approximately 123 kg for “conventional” finishing (the final stage in swine production) [29].

c) Antimicrobials, growth hormones, and other additives

Our landscape assessment found no studies on antimicrobial use, growth hormones, or other feed additives in livestock farming in Turkey. A few sources highlighted the challenge of animal diseases in Turkish agriculture. The USDA described the Turkish livestock sector as “beset with animal health and public health problems,” such as foot and mouth disease, which is endemic in every province in Turkey, as well as a high incidence of tuberculosis⁶ and brucellosis⁷ [5, p. 5]. The US government was expected to provide support for vaccine manufacturing and epidemiological training to central and provincial veterinary services in Turkey [5]. For poultry slaughterhouses in particular, the USDA reported that all facilities are inspected by official veterinarians, with facilities that export to the European Union permanently staffed with four official veterinarians on-site [23].

d) Facilities for housing, slaughtering, and processing

Housing infrastructure

There was very limited information about housing infrastructure for cattle. A 2010 USDA report described traditional barns as having very “primitive and unhealthy” animal welfare conditions, but did not provide further details [5]. However, larger farms, especially ones in the western regions of Turkey, were recognized as having improved barn management. Another source stated that farms in the western regions employed the lat-

6. Bovine tuberculosis is caused by the bacterium *Mycobacterium bovis*, which can also cause tuberculosis in humans, affecting the lungs and lymph nodes, among other body parts. The disease is spread to humans through consumption of raw dairy products of infected animals, inhaling bacteria in the air, or coming into direct contact with a wound of an infected animal. See Centers for Disease Control and Prevention—Publications—Factsheets—*Mycobacterium bovis* (Bovine Tuberculosis) in Humans, available at <http://www.cdc.gov/tb/publications/factsheets/general/mbovis.pdf>, last visited Feb. 26, 2016.

7. Brucellosis, a bacterial infection, may also spread from animals to humans, causing symptoms such as fever, chills, and fatigue. It may become chronic and have long-term symptoms. The disease is spread to humans through consumption of raw dairy products of infected animals, inhalation of bacteria, and direct contact with certain body fluids of infected animals. See Mayo Clinic—Diseases and Conditions—Brucellosis, available at <http://www.mayoclinic.org/diseases-conditions/brucellosis/basics/causes/con-20028263>, last visited Feb. 26, 2016.

est technologies, though again there were no additional details provided [9].

A 2007 study of waste management systems in 476 cattle breeding enterprises in the Central Anatolia province documented that nearly all of the farms kept cattle confined to stalls their entire lives in tie-stall barns [30]. Moreover, in barns with slatted floors, ventilation was insufficient, such that waste stored beneath the slats released odors and gases that polluted the inside of the barn [30].

Regarding poultry production, one source from 2006 maintained that broiler production technologies in Turkey were as advanced as those used in developed countries [18]. Adoption of these technologies had enabled the country's broiler firms to be competitive globally and land major export deals. However, no further information was provided about the infrastructure itself. A 2010 USDA report described one "poultry house" belonging to the firm Beypilic, with a capacity to hold 600,000 head [23].

Processing and slaughtering infrastructure

A limited number of statistics concerning slaughtering facilities and their capacities were identified. In the mid-2000s, broiler slaughterhouses in Turkey met standards for exporting to the European Union; their average daily slaughtering capacity was 3,500 metric tons, and they were operating at 84% capacity [18]. In 2010, there were 66 industrial, integrated poultry slaughterhouses with a combined capacity of 220,000 heads per hour, and 13 other slaughterhouses with a combined capacity of 7,500 heads per hour [23]. Four of the six factories were certified to export to Russia in 2009 (Keskinoglu, Beypilic, Banvit, and Erpilic) and each had the capacity to process around 300,000 heads daily. Regarding the operations themselves, all broiler slaughtering operations are inspected by official veterinarians tasked with ensuring regulations are followed [23]. For example, chlorine is used, presumably for disinfection, and regulations restrict the chlorine to 0.5 parts per million [23].

The Turkish Meat and Milk Board (ESK), a state-owned enterprise, operated nine slaughterhouses as of 2013, with a combined yearly capacity of 150,000 heads of bovines, 8,800 tons of poultry, and 120,000 heads of sheep and goat [8]. After slaughtering, meat is sold in a retail chain of over 81 stores, most of them franchisees. ESK is described as an "intervention agency" responsible for keeping domestic market prices stable, presumably by controlling some of the supply of meat and milk.

e) Land use and land acquisitions

Compared to other European countries, Turkey has a relatively large amount of fresh water resources and arable land [19]. Pastures belong to the government, but new regulations allow private individuals to use them [10]. However, improper management of pastures and fodder cultivation are cited as challenges [5], and the country is not self-sufficient in feed [21]. In 2010, only 6% of arable land was used for fodder crop cultivation, but one source stated that the percentage should be 25% to 30% [21]. As described in the earlier sub-section on feed, the government has undertaken efforts to reclaim land for fodder crop cultivation and to improve the state of the pastures. The area of improved pastures increased from 8,300 ha to 446,000 ha between 2002 and 2012, while the area used for fodder crop cultivation increased from 1.2 million ha in 2002 to 2.2 million ha in 2011 [27].

5) Waste management

Manure has no market value in most parts of Turkey, so selling it is difficult [13]. According to official government statistics from 1997, about a quarter of the animal waste generated from livestock production was being used as fertilizer for agriculture [30]. Most waste was used as dried manure for heating fuel [13, 30]. The FAO reported that replacing open anaerobic lagoons, used by 30% of slaughterhouses, with anaerobic digestion would have the greatest potential for reducing methane emissions and provide a renewable source of energy [31].

Cattle farms

Cattle-fattening enterprises often dump manure onto unoccupied areas, where it leaks into groundwater and surface water and affects air quality [13]. A 2007 study on 476 cattle breeding enterprises located in Central Anatolia found that waste management measures were insufficient, as 76% of the barns did not have any facilities for storing waste [30]. For the smallest barns, waste was stored in an open, common area of the village, and larger barns lacking storage facilities kept waste in an open area near the barn without any further measures for a period of four to six months, during which time liquid waste could seep into the soil or surrounding surface water. The 24% of barns that did have storage facilities were mostly the largest enterprises, but even for those farms the only treatment undertaken was occasional drying. Larger enterprises used some of the waste for plant cultivation,

dried and sold waste to other cultivators, or gave some away to commercial fertilizer producers.

In the same study, it was also documented that regulations on the distance required between water resources and waste storage facilities were not followed [30]. Moreover, although smaller enterprises generated less waste, they were located closer to each other and to residential areas, therefore they had negative impacts on soil and water resources, as well as human health.

A 2011 study on 135 farms in western Turkey found that 87% of the barns were situated within 500 meters of a residence, and the environmental and health impacts of animal waste were not considered in deciding where to locate the barns [11]. In the study, 28% of farms had more than 50 heads of cattle and 72% had 50 or fewer heads. Moreover, 95% of the farm owners reported disposing of waste in an open area, anywhere on the farm, near a creek, in the garden, or by the side of the barn, without taking any precautions [11]. The remaining 5% stored waste in manure storage holes; however, the holes are reportedly inadequately built [11]. Although Turkish environmental regulations specified that animal waste should be stored for no longer than three months, 16% of the respondents stored waste for four months, 36% stored it for six months, and 48% stored it for eight months [11]. As for the ultimate outcome of the waste, 82% of the respondents reported applying it as fertilizer without any treatment, and 18% reported leaving the waste in an empty area [11].

Broiler farms

A 2013 study focused on Bolu province, where over 10% of the country's broiler production occurs, and found that a common practice for disposing of waste was to stockpile broiler litter and store it uncovered before eventually applying it to cropland [32]. We did not find other studies on management of waste by poultry farms.

6) *Transnational corporations*

There was limited information about livestock production activities undertaken by transnational enterprises within Turkey. A 2010 study mentioned that Cargill was importing animal feed into Turkey, as well as implementing contract farming for maize production for animal feed [1]. A 2015 news source added that Cargill had acquired a leading stake in Ekol Gıda, a key Turkish premix and feed additive company [33].

7) *Regulation of livestock production*

Government supports for industrialization and expansion

Since the 1960s, the government has implemented plans, regulations, and legislation to promote modernization, capitalization, privatization, and expansion of the livestock sector [1]. Provision of subsidies and credit are two concrete forms of support commonly used by the government [1]. There have also been agriculture price supports consisting of payments to livestock breeders, with organic livestock breeders receiving a 50% higher payment, and payments to producers for taking actions against animal disease [19].

More recently, there has been support for other areas of agricultural development, such as genetic resource conservation, pasture reclamation, environmental protection, fodder production, hygiene, animal welfare, animal identification, specialization, processing, and marketing [4, 26]. In fact, the share of the agricultural budget devoted to livestock production in Turkey increased from 3.2% in 2000 to 22.6% in 2008, with much of it devoted to fodder crop production and a milk incentive premium [26]. However, the amount of spending was criticized as being too low compared to developed countries [26], and not commensurate with the contribution by the livestock sector to the national economy [2]. Another criticism has been that policies to increase livestock production have not been very successful, and have sometimes had a negative impact on productivity and competitiveness, especially for small producers [2]. This may be related to the fact that there are insufficient links between research and extension services [2]. Experts have recommended incentives and subsidies to reverse migration to cities, a measure they believe would help the livestock sector [3].

Regulations or lack thereof

Our assessment identified several sources that commented on the regulatory landscape related to a given component of livestock production. For example, one 2010 source described the legal framework regulating the environmental impacts of food animal production activities as legally complex, poorly coordinated, and inadequately enforced [13]. In this regard, two studies revealed that environmental regulations regarding storage of animal waste were not being followed [11, 30]. These studies are described in detail in the subsection on waste management.

The 2004 Animal Protection Law Number 5199 regulates animal welfare issues in relation to farm animals and slaughterhouses, among others [2]. However, the USDA reported that in 2010, 40% of Turkish livestock slaughtering was not regulated [5], and the organizations Compassion in World Farming and Humane Society International criticized animal welfare standards in Turkey, among other “transitional” countries, as falling considerably short of EU standards [34].

Regarding organic food animal production, in 2014 the Turkish Ministry of Food, Agriculture and Livestock had prepared legislation for organic certification, but some industry representatives and academics were calling the organic label a scam and the public lacked confidence about the certification system [24]. On the other hand, a 2014 source co-authored by a representative of that ministry reported that organic poultry production was being carried out in “poultry houses that comply with organic production conditions and in accordance with the rules of organic animal breeding and veterinary intervention,” including feeding with completely organic feed, no genetic modification, and certification by the competent authorities [16, p. 1045].

Impacts of industrial food animal production

1) Impacts on worker health

Our landscape assessment did not identify any information about the impacts of industrial livestock production on occupational health.

2) Impacts on surrounding communities and others

Governmental initiatives to promote expansion of the livestock sector have been criticized by some researchers as being detrimental to smallholder producers, who have not been able to remain competitive in the new policy and economic environment [1, 2]. Rather than focusing on the impacts of large-scale livestock production, one study criticized small farms for negatively affecting soil, water, and human health, since they were located close to residential areas and to each other [30], while another study from 2011 found that their sample of 135 farms, nearly three-quarters of which were considered small family farms, was criticized by surrounding communities for creating noxious odors and unpleasant sights [11]. Researchers of the latter study also found significant levels of contamination of neighboring water sources by nitrite and coliform bacteria, which they hypothesized was

due to animal waste. They recommended that “to prevent all these environmental problems, small farms should be unified under a cooperative and shifted to a certain safe distance” from the residential areas and water sources [11, p. 1536].

3) Impacts on natural resources

Our landscape assessment found very few studies collecting primary data and analyzing the environmental impacts of food animal production, but several sources mentioned that such impacts were occurring. For example, one source maintained that it was common for manure to be disposed of in areas where it could leak into groundwater and surface water and harm air quality [13]. Although no details were provided, that source also argued that intensive farming at an industrial scale in particular had led to water and air pollution [13]. An FAO report found that animal manure and enteric fermentation accounted for 2% and almost 30% of total methane emissions in Turkey in 2004, respectively, based on official data [31].

One of the studies that did collect primary data on environmental impacts focused on 476 cattle breeding operations in Central Anatolia, and documented that animal waste was being inadequately stored and therefore created odors, attracted flies, and contaminated soil and water resources [30]. Liquid waste management was especially detrimental for the environment, and addressing this problem was seen as the most important step for environmental protection [30].

A more recent study based in the Bolu area tested 50 samples of broiler litter for physicochemical characteristics [32]. It found that micronutrient and trace element concentrations of the broiler litter were low enough so that the litter could be applied to land and used as fertilizer for organic crop production [32]. On the other hand, the author explained that if animal feeding operations were to expand, then there could be long-term accumulation of zinc and cadmium in the soil to the point where guidelines would be exceeded, as well as phosphorous imbalance and accumulation beyond agronomic needs within the next decade [32].

Public engagement with industrial food animal production

1) Transparency and access to information

A few sources mentioned problems with accessing information on livestock production in Turkey. According to the USDA, statistics on livestock collected by Turkish officials are not reliable because supports are given based on the number of head of cattle owned, thus farmers sometimes do not notify officials when their cattle are slaughtered [5]. The FAO reported that there was a lack of published data on animal waste in Turkey [31].

2) Public awareness and attitudes

One Turkish researcher views livestock sector integration and concentration as positive developments which benefit food quality and safety and lower consumer prices [22]. However, there were several sources noting public concern about animal welfare and inputs used in livestock production. For example, a 2012 survey of 2,241 families across 61 provinces found that 67% of respondents believed that poultry production was not inspected sufficiently by the authorities, and 36%, 40%, and 9% of the respondents were willing to pay 10%, 20%, and 50% higher prices for slow-growing broilers, respectively [25]. Another study cited relatively less public attention to sustainability and little knowledge about alternative production systems, but more public concern about issues like genetically-modified organisms, antibiotics, animal by-product feedstuffs, and welfare of farmed chickens [24]. Several studies from 2014 have also cited growing attention within Turkey to animal welfare [15, 16, 24].

Consumers are paying more attention to organic poultry production, although they confuse organic production with village-type production, and conflate “natural products” with “organic products” [16]. Although most organic products are exported, domestic demand for these products is increasing [10], however, the public reportedly lacks confidence in the organic certification system [24].

3) Media interest in IFAP

One media source that we found was focused on the “problem” of declining livestock numbers in Turkey and rising meat prices for domestic consumers, and cited small herd sizes as one of the factors behind this situation [3]. Beyond this, our landscape assessment did not find

other media sources that discussed industrialized food animal production in Turkey.

4) NGO or community campaigns, advocacy and other efforts targeting IFAP

The NGOs Compassion in World Farming and Humane Society International have examined the role of international finance institutions, such as the International Finance Corporation (IFC) and the European Bank for Reconstruction and Development (EBRD), in providing capital to large-scale agribusinesses in Turkey, among other countries [34]. They found that these investments are not bound by animal welfare standards, and hence recommend that financial institutions adopt binding performance standards and policies to guide such investments [34].

5) Description of other civil society actors engaged in IFAP

Academic researchers are engaged in studying industrialized food animal production in Turkey, with some academic researchers viewing it as a positive development and urging the government to promote further commercialization, larger producers, greater productivity, and larger farm size [7, 22], and other researchers focusing on the negative impacts deriving from this style of production [1, 30, 32].

Our landscape assessment did not find information about other NGOs engaging with the issue of industrial livestock production in Turkey. However, we did find some information about international institutions supporting livestock producers within Turkey, with the international finance institutions mentioned above providing capital to large-scale agribusinesses [34] and the International Fund for Rural Development (a UN agency) funding a nine-year project to help rural households in two provinces improve a range of animal husbandry activities [35].

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Uganda



Overview

The livestock sector is growing in Uganda, with pig production in particular emerging as a new development. However, current livestock production is still only able to meet half of the country's demand for animal protein [1]. Like many of the other countries surveyed in this landscape assessment, challenges faced by the sector include poor breeds, inadequate feed, animal disease, insufficient veterinary services and quality drugs, expensive inputs, and lack of market access. More specific to Uganda, other factors that may have hampered livestock development are the conflict between the Lord's Resistance Army and the Ugandan army, forced displacement, and cattle raiding.

FAO statistics on food animal production

Uganda had a total of 14,935,340 animal units (AUs) in 2013, resulting in an overall livestock density of 1.04 AU per hectare (ha) of agricultural area. The numbers of live animals raised in 2013 were 2,497,600 pigs, 31,680,000 chickens, and 12,985,900 cattle. FAO 2011 estimates of livestock densities, by specific animal class, were 0.17 pigs per ha, 2.46 poultry birds per ha, and 0.58 cattle and buffalo per ha.

In 2012, production was 115,000 tonnes of pork, 63,000 tonnes of chicken, 191,280 tonnes of cattle meat, and 1,207,500 tonnes of cow's milk. From 2002 to 2012, pork, chicken, cattle meat, and cow's milk production increased by 37%, 17%, 66%, and 73%, respectively. The five-year period of 2007 to 2012 saw increases of 10%, 45%, 10%, and 11% for pork, chicken, cattle meat, and cow's milk, respectively.

Production, imports, exports, and net balance by livestock product

	Production (mt)			Imports (mt)	Exports (mt)	Net (mt)
	2002	2007	2012	2012	2012	2012
Pig meat	84,000	105,000	115,000	11	0	115,011
Chicken meat	53,625	43,550	63,000	682	37	63,645
Cattle meat	115,000	174,150	191,280	0	1	191,279
Milk, whole fresh cow	700,000	1,085,000	1,207,500	1,593	9,418	1,199,675

Industry characteristics

1) Scale

The scale of livestock production varies based on geography in Uganda, with more extensive systems of subsistence-based production present in the arid and semi-arid regions and more intensive, though still generally small-scale, market-oriented production in urban and peri-urban settings [2]. One 2013 study used 2008 National Livestock Census data to examine livestock stocking rates, and found that there were more understocked than overstocked areas in the country [3]¹. Most of the understocked areas were located in northern Uganda, with understocking potentially due to armed conflict between the national army and the Lord's Resistance Army and forced displacement there, along with a few understocked clusters in the southwest. Overstocked areas were more dispersed and found in the northern West Nile area of the northwest, parts of Karamoja in the northeast, densely populated areas on the eastern border, on the northern shore of Lake Victoria, and in the cattle belt, among others [3].

Scale of cattle production

Most beef cattle production is found in the "cattle corridor" stretching across Central Uganda from the southwest to the northeast [4]. Production is mostly extensive in the cattle belt, but there are also intensive cattle production in areas of high population density [3] and agro-pastoralism in the east and west [2]. Around 95% of the cattle production and consumption in Uganda is attributed to nomadic pastoralists, pastoral communal grazers, and small farmers [1, 2, 5]. In the beef sector, large-scale commercial ranches, of which there were 165

in 2012, raise as many as 7,000 heads but account for only 2% of the total (beef) cattle production in the country [6]. While commercial ranchers will take cattle to city slaughterhouses or export them live, the agro-pastoralists and pastoralists² go through primary traders, who in turn sell animals at livestock markets to secondary traders with access to slaughter slabs or export avenues, or go directly to the livestock markets themselves [5].

Few studies have quantified the scale of cattle production based on herd size. One investigation, based on a sample of 100 beef producers and 32 traders located across three districts of the Lake Victoria Basin, offered the following typology: small-scale (one to ten heads), medium-scale (51 to 100 heads), and large-scale (over 100 heads) accounted for 48%, 26%, and 26% of the households surveyed, respectively [5]. The size and scale of the operation influenced the uptake of agricultural technologies, with medium and large farms using industrial beef production techniques, improved breeds, and better marketing [5].

In this context, the Dutch Embassy has identified opportunities for investing in the beef sector, which include establishing feedlots, commercial ranches, and combined slaughterhouse-processing facilities [6]. While the Ugandan government has implemented a strategy to improve animal health, nutrition, and farmer training, which has led to expanded cattle production, productivity gains are lower than necessary to meet growing demand [6].

1. Understocking and overstocking refer to areas where actual livestock densities were either below or above densities predicted by a quantitative model developed by the researchers, which incorporated the variables of population density, agro-ecological characteristics, and market access. See Benson T, Mugarura S. Livestock development planning in Uganda: Identification of areas of opportunity and challenge. *Land Use Policy*. 2013;35:131-9.

2. Agro-pastoralism, derived from pastoralism, is defined as follows: "Historically, land was communally owned under pastoral systems and cattle production largely depended on mobility of pastoralists to search for pasture and water. Mobility would enable the restoration of depleted grazing areas and maximize herd sizes without further degradation of land. However, the individualization of land ownership undermined pastoral mobility in Uganda's rangelands and paved the way for sedentary and agro-pastoral systems. Under agro-pastoral systems, cattle production requires more investment in pasture, water and feeding practices if sustainable production is to be achieved without degrading natural resources" See Mpairwe D, Zziwa E, Mugasi SK, Lawasi GH. Characterizing beef cattle value chains in agro-pastoral communities of Uganda's Lake Victoria Basin. *Frontiers of Science*. 2015;5(1):1.

Scale of poultry production

According to the classification system provided in the Dutch Embassy report, small poultry farms have up to 1,000 birds, medium-sized farms have between 1,000 and 5,000 birds, and large farms have over 5,000 birds [6]. A lack of data, however, complicates classification of poultry farms according to intensity [7]. At the least intensive scale of production, a typical household raises six to ten indigenous birds [6] using a free-range, subsistence-based mode of production [7]. According to a 2007 FAO consultant report, free-range production accounts for 80% of poultry production [7]. Semi-intensive “backyard production” is one type of commercial production that involves raising tens to hundreds of birds, which have housing but are allowed to scavenge in an enclosure [7]. This type of production is found in peri-urban areas, but is reportedly uncommon [8]. Another semi-intensive form of production involves farmers raising commercial layers and broilers supplied to them by companies [8]. This is found in both peri-urban and urban areas [8]. Free-range, backyard, and semi-intensive production are considered small in scale [8]. Intensive production occurs on farms raising flocks of over one thousand birds [6], with completely indoor housing and commercial feed [7]. Contract farming can also occur at this level of production, with some growers “tak[ing] over 20,000 chickens per month” [7, p. 30].

Intensive poultry production has increased in peri-urban areas over the past 15 years, according to a 2013 study [3]. A 2007 FAO report explains: “The entire poultry production is largely private sector driven for both supply of inputs, feeds, vaccines, drugs, and the farming itself, while the public sector is restricted to regulatory services, some training and research services” [7, p. viii]. According to a 2007 industry magazine article, there are a few large-scale broiler companies operating in Uganda, the largest of which is Ugachic Poultry Breeders, which produces over one million broilers annually for its own processing plants [9]. Greater investments in commercial hatcheries and poultry farms were identified as a business opportunity by a consultant report financed by the Dutch Embassy in Uganda [6].

Regarding marketing, poultry marketing is considered quite informal [7]. Local poultry are sold at informal markets set up within villages, primary markets where various villages come together, larger secondary markets, and urban markets [8].

Scale of pig production

A 2011 report by the global agricultural research consortium CGIAR³ described pig keeping in Uganda as a relatively recent development, and therefore there has not been much research on it to date [10]. Pigs are produced throughout Uganda in both village systems and in somewhat larger peri-urban herds [10]. According to the 2008 Livestock Census, there were 1.1 million pig-raising households, raising 2.8 pigs, on average [11]. The census showed that pork production had expanded quickly in peri-urban areas [3]. The most concentrated areas of production are located around Kampala [10] and other towns in central Uganda [12]. One local official reported that between 300 to 500 pigs are slaughtered daily in Kampala [13]. However, overall productivity, as measured by feed conversion and reproduction rates, is low [10].

Regarding intensity, there are three types of pig production: extensive small-scale production, semi-intensive, and intensive. Extensive small-scale systems involve herds of up to five pigs that are tethered or allowed to scavenge freely on outdoor pastures all the time. This type of production, which is subsistence-based, accounts for 90% of the country’s pigs. Intensive production can happen at small (fewer than five pigs), medium (five to 30 pigs), or large (more than 30 pigs) scales [13]. Most farms are small, while the few farms that have herds of more than 500 pigs are considered industrial-scale [11, 13]. Intensive production, which keeps pigs in total confinement, is on the rise in Uganda because of land scarcity and greater information/awareness about commercial pig farming [13]. Semi-intensive systems, which involve partial confinement, are not common.

2) *Industry consolidation or concentration*

There was little information about concentration of livestock industries in Uganda. One 2014 International Livestock Research Institute (ILRI) report referred to the company Quality/Fresh Cuts as dominating the processed and packaged meat market [11]. The company processes 11 tons of fresh meat daily and covers 85% of Kampala’s processed meat market, holding a monopoly over beef processing [6]. There are a few other minor meat processing companies, but, in general, processing facilities operate at less than 50% capacity due to the lack of live animals [6].

3. The CGIAR consortium is currently referred to as such (i.e., it is not an abbreviation).

For production of animal feed, the 2012 Dutch Embassy-commissioned report stated that there were five main producers of livestock feed in Uganda, but did not state the market share attributed to those companies [6]. In addition, there were over 70 small-scale, non-mechanized feed producers [6].

3) *Vertical integration*

Integration in the poultry sector

There were a few references to contract farming for poultry production. A 2007 FAO consultancy report noted the presence of a few “organized” companies that had established contract farming for broilers and layers, with some farmers raising over 20,000 chickens per month [7]. In 2014, *The Independent* reported the intentions of one company, Hudani Manji Holdings, to launch new, modernized broiler and processing facilities as part of an “integrated agri-business venture” that would be able to process 220,000 birds per week [14].

One Ministry of Agriculture report from 2010 proposed streamlining poultry production and marketing of poultry and poultry feeds. The report did not use the term, “integration,” but the recommendation seemed to promote moving the industry in that direction [1].

Forms of vertical coordination for other livestock production

We did not find any information about the extent to which production of pigs or cattle is already integrated in Uganda. A CGIAR report from 2013 did not use the term “vertical integration,” but did identify “[c]loser coordination of production and post-farm activities to ensure delivery of high quality and homogenous products” as a factor for successful pig production [13, p. 49]. It further recommended incentives for contract farming to improve contract/out-grower schemes between small pig farmers and processors, restaurants, and retailers, as well as more linkages among actors in the value chain [13].

4) *Inputs*

a) Breeding stock

Poultry breeds

According to the 2008 National Livestock Census, a little less than 90% of chickens are indigenous breeds, while 12%—most of which are broilers—are considered exotic [6]. The exotic chickens tend to be found in central Uganda, especially in Kampala and neighboring dis-

tricts, as those areas are where commercial production are most concentrated [6].

Commercial breeds, which maximize meat and egg production, are not broody (i.e., they do not have the tendency to sit on eggs to incubate them) and cannot reproduce naturally [15]. Perhaps for this reason, commercial hatcheries were identified by the Dutch Embassy-commissioned report as an investment opportunity [6], while the Ministry of Agriculture identified local poultry hatcheries as needing more support [1].

In this regard, one publicized initiative to improve poultry breeds consists of the Kuroiler chicken, a highly productive breed first introduced in India to work well in poor village environments [16, 17]. Kuroilers can survive on household waste and agricultural byproducts, and provide both meat and eggs, yielding 150 to 200 eggs per year, compared to 30 to 40 eggs per year of normal indigenous chickens [16]. Raised free-range, they are also aggressive and feed continuously, putting on weight faster and attaining twice the body weight of normal indigenous chickens [16, 18]. One study distributed Kuroilers and local chickens to five districts in Uganda found that farming Kuroilers was associated with increases in meat production, egg production, and household income [17]. Half a million Kuroilers were distributed to Ugandan farmers by the summer of 2014, and the Gates Foundation dedicated \$1.4 million to supplement the Ugandan initiative through the spring of 2016, as well as additional funding to trial Kuroilers against native chickens in Ethiopia, Tanzania, and Nigeria [19].

Cattle breeds

Indigenous cattle breeds, which are farmed extensively, dominate the national herd [4]. Although they are considered to have low productivity, they account for the majority of the beef supply [6]. One 2005 government report documented that pastoral communal grazers, nomadic pastoralists and small farmers, all of whom mostly use indigenous cattle breeds, contributed 89% of the cattle slaughtered and raised 91% of the cattle in Uganda [2]. Improved cattle breeds are farmed intensively, mostly in small and medium dairy farms that use zero-grazing systems [4]. In its 2010 report, the Ministry of Agriculture expressed a need to improve cattle genetics [1].

Pig breeds

Information about pig breeds was found only in two site-specific studies. One study on 96 peri-urban and ur-

ban households located in northern and eastern Uganda found that 64% of the sample kept indigenous pig breeds [20]. Another study, based on a random sample of 135 farmers in one district of central Uganda, found that most pig breeds were crossbreeds of local and exotic pigs and that the lack of improved breeds was a challenge to pig production [12].

b) Feed

The Dutch Embassy consultancy report identified five main producers of livestock feed in Uganda, and their monthly feed output was in the range of 600 to 1,500 metric tons, according to one 2006 source [6]. A few of the larger companies had national distribution networks, with agents operating in the larger towns [6]. Besides these main producers, there were also more than 70 small-scale producers who were not mechanized and mixed feeds manually with rudimentary tools like spades and shovels [6].

Challenges with animal feed quality

A major challenge for livestock production in Uganda is poor feed quality. According to a nationwide survey conducted between 2002 and 2005, 75% of manufactured animal feeds did not meet required standards [21]. Problems included feeds containing fewer nutrients than required, feeds being deliberately mixed with materials to increase the weight of the feed, feeds that had been moistened, and feeds that contained toxins harmful to humans (as well as animals), such as aflatoxin [21]. The issue of contaminants is particularly troublesome. In 2012, officials estimated that 80% of feeds were adulterated with sand, ash, sawdust, and other substances, which can stunt animal growth or even cause death [22]. They reported that medium and large feed milling companies added sand and shells to feed to increase weight of the feed and thus their profits, a problem that still needed adequate legislation and [22].

When farmers mix their own feeds, there are also concerns about feed quality because farmers generally lack knowledge about how to mix feed properly [21]. In addition, one recent study of 125 farming households in Kampala found that in order to address feed scarcity in urban livestock farming, the practice of using market crop wastes as supplementary animal feed was common and growing, but that the wastes could be contaminated and cause diarrhea in the animals [23].

Cattle feeding practices

Raised by pastoralists and agro-pastoralists, the majority of cattle in Uganda are grazed on pastures, many of which are communally owned [2]. A 2013 case study by the Ugandan Wildlife Society found three types of cattle production present in the Albertine Rift: extensive production, which allowed animals to graze on unimproved, communally owned pastures; semi-intensive production, which combined daytime grazing with nighttime supplementation (for example, with Napier grass); and intensive production, which was a zero-grazing system that provided feed and water, with forage being grown on the farm or purchased [24]. Intensive production, found in urban or other densely populated areas, was deemed to be advantageous because it eliminated the risk of diseases associated with communal grazing, and generated enough manure for crop fertilization and biogas production; however, intensive systems were recognized as labor intensive with high initial startup costs [24].

It appears that the intensive, zero-grazing systems found in the Albertine Rift are not the same as cattle feedlots. According to the 2012 Dutch Embassy consultancy report, cattle fattening infrastructure is essentially non-existent, and investment in feedlots, which requires finding affordable and suitable feed, is a business opportunity [6]. A recent study with 100 beef producers and 32 traders across three districts of the Lake Victoria Basin found that, in addition to a lack of adequate feed, an even greater obstacle to cattle fattening was skepticism about its profitability [5]. Consequently, the researchers recommended doing “participatory feedlot training” to assess profitability of cattle fattening [5].

Poultry feeding practices

Feeding practices for poultry vary based on the system of production. Free-range production is based on poultry scavenging household scraps [8]. Households may provide some supplementation, such as cereal grains and agricultural byproducts [25]. In backyard production, which involves partial confinement, poultry are given feed and water, and finding adequate feed for the birds is a challenge [8]. In small-scale, semi-intensive production, farmers provide feed to the birds, such as commercially-compounded feed [8]. In larger-scale intensive systems, commercial feed is also used [7]. The cost of feed is high, accounting for 60-70% of the cost of production, so farmers may self-mix the feed to reduce expenses [7].

Maize and its byproducts are the main ingredients used in poultry feed in Uganda [9]. One source reported that broilers can reach 1.45 kg in 45 days with a feed conversion ratio of 2.5 [9], while another reported that broilers raised in confinement reach 2.0 kg in only five weeks [15]. The biggest poultry feed producer in the country is a Kenyan company operating as Uganda Feeds Limited, while other large broiler producers, such as Ugachic Poultry Breeders and Hudani Manji Holdings, also manufacture their own feed [14].

Feed production is considered an investment opportunity in the poultry sector [6]. Emerging organic poultry production is said to be limited by the lack of organic feed, which is due to diminished and overexploited natural grasslands [2].

Swine feeding practices

According to a 2014 ILRI report on pig farming, the use of commercial feeds in intensive and semi-intensive pig farming is on the rise [11]. Intensively raised pigs are confined in pens and typically fed indoors, using feed based on maize bran and crop residues [11]. Despite the presence of a few larger producers who make compound feeds, obtaining adequate feed remains a challenge because the industry is underdeveloped, most producers operate on a small-scale and informally, and feeds are not well regulated and often contaminated [11]. In addition, feed conversion rates are not optimal [10].

Given the costs of commercial feed, pig keeping households often cannot depend on such feeds. For example, in one study on 96 peri-urban and urban households in northern and eastern Uganda, 88% of the households used homemade feeds consisting of cassava, brew waste, and potatoes, and no household relied exclusively on commercial feed [20]. Another study based on 135 pig-keeping households in central Uganda also found that no farmer used only commercial feeds, and 59% gave pigs cassava, potatoes, and crop residues [12].

c) Antimicrobials, growth hormones, and other additives

There are various problems related to the use of veterinary drugs in Uganda. The drugs are readily sold without a prescription, inappropriately stored and handled, and administered by farmers themselves [26, 27]. A few studies have examined the use of antibiotics in livestock production in general. Others, which will be described in the sub-

sections below, have focused on antibiotics in swine or poultry production specifically. One 2014 study based on surveys and interviews conducted with 36 drug stockists and 53 village veterinarians, who were randomly selected from three districts, reported that the most commonly used antibiotics were oxytetracyclin, penicillin/streptomycin, tylosin, sulfonamides, and almayalin, and that farmers used antibiotics prophylactically [27]. The study found that there were three types of drug stockists: retailer drug shops (55%), which bought drugs from wholesalers or from veterinary pharmacies and resold directly to farmers and others; veterinary pharmacists (31%), who were university-trained veterinarians owning animal drug shops; and wholesale drug shop sellers (14%), which bought large supplies in the capital and stored and resold drugs to retailers, private veterinarians, and others. On the training and qualifications of the village veterinarians, the study found that only 5% of them had an advanced degree in animal health, such as a Bachelor of Veterinary Medicine; the others had a diploma in animal husbandry, a certificate in any topic related to agriculture or livestock, or simply training related to extension services.

Another study, which did not mention the location of the sites where samples were obtained, isolated *Enterococci* and *E. coli* (types 387 and 441, specifically) from the feces of chickens, cattle, swine, and small ruminants [26]. That study found high levels of resistance for *Enterococci* species to gentamycin (63.4%), erythromycin (60.4%) and tetracycline (46.8%), while *E. coli* was most resistant to erythromycin (96%), tetracycline (61%) and ampicillin (55%) [26]. Moreover, 60% and 78% of the *Enterococci* and *E. coli* isolates showed multi-drug resistance, respectively [26]. Comparing species, chickens had the highest level of resistance, followed by swine, then cattle, and finally small ruminants [26]. The researchers remarked that antibiotics were frequently used in chicken production, with the drugs—especially erythromycin and tetracycline—being administered through water or feed to the entire flock, while small ruminants were generally not given antibiotics [26].

One 2011 study noted that veterinary drugs were used in a limited way in free-range or organic livestock farming; farmers used herbal remedies and turned to veterinary drugs when those remedies failed [2]. Both free-range and organic farming also used fewer synthetic feed additives [2]. In fact, these similarities between free-range and organic livestock farming led to a common misperception that the two types of production were equivalent

[2]. The researchers of that study maintained, however, that prohibiting veterinary drugs would not be appropriate for livestock farming in the tropics, given the presence of vectors and vector-borne diseases [2].

Veterinary inputs and swine production

A 2011 CGIAR report noted that there was very limited availability of veterinary and extension services for small-holder pig farmers [10]. Parasites and disease, especially helminthes and African Swine Fever, were identified as major challenges by one study population consisting of 135 pig-keeping households in central Uganda [12]. While 96% of the farmers received veterinary services one to three times per month, these services and animal medicines were considered too expensive [12]. A 2014 NGO report based on interviews and focus group discussions with 1,400 pig farmers in 35 villages found poor management, including misuse of veterinary drugs [28]. Another 2014 study on pig production, conducted by ILRI, reported significant problems with fake drugs on the market [11].

Veterinary inputs and poultry production

A 2007 FAO consultancy report on poultry production in Uganda found that poultry drugs, vitamins, minerals, and vaccines were expensive and usually only available in urban areas [7]. A 2007 trade magazine article, however, stated that supply of medicines had improved, and that antimicrobials were used prophylactically when vaccination and hygiene practices were insufficient to prevent disease, as prevention was more cost-effective than treatment by farmers earning small profit margins [9]. The article provided the example of chronic respiratory disease in poultry, which was reported to be costly to treat and have 40% mortality; therefore, antibiotics against all mycoplasma and *E. coli* were added to drinking water, with dosage based on kilogram of body weight [9]. There was one media report that the Ugandan government subsidized poultry drugs and vaccines to help small farmers [29].

We also found one study from 2010, where broiler fecal samples from farms raising at least 100 broilers in central and northern Uganda were tested. Of the 182 *E. coli* isolates obtained, 168 isolates, or 92%, were resistant to at least one antimicrobial, while 108 isolates, or 65%, were resistant to multiple antimicrobials. The drug with the most resistance was ampicillin, which is reportedly often used for both prophylactic and therapeutic purposes in chicken farming. Researchers also stated that

chicken farmers, who are subjected to aggressive marketing by pharmaceutical companies, were increasingly overusing antimicrobials [30].

d) Facilities for housing, slaughtering, and processing

Poultry housing

Our landscape assessment only found brief descriptions about poultry housing infrastructure. For free-range poultry production, structures used for nighttime shelter were described as generally inadequate, as they lacked ventilation, sufficient space, leak-proof roofs, protection from predators, and proper hygiene [8, 31]. In more intensive production, one popular housing system for broilers is the “dip litter system” that confines chickens in houses with coffee husks and/or sawdust-covered floors [30]. Two news sources described new broiler housing facilities built by Hudani Manji Holdings as automated, environmentally regulated, with a superior temperature control system, and having the capacity for up to 40,000 birds [14, 32].

Pig housing

Limited details were found about pig housing facilities. Features of housing vary based on the intensity of production. Extensive small-scale pig farmers use free-range or tethered systems, keeping pigs outdoors on open pastures all of the time [10, 13]. For example, in one study of 96 peri-urban and urban households in northern and eastern Uganda, the majority of households used a tethering system whereby adults and pigs that had been weaned were tied to pegs with ropes, while piglets were let loose [20]. With more intensive production, pigs are housed part or all of the time, and the practice of total confinement is on the rise in Uganda [13]. In a report, the CGIAR global agricultural research consortium promoted the view that total confinement offered greater biosecurity and reduced the risk of diseases like African Swine Fever and porcine cysticercosis by preventing pigs from roaming where there may be infected animals and waste [33].

There was limited information on the characteristics of structures used to house pigs. One 2012 study with 135 farmers in central Uganda found that while nearly all farmers provided some kind of housing for their pigs, most used mud houses; housing materials were a challenge because they were expensive [12]. Another study of intensive pig farming found that in Kampala, almost

half of the 90 sampled pig farms had shelters that met “average” standards, meaning that they were leak-proof, well-ventilated, had moderate hygiene, and there was a concrete or wooden floor above the ground that was cleaned occasionally [34].

Slaughtering and processing facilities

Slaughtering facilities in Uganda include slaughterhouses in and around Kampala, at-the-farm slaughtering, village market slaughtering, town slaughter slabs, and urban slaughterhouses [4]. Slaughtering done at butcheries by the roadside or in market stalls accounts for 75% to 80% of retailed meat, as of 2012 [6]. At the urban slaughterhouses, live animals coming in on foot or by truck may be kept alive two to ten days before slaughtering [4]. The existing slaughterhouses are constrained in terms of capacity and poor hygiene, with existing processing facilities operating at under 50% of their capacity due to a lack of animals [6]. The three main slaughterhouses that serve Kampala—City Abattoir, Ugandan Meat Packers Ltd., and Nsooba Slaughterhouse Ltd. —have a daily throughput of 250-300, 30-100, and 150-200 animals, respectively, but are not considered by the Dutch Embassy to be “modern” slaughterhouses. The Embassy described these three slaughterhouses as being “overstrained” and presenting either a “hygienic risk” or meeting only a “basic hygiene standard” [6, p. 42].

Meat processing is essentially monopolized by one company, Quality/Fresh Cuts, which covers 85% of Kampala’s processed meat market and produces a range of packaged meat products (beef, pork, and poultry) [6]. In 2014, Hudani Manji Holdings made plans to construct and launch a 15,000-square meter poultry slaughterhouse, which would be the country’s first highly mechanized slaughterhouse and the largest chicken processing facility in East Africa, processing 220,000 birds per week [14]. The Dutch Embassy highlighted slaughterhouse processing facilities as an investment opportunity in the beef sector [6].

e) Land use and land acquisitions

Some reports made brief references to land and natural resource use for livestock production. In the areas of Uganda that are considered to be overstocked, researchers recommended intensifying production and possibly resorting to zero-grazing systems, as well as importing feed and fodder from surrounding districts [3]. A 2013 government document also portrayed free-range ex-

tensive production systems as inefficient and a cause of resource management conflicts between ranchers, fishermen, and farmers in the Albertine Rift region [24]. The Ministry of Agriculture warned that increasing livestock numbers would put greater pressure on rangelands and hydrological systems [1]. The reduction of pasturelands was considered to hamper organic livestock development, in addition to normal production, as there would be insufficient organic feed [2].

Factors contributing to understocking in other areas were hypothesized to include being designated as parks or some other protected area, and land tenure regimes that restricted grazing access [3].

We did not find any information about overseas land acquisition by Ugandan enterprises for the purposes of livestock production.

5) Waste management

Our landscape assessment found very few details about waste management practices in livestock production. One study carried out in two districts of Northern Uganda found that about 59% of 121 smallholder chicken farming households put the chicken manure to use (though did not specify how), while the remaining households did not use the chicken waste in any way [25]. In a study of 90 pig farms, a 2015 investigation found that most farms used composting, and that this method still caused pollution; however, not many of the farms identified manure disposal as a challenge [34]. In a 2013 report, the Ugandan Wildlife Society found that cattle manure was being used to fertilize crops and produce biogas in the Albertine Rift region [24]. A 2014 ILRI report only briefly stated that improved manure management was a key area for intervention [11].

6) Transnational corporations

We found reference to one transnational company, Ugachic Poultry Breeders, the largest broiler producer in Uganda, which is Ugandan-German-South African [9]. As of 2007, in addition to producing over a million broilers in Uganda annually, it also made several thousand metric tons of feed, mostly from its own grain [9]. A 2007 FAO report credits Ugachic with heavily investing in the industry and supporting outreach to farmers through animal vaccinations, training, financing, and marketing [7]. In fact, the report attributes major developments in the in-

dustry to efforts by the private sector (including Ugachic and other private farms), rather than the government.

Separately, one annex of the Dutch Embassy's 2012 report on investment opportunities in the Ugandan livestock industry consisted of a list of twelve Dutch companies "interested in livestock in Uganda," among them: Agrifirm Group BV, Cobb Africa, Jansen Poultry Equipment, KI Samen, Merck Animal Health, Plumex, Mueller BV, Teeuwissen, and VION Food Group [6].

7) *Regulation of livestock production*

Our landscape assessment revealed that there have been a few domestic policies and laws that address livestock farming. The 1964 Animal Diseases Act regulates animal disease control in poultry, swine, and cattle, among other animals, specifying the roles of positions like the Commissioner of Veterinary Services, Veterinary Officers, and law enforcement agents [7]. A 2007 FAO report noted that "[t]here have been several efforts to make amendments to the Act to align it with global developments in the livestock industry but this has been slow and this is yet to be done," though provisions of the 1964 Act had allowed the Ministry of Agriculture to take action on the relatively recent HPAI threat [7, p. 35].

The National Veterinary Drug Policy from 2002 controls the supply of veterinary drugs and guides laws on veterinary drugs [11]. According to a 2014 CGIAR report, the 2002 Policy aims to control the supply of veterinary drugs, improve veterinary drug legislation and inspection, and supervise licensing of veterinary drug retailers [11]. However, as of the writing of that report, the Directorate of Animal Resources had not created any mechanism to enforce the regulation of drugs.

A 2012 FAO report noted that a law to improve production, processing, and marketing of meat had recently been enacted as well, though no further details or citations were provided in the report [4]. Even more recently, the President launched the National Agriculture Policy in September 2014, which contains six objectives: food security, increasing farming household income, specialization and value addition through zoning, sustainable agricultural resource use and management, trade in agricultural products, and developing human resources [35]. Among other strategies, the policy calls for intra- and inter-sector coordination, for local governments to enact laws to promote household food security through pro-

duction and storage practices, and for the establishment of a "national strategic food serve system."

However, one criticism of the 2014 Policy raised by a researcher at the Kampala-based Economic Policy Research Centre is that the policy still envisions that the primary source of investment in agriculture will come from the private sector, when the government itself should be providing incentives and lending to farmers who cannot afford inputs [35]. In fact, in this regard an earlier report by the FAO had noted that the "major developments in the [livestock] sector [had] been mainly supported by the private sector" [7, p. 31].

Researchers at CGIAR noted that in terms of specific actions, the government supported the development of commercial livestock production through implementing animal health standards, providing better advisory services, supporting research, and improving disease control, nutrition, genetics, and marketing [11]. The government's National Livestock Productivity Improvement Programme (NALPIP), which received funding from African Development Bank, provided vaccines for cattle and planned livestock censuses to facilitate planning [7, p. 31]. For improving beef cattle production specifically, the Ministry of Agriculture also planned to increase land dedicated to raising cattle [1]. For poultry production, the Ministry planned to streamline production and marketing of poultry and poultry feeds [1]. There have also been government programs, such as the Northern Uganda Social Action Fund, which have tried to provide direct support in the form of day-old chicks, training, and infrastructure to conflict-affected communities; however, FAO visits and interviews with extension workers in the region revealed that these programs "have not been sustainable and have frequently disintegrated after a few cycles" [7, p. 31].

The problem of contaminated animal feeds described above has been a challenge. Although the need for regulation was apparent from the Ministry of Agriculture's own research, as of 2014, legislation to regulate feed and protect against residues affecting human health was still lacking [21]. One 2005 report from the FAO's Pro-Poor Livestock Policy Initiative maintains that the government has had less money to spend on livestock development and other economic development because it was forced to devote resources to addressing an internal armed conflict [36].

Impacts of industrial food animal production

1) *Impacts on worker health*

Our review did not yield any information on worker health in animal production or processing facilities.

2) *Impacts on surrounding communities and others*

We did not find any research on the impacts of livestock production on communities. A 2014 ILRI report on pig farming mentioned that the activity generated animal waste, which could cause nuisances, multiplication of disease agents, and public health problems, and indicated that better manure management was needed [11].

3) *Impacts on natural resources*

We found no research regarding the impacts of livestock production on natural resources, though a statement by the Ministry of Agriculture was identified that recognized that increasing livestock numbers would mean putting more “pressure on rangeland ecosystems and water systems” [1, p. 31]. The 2014 ILRI report cited above also briefly mentioned that pig farming could result in environmental pollution and more greenhouse gas emissions; however, the report pointed out that the relationship between livestock farming, greenhouse gases, and climate change was not well understood in Uganda and required urgent investigation [11].

Public engagement with industrial food animal production

1) *Transparency and access to information*

Our search methodology did not produce any results related to this topic.

2) *Public awareness and attitudes*

Limited information could be gleaned about public awareness and attitudes toward animal agriculture in Uganda; however, consumers concerns about animal health, environmental impacts, and food safety are reportedly increasing [2]. For example, one 2015 study on pig farming stated that there has been growing concern about the pollution resulting from composting animal waste in recent years [34].

Consumers prefer the taste of free-range poultry and eggs over that of commercial broilers and layer eggs,

but the former are more expensive [7]. According to an industry magazine article, local poultry breeds raised extensively have firmer and tastier meat, and are worth three times the price of broilers [9]. Free-range systems in the context of cattle production, however, are viewed as inefficient and a cause of resource management conflicts in the Albertine Rift region, and there is pressure to stop extensive cattle production there [24].

There is also a misperception among Ugandan farmers that free-range livestock production is the same thing as organic production, since there are limited inputs (veterinary drugs and synthetic feed additives) in both systems [2]. Because it is difficult to have sufficient production in organic free-range farming in this setting, some organic poultry farmers now operate semi-intensively [2].

On the topic of food safety, one source mentioned that the public was very concerned about avian flu, due to negative media reports, and even initially boycotted poultry when the disease came closer to Uganda [7]. Consumers are also concerned that pig producers and traders do not have much awareness about pork safety issues [11].

3) *Media interest in IFAP*

The media sources we found were focused on the improved Kuroiler breed for rural poultry production and the challenge of animal feed contamination. Reports on industrialized livestock production were few, and those sources did not critically examine this type of production, only commenting favorably about the technological-ly-advanced nature of the facilities.

4) *NGO or community campaigns, advocacy, and other efforts targeting IFAP*

Our landscape assessment produced almost no information about campaigns or organizations working on industrial livestock production. There was only one news article, which discussed a campaign launched by a group of pastoralists to preserve indigenous cattle breeds [37]. The pastoralists also argued that pastoralism did not cause environmental degradation and that antibiotics and other chemicals used for exotic breeds and crossbreeds might have contributed to diseases [37].

Apart from industrial livestock production, a 2007 FAO report noted that some non-governmental entities, including churches in the Teso region and the UK-based

charity, Send a Cow, have attempted to support vulnerable communities through poultry programs providing animals and training [7].

5) *Description of other civil society actors engaged in IFAP*

In addition to the government, individual researchers and entities like the Dutch Embassy have also promoted industrialized livestock production in Uganda. The Dutch Embassy, for example, has recommended investments in commercial poultry farms, commercial ranches, and feedlots [6]. We note that in promoting intensification, researchers focus on the outcome of greater productivity or profits, and do not discuss the environmental, public health, or animal welfare impacts of this production model [5, 31].

Others have promoted developing livestock production without explicitly supporting industrializing or commercializing the sector. For example, the initiative to introduce Kuroiler chickens in Uganda, undertaken by Arizona State University's Biodesign Institute, the Bill & Melinda Gates Foundation, ILRI, and Uganda's National Animal Genetic Resource Centre and Databank, among others, seeks to make poultry production more viable for rural, small-scale poultry farmers [19].

There is also a multi-phase, multimillion dollar East Africa Dairy Development (EADD) program, funded by the Bill & Melinda Gates Foundation, which helped revitalize/establish 39 dairy farmer cooperatives and associations in Uganda [6]. The program, currently in its second phase, aims to increase milk yields and small-scale farmers' incomes by connecting small-scale farmers with institutions and services.⁴ Spearheaded by US-based Heifer International, its implementing partners include the World Agroforestry Centre, ILRI, TechnoServe, and African Breeders Services, and the US-based corporate partner Elanco Animal Health.

4. See Heifer International—East Africa Dairy Development, available at <http://www.heifer.org/eadd/index.html>, last visited Feb. 21, 2016.

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Vietnam



Overview

Meat production in Vietnam has grown substantially in recent years, particularly in the poultry and pig sectors, propelled by government strategies to restructure, industrialize, and intensify production. Although there are still many small farms, the presence of large-scale commercial enterprises, multinational agribusinesses, and integrators has also been noted. Within the Southeast Asia region, changes to livestock production have been most evident in Vietnam's Red River Delta. Urbanization, increasing consumer purchasing power, changing food habits and preferences, and trade liberalization continue to drive forward this transformation [1].

Food and Agriculture Organization of the United Nations (FAO) statistics on food animal production

Vietnam had a total of 22,697,760 animal units (AUs) in 2013, resulting in an overall livestock density of 2.09 AU per hectare (ha) of agricultural area. The numbers of live animals raised in 2013 were 26,264,408 pigs, 234,509,000 chickens, and 5,156,727 cattle. FAO 2011 estimates of livestock densities, by specific animal class, were 2.50 pigs per ha, 29.75 poultry birds per ha, and 0.75 cattle and buffalo per ha.

In 2012, production was 3,160,048 tonnes of pork, 525,961 tonnes of chicken, 293,969 tonnes of cattle meat, and 381,700 tonnes of cow's milk. From 2002 to 2012, pork, chicken, cattle meat, and cow's milk production increased by 91%, 55%, 187%, and 387%, respectively. The five-year period of 2007 to 2012 saw increases of 19%, 47%, 43%, and 63% for pork, chicken, cattle meat, and cow's milk, respectively.

Production, imports, exports, and net balance by livestock product

	Production (mt)			Imports (mt)	Exports (mt)	Net (mt)
	2002	2007	2012	2012	2012	2012
Pig meat	1,653,595	2,662,700	3,160,048	n.d.	9,963	n.d.
Chicken meat	338,402	358,800	525,961	515,697	476	1,041,182
Cattle meat	102,454	206,145	293,969	n.d.	0	580,170
Milk, whole fresh cow	78,453	234,438	381,700	7,400	760	388,340

Industry characteristics

1) Scale

In a country with traditionally small farms and landholdings, expanding the scale of intensive animal production has been identified as a government priority [2]. According to the 2006 agricultural census, 69% of landholdings in Vietnam consisted of less than half a hectare of land, while 94% were less than two hectares of land [3]. Most households raised livestock (80% of households had chickens, 65% kept pigs, and 28% had cattle), but the number of animals kept was small; 70% of cattle-possessing households had only one or two cattle, 57% of pig-owning households had one or two pigs, and about two-thirds of chicken-raising households had fewer than 20 birds [3].

The government's National Strategy for Livestock Development was promulgated in 2008, and this policy has promoted a shift toward commercial and industrialized production models [2]. The goal is to have large-scale and intensive farms account for 70% of meat production by 2020, with scale increases made possible through favorable land, credit, tariff, and other policies [2]. As will be described in greater detail below, medium- and large-scale animal production are already observed in certain geographic areas.

Scale of cattle production

Compared to swine and poultry production, fewer sources indicated an expansion of cattle production in Vietnam. According to a Canadian government consultancy report, beef cattle farming occurs mostly in the northern region of Vietnam [4]. There are three types of cattle farming systems: extensive calf-cow systems, where predominantly indigenous breeds are grazed on open pastures but housed in pens overnight; intensive calf-cow systems, where cattle graze openly for a few hours every day; and cattle-fattening systems, which are undertaken at both large and small scales [4]. Feeding practices,

as described in the section on inputs, also vary between these production systems. A site-specific study based in one province of northwestern Vietnam surveyed 73 beef-producing farms in 2007 and found three types of farms: small farms, averaging two to four cattle, which were raised free-range, used mostly for farm work (i.e., draught) and manure, and then later sold for beef when unsuitable for draught; medium farms, averaging nine heads per farm, raised free-range on communal pastures for feeding; and large farms, with around 100 to 650 heads, which were raised and fed in stalls [5].

A 2005 FAO report noted that semi-intensive and intensive dairy, but not beef, production was growing quickly [6], while the 2020 livestock development strategy aims to have 13 million cows by 2020, half of which will be dairy cows [7]. One 2013 study noted that although there has been growing domestic demand for cattle, production is constrained by limited feed, animal disease, low growth rates, and poor husbandry methods [8]. Among the sample of 180 cattle-producing households surveyed in three provinces in South Central Coastal Vietnam, the biggest reported obstacle to productivity was a lack of capital [8]. Similarly, the study of 73 farms in northwestern Vietnam mentioned above also found that, although the large farms received significant government subsidies when they were first established, they faced feed shortages afterwards and had difficulties accessing markets [5]. On the other hand, the medium-scale farms actually showed greater potential in that region because they could use underutilized pastures for fodder [5].

Scale of poultry production

Poultry production in Vietnam is well developed and found all over the country, however much production is concentrated in urban areas and the Red River and Mekong River deltas [9-11]. As described in a 2008 report by the FAO, the International Food Policy Research Institute (IFPRI), the International Livestock Research Institute (ILRI), and other institutional collaborators, there are three systems of production: (1) traditional, small-

scale extensive backyard production, with flocks up to 50 birds raised on free-range scavenging; (2) semi-intensive, commercial small- to medium-scale production, a type of production that took off in the late 1990s, raising flocks between 51 and 2,000 and producing meat birds in cycles of 70 to 90 days; and (3) intensive, large-scale industrial chicken production, “modelled [sic] after modern industrial poultry systems found in OECD countries,” with birds raised indoors and broilers produced in cycles of about six weeks [10].

Industrial production is mostly located in the Red River Delta, North-South Region, Mekong River Delta, and South Central Coastal Region of Vietnam [9]. It developed in the late 1990s, promoted by large-scale foreign direct investment and structural policies [10]. The 2008 FAO report recounted that these unnamed “[m]ultinational agro-food conglomerates expanded their networks through contract farming with more established local agricultural interests” [10, p. 9]. By 2006, there were officially 2,837 intensive poultry farms (those with over 2,000 birds), of which 69% were broiler chicken farms, 8% were breeding farms, and 24% raised ducks [9, 12]. Among industrial chicken farms, 93.5% had 2,000 to 11,000 birds; 3.4% had 11,000 to 15,000 birds; and 3.1% had over 15,000 birds [12]. Most industrial poultry operations—about 70%—raised between 2,000 and 5,000 birds at a time [9].

As of the mid-2000s, over 90% of poultry farms were traditional, small-scale operations, and these farms produced most of the poultry in Vietnam [9, 10]. Semi-intensive farms accounted for around a quarter of chickens produced, while intensive farms using automated equipment to raise flocks from 8,000 to 15,000 or more accounted for 10% of chicken production [9].

The largest farms tend to be joint ventures or wholly foreign-owned enterprises [13]. Multinational food companies may use contract farming with larger domestic farms, which raise 2,000 to 100,000 birds, and the largest operators may hire 15 to 20 workers [10]. For example, one 2010 study of a sample of 270 chicken farms in suburban areas of Hanoi found that the most intensive farms were contract farms raising on average 18,227 broilers per year, with cycles of approximately 42 days [14].

The Ministry of Agriculture’s livestock development strategy (for 2020), created in 2008, is to reach 252 million chickens in 2015 and 306 million chickens by 2020

[7]. However, scaling up poultry farming is challenging because of large fluctuations in prices of inputs and outputs, as well as epidemic diseases, and small-scale traditional systems remain prevalent [14]. These free-range systems are described as suffering from inadequate management and high mortality [15]. A report by the FAO’s Pro-Poor Livestock Policy Initiative (PPLPI) points out that chickens raised intensively in South Asia and the Mekong region perform better than their traditionally raised counterparts, as reflected by indicators such as age when chickens start laying eggs, live weights, and mortality risk [16].

Scale of pig production

Pig production in Vietnam has expanded over the past several decades, and continued expansion is one of the government’s key goals. In 2008, the Ministry of Agriculture’s livestock development strategy anticipated growing the country’s pig herd to 33 million by 2015 and 35 million by 2020; in terms of output, it hoped to reach 3.9 million metric tons of pork in 2015 and 5 million metric tons by 2020 [7]. Larger farms figure prominently into this plan.

A 2011 report by the Australian Centre for International Agricultural Research (ACIAR) provides the following typology of pig production scales in Vietnam: (1) small-scale, non-commercial production, with one to two sows and less than 20 fattening pigs, accounting for 70% of pig farms; (2) small-scale commercial production, with five to 20 sows or fewer than 100 fattening pigs, corresponding to 15% of pig farms; (3) large-scale commercial production with 600 to 2,400 sows or 500 to 10,000 fattening pigs, accounting for 13% of pig farms; and (4) farms that are part of co-ops or collectives, raising 20 to 50 sows or 100 to 200 fattening pigs, amounting to 2% of farms [2]. A 2011 Canadian government consultancy report adds another type of farm, medium-scale commercial farms, with 20 to 500 sows, and reports that 15% of the country’s sows are raised at this scale [4].

Intensification and scaling up are reflected in the declining numbers of the smallest farms: 80% of pigs in 1999 were raised on farms with up to ten pigs in total, but this percentage fell to 64% by 2006 [17]. In 2001, 67% of Vietnamese households had two pigs or fewer, while 0.3% had more than 20 pigs, and these percentages shifted to 56% and 2%, respectively, in 2006 [18]. During that same five-year period, the number of households raising pigs fell by one million, but the number of households

raising six to 20 pigs increased, as did the number raising more than 20 pigs [19]. These statistics reflect an expansion in scale of production, though not a dramatic one, since pork production is still dominated by small farms [18]. Although intensification has increased, especially from 2003 onwards [20], as of 2011, half of pig producers still kept only one or two pigs [7]. The FAO reported that around 2009, 7.9 million small household farms were raising pigs, typically on a small scale, producing about ten pigs per year [21].

Intensification, a trend viewed favorably and advocated by the government, varies based on region. Areas near major cities are the most intensified and market-dependent [18]. The three regions with the most concentrated pig production are the Red River Delta, the Northeast, and the Mekong River Delta, with the Red River Delta home to 7.1 million pigs at a density of 909 pigs per square kilometer of agricultural land [7]. In the southern provinces, producers tend to have larger farms and full-cycle systems, while in the northern provinces, full-cycle systems are less common [22]. Regional diversity is also reflected in pork yields. For example, there is a three-fold difference in pork yields between the Mekong River Delta in the south and the North West region: 123 kg per pig versus 39 kg per pig in 2006 [23].

Intensive production is undertaken by private farms, state-owned enterprises, and foreign-owned businesses, and although private firms originally settled in the south of Vietnam, they have also developed their presence in the north [24]. The government has promoted larger production units, such as joint stock companies, and foreign investment in an attempt to modernize and industrialize pig production [25]. A 2011 FAO report noted the presence of large farms established by Charoen Pokphand Group of Thailand and Vietnam-based DABACO, among others, which had 600 to 1,200 sows and as many as 2,400 sows [21]. Pig contract farming, which will be described in greater detail below, has also developed since 2000, and typical contract growers raise 1,000 to 10,000 pigs and 600 to 2,400 sows on large, intensive livestock farms [21]. In between small farms and large farms, there are also some co-op pig farms. Though they still do not produce nearly as many pigs as the industrial enterprises just described, they are nevertheless efficient at supplying the market with large volumes of pigs with uniform quality [21].

From the literature, there appears to be some discussion whether the scale of production will continue to increase at the same pace and whether the decline of smaller units of production should be taken for granted. The government aims for industrial-type production to account for 37% of production by 2020 [2] and for Vietnam to be not only self-sufficient in producing pork, but also an exporter [26]. However, while the number of pigs increased between 1990 and 2012, the growth rate is declining [7], and the rate from 2011 to 2015 was less than anticipated [27]. According to one media source, reasons behind the shortfall included animal diseases, low market pig prices, farmers leaving the market or reducing their stocks, and shortage of credit from banks [27]. The source also cited the fact that most production was still in the hands of small, less efficient farmers [27].

In fact, it remains an open question whether small or large pig farms perform better, and whether smallholders would benefit from increasing the number of pigs they raise. A PPLPI paper notes that in the Mekong region, intensive systems perform better than traditional systems, as shown by indicators such as shorter rearing periods, higher number of litters per sow, and heavier fattened pigs [16]. However, other studies have concluded that households may not necessarily benefit from higher returns by raising a greater number of pigs due to costs associated with inputs (e.g., feed). For example, one 2010 study based on an ACIAR-funded project found that bringing in more profits per unit of output due to increasing scale of production depended on the stage of production (e.g., farrow-to-wean versus farrow-to-finish) [28]. Household farms that maintained smaller scales of production could be competitive because they could produce their own feed and rely on family labor¹ [28]. Households with more pigs tend to use less (proportionally) of their own produce and local produce [23]. The author noted that there was little evidence supporting the idea that larger scales of production would actually be cost-effective [28].

Similarly, a different 2010 study based on ACIAR project data found, after surveying 700 pig producers across six

1. One of the reasons why there is no costing of family labor in studies that analyze the competitiveness of small versus large farms is that it is difficult to put a value on family labor, since family members might not have employment alternatives or might be able to raise pigs while doing other jobs. See Nga NTD, Ninh HN, Hung PV, Lapar ML. Smallholder pig value chain development in Vietnam: Situation analysis and trends. CGIAR, ICARDA, ILRI, CIAT, Worldfish, 2014.

provinces, that some stages of production (e.g., raising piglets) would benefit from increasing pig herds from one sow to two or three sows, whereas increasing pigs raised in fattening or full-cycle systems would not lead to higher returns [29]. These authors also cautioned against assuming that increasing scales would lead to greater efficiency [29]. They recommended that instead of promoting larger herd sizes, ways to reduce the cost of production should be explored [22]. Although their study was based on comparisons of economies of scale *within* smallholder systems (and namely did not compare large-scale intensive to smallholder extensive production), the authors predicted that “the modern-large-scale sector [would be] too small to threaten [the] traditional small-scale sector for at least 10 years” [22, p. 18]. A 2014 CGIAR report concurred with this prediction, adding that modeling studies have shown that large-scale commercial pig farms would increase, but would not dominate production within the next decade; rather, small- and medium-sized farms would dominate, even in a policy environment favoring commercial farms [7].

In addition to the ability of small household farms to use family labor and homemade feed, characteristics related to Vietnam’s status as a transitional economy could also contribute to the survival of small farms [23]. For example, there are restrictions on the transfer of property rights and increasing farm sizes that inhibit scaling up [19, 23]. The scarcity of supermarkets has also helped pig smallholders remain competitive, since supermarkets favor standardized products and source from large producers [23]. As one researcher has noted, “[t]here is little available evidence that larger scale production units for livestock in Vietnam will substantially lower its average cost of livestock production given the current stage of its economic transition” [23, p. 13].

2) *Industry consolidation or concentration*

We did not find information about the market shares held by large agribusinesses in the pig or poultry sectors. As described above, some data indicate that swine production has become concentrated into fewer and larger farms. Concentration has been promoted at both the national level and within certain provinces [30]. However, there were still 7.9 million pig-producing households in 2011 [21].

Concentration has also been noted in the animal feed sector. One news article reported that Masan Group, which

became the second largest animal feed producer in Vietnam after acquiring stakes in Vietnam French Cattle Feed (Proconco) and Agro Nutrition Company, seeks to attain 50% of the country’s feed market by 2020 [31].

3) *Vertical integration*

Within the framework of the 2020 strategy for livestock development, vertical integration and the participation of large-scale traders are promoted through favorable land, credit, tariff, and other policies, so that production, slaughtering, and processing can operate at industrial scales [2]. Contract farming has also become prevalent in both the swine and poultry sectors, motivating studies on its efficiency, effectiveness, and impact on small farmers. A multi-country study conducted as part of the PPLPI, which included India, Thailand, the Philippines, and Vietnam, found that farmers with contracts were usually more efficient than independent farmers in terms of using new technologies, accessing markets to achieve cheaper inputs or higher product prices, and obtaining higher net income per unit product; however, this was not always the case [32]. At the same time, formal contracts tended to exclude small farms and favor large-scale farms, while informal contracts with cooperatives and traders were more flexible in accommodating farms of all sizes [32]. These results and other studies on vertical integration and contract farming will be described in greater detail below, distinguished by the type of livestock produced.

Integration in the poultry sector

There are two types of contract farming in the region: formal integrator-farmer contracts, which tend to be fixed fee or wage contracts, and unwritten informal contracts between farmers and an intermediary for either inputs or outputs [32]. For broiler production in Vietnam, formal contracts are much more common than informal contracts [32]. Contracted farms raise over 10,000 birds per cycle, receiving day-old chicks and formula mixed feeds from the few large broiler integrators, which control the supply of those inputs in the country [32]. Some of these large integrators are multinational food companies [10]. For example, foreign feed companies like CP Group, Japfa, Cargill, and Proconco serve as integrators, importing grandparent flocks to produce parents, and then supplying day-old chicks or pullets to contract farms [12].

There are also other types of vertical coordination and looser forms of integration. There is a spectrum of integration ranging from spot market/open markets (called

simple vertical integration) to full vertical integration with an integrator firm [33]. For example, a 2011 study examined 62 chicken farming households in Bac Giang province to see how rapid expansion of production had led to integration of actors in the value chain [33]. The local government had implemented programs in 2007 and 2008 for chicken breeding and sustainable development of chicken production, and these efforts partly contributed to the rapid increase of chicken production in the area. The study found that there had been integration, but not a very formalized type. Rather, households organized themselves into groups called chicken farming groups, and used mostly verbal contracts [33]. These groups consisted of seven to 15 members, charged a membership fee, obtained inputs, marketed outputs, and exchanged information [33]. Buying as a group, they were able to negotiate lower feed prices and chick prices, as well as higher selling prices for products [33]. All farmers desired having regular buyers, and 75% of those affiliated with chicken farming groups managed this, while only 18% of independent farmers were able to do so [33]. At the time of the study, there were no large firms engaging in poultry contract farming in the study area, but there were 15 firms that provided concentrated feed on credit through feed agents to chicken growers [33].

Comparing independent farmers to farmers in chicken farming groups, the latter tended to have more production, higher education, and more experience [33]. Although most respondents received advice about feeding, prevention of disease, and management, farmers in the chicken farming groups had more permanent contacts with input and service providers, so they also tended to have improved management practices (e.g., improved barn hygiene and more vaccinations) [33]. Nevertheless, most respondents reported that quality of medicines and veterinary services was poor, and even farmers in chicken farming groups reported that feed quality was a challenge [33].

Integration in the swine sector

Contract farming for industrial pig production has increased in Vietnam since 2000 [21]. One mode of contracting involves formal contracts with large-scale hog farms producing over 100 pigs per cycle [34]. A 2009 PPLPI report stated that formal contracts were uncommon but increasing, and that most formal pig production

contracts were of the fixed fee type [32].² Integrated operations in Vietnam are run by large domestic and multinational agribusinesses, such as Thailand's CP, Indonesia's Japfa Comfeed, Philippines' San Miguel Purefoods, and Vietnam-based DABACO group [4, 7]. These feed and food companies contract farmers who run farrow-to-wean or grow-to-finish operations, supplying them with inputs (piglets and feed) and veterinary services [7]. A study based in northern Vietnam found that some of the reported benefits of formal contracts included better access to inputs and services, financing, markets for outputs, information about technology, recognition of quality of their products, and reduced transaction costs [35]. However, a key barrier for entering into formal contracts was scale—integrators only contracted with producers of a certain scale, as it was easier for them to monitor a smaller number of larger farms [35]. Low education and non-specialization in pigs have also been cited as barriers to participating in formal pig farming contracts [32, 34].

Unlike the broiler sector, where the sources of day-old chicks and formula mixed feeds are controlled by a few large integrators, the swine sector has alternative sources of feed, feed ingredients, commercial breeding, and pig fattening stocks [32]. Thus, some industrial hog production also takes the form of informal contracts between pig farmers and cooperatives, or between pig farmers and input/output traders [32]. Compared to formal contracts, informal contracts are more flexible and provide a way to engage smaller-scale producers, at least to some extent [34, 35]. Pigs are still produced using industrialized methods, and the informal contracts somewhat resemble profit-sharing contracts [32].³ Smaller-scale producers generally have contracts with traders, while larger-scale producers generally work through coopera-

2. In fixed-fee contracts, integrators provide inputs and stipulate input-output ratios and quality specifications, while farmers are paid a fee for their labor and facilities. The amount farmers receive is based on their feed conversion ratios and mortality rates. Thus, integrators assume market risks, but production risks are assumed by both integrators and producers. See Catelo MAO, Costales AC. Contract farming and other market institutions as mechanisms for integrating smallholder livestock producers in the growth and development of the livestock sector in developing countries. Pro-Poor Livestock Policy Initiative, 2008; Tiongco M, Catelo MAO, Lapar ML. Contract farming of swine in Southeast Asia as a response to changing market demand for quality and safety in pork. International Food Policy Research Institute, 2008.

3. In profit-sharing contracts, farmers are not always guaranteed marketing of output. Integrators provide inputs on credit, and then charge these costs when the farmer sells the output. See Catelo MAO, Costales AC. Contract farming and other market institutions as mechanisms for integrating smallholder livestock producers in the growth and development of the livestock sector in developing countries. Pro-Poor Livestock Policy Initiative, 2008.

tives [34]. Members of cooperatives also tend to be more specialized in pig production, have higher levels of education, have more experience, and are located farther from markets [34]. Serving as horizontal networks, cooperatives can allow member farms to enjoy some economies of scale [36]. They may also protect farmers by serving as a “market of last resort” when market conditions are not good [35].

According to a 2011 FAO report, contract farms account for about 10% of the total number of pigs and 20% of total pork production in the country [21]. Pig value chains are more complex and longer in the lowland areas compared to upland areas [7, 37]. Some sources indicate that contract pig farming is on the rise [21, 32], while others point out that the pig value chain still lacks strong vertical and horizontal linkages [7], and criticize the expansion of state-owned enterprises and private commercial farms for not being very coordinated or integrated [25].⁴ The abundance of small pig producers makes sourcing from them an endeavor with high transaction costs [25]. For farmers who want to participate as contract farmers, there are substantial initial costs of investment, and the government is trying to encourage intensive farming by providing access to land and loans [21]. Monitoring the extent of integration in the sector is difficult, however, as a recent CGIAR report emphasizes the problem that there are no updated statistics on the number of contract pig farms in Vietnam [7].⁵

Another research gap highlighted by the PPLPI is that there is no conclusive evidence on whether contract farming is more holistically beneficial for the producer, not just in terms of whether the producer has been able to increase livestock output [34]. This is important, as many farmers engage in mixed livestock-crop produc-

tion [34]. The PPLPI found a study in Vietnam on informal contracting, which suggested that although informal contracts helped increase income from pig production, they did not increase overall household income [34].

Additional complexities related to contract farming have been highlighted by a study undertaken jointly by the PPLPI, ILRI, and IFPRI, among others. Surveying a randomly selected sample of 400 smallholder pig farmers across four provinces in northern Vietnam, the study found that pig contract growers perceived formal contract terms to be inequitable and biased toward the integrators; nevertheless, producers still wanted to engage in contracting, but with more favorable terms [32, 34]. In addition, after comparing farmers who had informal contracts with cooperatives to farmers who operated independently, the researchers found that cooperative members had higher returns for some of their activities (production of crossbreeds in farrow-to-weaning and grow-to-finish systems), but independent farmers had higher returns for activities that entailed longer production cycles (farrow-to-finish) [35]. From the perspective of the integrators, one reported challenge entailed the diversion of inputs, such as feed, by contract farmers to use in their own businesses or to sell to others [38].

4) *Inputs*

a) *Breeding stock*

According to a 2011 Canadian government consultancy report, official government reports indicate that many breeding animals for various types of livestock are being imported into Vietnam [4]. The extent to which imported breeds are used in production depends on the scale and intensity of production, as will be described for each type of livestock below.

Poultry breeds

As discussed earlier, there are three types of production: traditional extensive household/backyard production; semi-intensive commercial production on medium or small scales; and intensive, industrial large-scale production [9]. In traditional systems, indigenous breeds with low productivity are used [9]. One 2014 study found that breeding in a sample of 363 indigenous chicken farms was uncontrolled [15]. For semi-intensive poultry production, either exotic breeds or exotic-local crossbreeds are used [9]. In intensive, industrial-scale poultry production, mostly imported breeds are used, with a typical broiler produced in a six-week cycle and weighing 2.2 to

4. For example, a 2008 survey of 1,051 randomly selected households in six provinces—Ha Tay in the Red River Delta, Phu Tho in the Northern Uplands, Nghe An in the Northern Central Coast, Dak Lak in the Central Highlands, Dong Nai in the Southeast Coast, and Tien Giang in the Mekong River Delta—documented a lack of large integrators in those provinces. See Lapar ML, Toan NN, Staal SJ, Minot N, Tisdell C, Que NN, et al. Smallholder competitiveness: insights from household pig production systems in Vietnam. International Livestock Research Institute, 2012.

5. Some survey data from northern Vietnam hinted at a significant increase in contract pig farming, as there were 34 pig farms at the end of 2005 formally contracted with Thailand-based CP and Indonesia's Japfa Comfeed (see Tiongco M, Catelo MAO, Lapar ML. Contract farming of swine in Southeast Asia as a response to changing market demand for quality and safety in pork. International Food Policy Research Institute, 2008.), and by 2011, CP alone had more than 230 pig contract growers in the region. See Nga NTD, Ninh HN, Hung PV, Lapar ML. Smallholder pig value chain development in Vietnam: Situation analysis and trends. CGIAR, ICARDA, ILRI, CIAT, Worldfish, 2014.

2.4 kg when finished [10]. A few foreign poultry companies own private breeding farms in Vietnam [12]. As of 2008, there were four fully integrated foreign companies that imported grandparent flocks to produce parents, which they used to produce day-old-chicks and pullets for contracted farms [12].

Cattle breeds

Cattle production in Vietnam is challenged by the lack of good quality breeds, breeding skill, and artificial insemination technology [13]. In extensive calf-cow production systems most breeds are local, while in intensive calf-cow production systems some improved breeds are used [4]. One study using a non-random sample of 88 cattle-owning households in three provinces in the South Central Coast found that the percentage of crossbreeds used was about 50% in two provinces and 33% in the third province [8].

Pig breeds

A 2009 review of the pig sector based on official statistics found that local-exotic crossbreeds made up more than 90% of pig stocks [20]. In 2011, the most popular crossbreed combination consisted of local Mong Cai pigs crossed with an exotic breed, used even in smallholder pig farming, while purely exotic breeds accounted for only 13% of the total sow herd in Vietnam [2]. While local breeds, such as the Mong Cai and Ban, remain popular, they have been criticized for having lower performance, feed efficiency, and percentage of lean meat [7]. A finished exotic breed pig weighs 80 to 130 kg, whereas an indigenous pig weighs 10 to 40 kg [7]. On the other hand, the disadvantages of exotic breeds have also been highlighted in the literature. For example, a study based on interviews conducted in 2006-2007 with pig farmers and breeders in Son La province found that small farmers did not purchase stock from large breeding firms or public institutions because the exotic sows sold were considered maladapted; they preferred to use local Mong Cai and Ban breeds, which had higher disease tolerance and could consume a variety of feeds [30].

Slow uptake of improved breeds has been cited as one reason why pig performance in Vietnam lags behind that of developed countries [17]. A 2008 source noted that uptake of improved breeds was found mostly among medium and large pig farms, while small pig farmers continued to use local breeds and unbalanced feeds, consequently suffering from lower productivity and producing fatter meat [17]. A 2008 survey of 1,051 randomly se-

lected households in six provinces, 700 of which were pig producers, found that in the south, where there were larger and wealthier producers, there was greater use of improved breeds [22]. Most pigs in the sample were crossbreeds, and only 10% of the households kept pure exotic breeds, usually in larger herds [29].

Some researchers have pointed out that more vertical integration would enable farmers to participate in organized breeding schemes, and crossbreeding schemes would benefit from being linked to marketing channels and supply chains [36]. One study, based on interviews conducted in 2004-2005 and secondary data, examined the degree to which policies and subsidies had favored substituting local breeds for imported ones [24]. It found that there were about 25 pig breeds in Vietnam, 15 local and 10 imported, and that subsidies for imported breeds were substantial, consisting of direct subsidies for breeding farms or subsidized prices for commercial farms' purchase of breeding stock from state breeding farms [24].

An ACIAR project introduced Australian breeds into Vietnam to compare their productivity with Vietnamese breeds, to evaluate Australian-Vietnamese cross-breeds, and to see how adaptive they were to local conditions (namely a tropical climate) [17]. The project also studied the nutrient requirements of pigs, comparing cross-breeds and exotic breeds, and used nutrition research to change the energy content of feed for fattening and finishing pigs [17]. Results reported for the project's impact included leaner pork, better feed-conversion ratios, and reduction in sows needed to produce a given annual stock [17]. At the end of the ACIAR project, the Australian Agency for International Development helped establish five artificial insemination centers across Vietnam to scale up the ACIAR project [17].

Some researchers and NGOs have warned against promoting imported breeds without regard for conserving local breeds, however. The FAO stated that 13 out of 15 local pig breeds were in danger of extinction in 2003 [24]. In 2014, the CGIAR research consortium reported that there has been no strategy for conserving animal genetic resources over the past several decades, so many indigenous breeds have become extinct following the introduction of exotic breeds and others are declining rapidly [7]. The government is only now starting to pay more attention to that issue [7], with efforts like the National Programme on Conservation of Vietnamese Animal Genetic Resources [39].

An even more critical NGO source maintained that the use of hybrid breeds could be seen as a “tool for market development and domination” because positive traits were not maintained in the next generation, forcing farmers to buy new breeding stock every time [39, p. 21]. Accordingly, this situation fuels the “unprecedented concentration, and dependence upon, the livestock breeding industry” [39, p. 58].

b) Feed

Depending on the type of production, livestock feeding can consist of leftover scraps/residues, manufactured compound feed, or a combination of both [7]. As of 2011, 45% of animal feed was industrially produced, and there were 224 feed factories, half of which were located in the Red River Delta [2]. Industrial feed production is concentrated in the Red River Delta and Mekong River Delta as well as the Southeast region, where livestock and fish production are based [7]. The government’s National Strategy for Livestock Development promulgated in 2008 expects industrial feed to account for 70% of total livestock feed by 2020 [2].

However, feed prices are higher in Vietnam compared to surrounding countries because domestic feed producers and the market for feed are not well organized [7]. There is a dependence on imports, and trade policies are not effective or transparent [7]. Although the cultivation of crops used for livestock feed, such as maize, paddy, soybean, and cassava, has increased as part of the government’s livestock development strategy, the country relies heavily on feed crop imports, and balancing soil conservation with the goal of feed self-sufficiency has been a challenge [7]. In 2011, significant proportions of different feed components were imported: 25% to 30% of rich energy materials, 70% to 75% rich protein materials, and 95% of minerals/vitamins raw materials [2]. A 2014 news source reported that Vietnam was projected to spend 4.5 billion USD on imports of animal feed materials, consisting mostly of corn and soybean, that year—a new high and an increase of \$600 million USD from the previous year [40]. A challenge for producing feed for Vietnam is that there are diverse types of farming systems, so feed products have to perform well across these systems [41].

Against this backdrop, foreign feed companies have stepped in and acquired a dominant role in providing feed to Vietnamese livestock producers. In 2010, 42 out of the 225 registered livestock feed mills were foreign-owned

[7]. Currently, a quarter of the 200 feed companies operating in the country are foreign companies [42]. Yet, as reported by the Vietnamese Feed Association, these companies accounted for 65% to 70% of the 17 million tons of animal feed produced domestically in 2013 [42].

The CGIAR research consortium describes foreign companies, such as US-based Cargill and Thailand-based CP, as being more competitive and using more modern technology, including premix technology, compared to domestic companies [7]. Cargill, operating in Vietnam since 1995, had seven feed factories supplying 750,000 tons of feed annually as of 2014, while CP, operating since 1993, had ten feed factories, and also supplied seeds and livestock breeds [7]. De Heus, a Dutch feed company, was reported to be constructing a new plant in the Mekong Delta that same year and investing in a new port facility to enhance delivery of its output; its six existing factories already had an annual output of 850,000 metric tons [43]. Austria-based Biomin is one of the top three premix producers in Vietnam and the only one with operations in both the north and south as of 2013 [44]. Its second premix facility, opened in 2013, was fully automated with solar panels, energy conservation technology, and a capacity to produce 60 metric tons of premix daily, allowing the company not only to produce for Vietnam but also to export premix to other countries in the region [44]. The system is also reportedly capable of identifying pesticides and antibiotic residues in raw ingredients, furthering Biomin’s efforts to sell itself as an environmentally friendly producer [44].

Cattle feeding practices

Cattle feeding practices vary based on type of production. In extensive calf-cow systems, animals are allowed to graze openly during the daytime [4]. In intensive calf-cow systems, animals may be allowed to graze for a few hours every day, but feeding is based on cultivated grass and some concentrates [4].⁶ In cattle fattening systems, cows are penned the entire time and stall-fed [4]. Stall-feeding has increased as a practice, especially with IFAD and the Asian Development Bank (ADB) implementing various projects from 2000 to 2010 to promote livestock farming through fodder production [45].

6. Concentrates are high-energy ingredients that include fats, cereal grains, high-protein oil meals/cakes, and agro-industrial byproducts (such as those resulting from sugarcane, animal, and fish processing). They are distinguished from roughages, which include pasture grasses, hay, silage, and straw.

One study has examined the adoption of fodder production by mixed farms at a rural site in the Daklak province, using surveys in 2007 and 2010 and market studies in 2004 and 2008 [45]. The researchers found that over the course of a decade, the introduction of farm-grown fodder production—stimulated by programs funded by IFAD and ADB and implemented by ILRI and the International Center for Tropical Agriculture, among others—had motivated farmers to engage in cattle-fattening and transition to stall-feeding systems [45]. In 2003, there were only three farms experimenting with cattle fattening, and by 2010, there were 525 farms fattening cattle and all used fodder grown on the farm [45]. In 2010, there were 3,000 small farms in the study area using farm-grown forages, consisting mostly of grasses and stall-feeding, and they committed, on average, 10% of their farmland to growing those crops [45]. Respondents' adoption of the practice of growing fodder on the farm was attributed to improved body condition of the cattle and labor savings; moreover, forage productivity was reported as high because almost all farmers used manure from cattle and small amounts of inorganic fertilizers (e.g., nitrogen fertilizer) on the forage crops [45]. The researchers also found that farmers who had specialized in cattle-fattening sold to larger traders, and by 2010 some of the farmers' groups that had been promoted by the district extension offices had signed contracts as a group with larger traders [45].

Other site-specific studies, which have sought to characterize cattle production systems more generally, have found that feed is still a constraint on production. A 2013 study characterizing cattle farming among 180 households in three provinces of the South Central Coast found there were three types of production systems—grazing, grazing with supplementation, and stall-feeding using rice straw, crop residues, concentrates, and grass [8]. Stall-feeding was undertaken by 40% of households in two of the provinces, and only 6% in the other; limited feed had constrained production, notwithstanding the domestic increase in demand for cattle [8]. Another study based on a sample of 73 farms surveyed in 2007 found three types of farms and feeding systems: small farms used cut-and-carry or free ranging on communal pastures; medium farms used free-range feeding on communal pastures; and large farms used stall-feeding, providing cattle with elephant grass, silage feeds, dry rice straw, and additional concentrate feed [5]. Researchers found that although the large farms had received significant government subsidies when they were established, they were now facing feed shortages, particularly during

the winter season, which led medium-scale farms to be more competitive because they could still use underutilized pastures for fodder [5].

Poultry feeding practices

As with cattle production, poultry feeding practices in Vietnam vary by different types of production systems. In traditional systems, poultry engage in free-range scavenging, receiving some locally available feeds or supplements [9]. For example, rice, maize, cassava, or potato may be provided irregularly to complement scavenging [11]. One study, based on a sample of 363 farmers of mostly free-range indigenous chickens, found that 49% of the chickens were fed chicken waste, 2% with grains, and 46% with commercial feeds [15]. In that sample, males and females reached an average weight at maturity of 2.6 kg and 2.0 kg, respectively [15]. (Though not distinguished by male or female, the typical US commercial broiler reaches a weight of approximately 2.8 kg over 48 days, according to the National Chicken Council.⁷)

In semi-intensive production, birds are given animal feeds and agro-industrial byproducts, and have a production cycle of 70 to 90 days [9]. A 2008 FAO report described feed conversion rates of 2.5 to 3.2 under this type of feeding system [11]. A study based on 270 chicken farms around Hanoi found that semi-commercial broilers were fed industrial feed, sometimes mixed with maize and paddy [46].

In intensive poultry production, caged systems accommodate internal feeding and water supply, and broilers are produced in six-week cycles, achieving finished weights of 2.2 to 2.4 kg [9]. One characteristic of this type of production is that these poultry farms may be integrated with foreign feed companies like CP, Japfa, Cargill, and Proconco, thus automatically connected with a supply of feed and other inputs [12].

Although the expansion of the animal feed industry was rarely criticized and generally viewed as a positive development in the literature that we found, one recent study on antibiotic resistance associated with chicken farming in the Mekong Delta found that the use of commercial poultry feed was associated with a statistically significant increased risk of antibiotic resistance and multidrug re-

7. National Chicken Council—U.S. Broiler Performance: 1925 to Present, available at <http://www.nationalchickencouncil.org/about-the-industry/statistics/u-s-broiler-performance>, last visited Dec. 20, 2015.

sistance [47].⁸ In that study, the total sample consisted of 208 farms—104 “household” farms raising ten to 200 birds and 104 “small” farms raising 201 to 2,000 birds. 70% of the 104 household farms used commercial feed, while 99% of the 104 small farms used commercial feed. According to the researchers, commercial poultry feed in the country was often medicated with antimicrobials; antimicrobials were present in all of the 25 randomly sampled feed samples tested by the researchers [47].⁹

Swine feeding practices

Feeding practices vary based on scale of the pig farming operation. According to a 2008 review, small-scale farmers generally feed pigs around 80% crop byproducts and 20% commercial feed, while the proportion is reversed for medium-scale farmers [25]. According to one study based on 700 pig producers across six provinces surveyed in 2008, smallholder pig farmers use proportionally less homemade feed compared to purchased feed as production intensifies [29]. Accordingly, in the northern areas (where farms were smaller), there was less use of industrially-produced feed compared to southern and urban areas; however, the sample did not reveal statistically significant differences in terms of feed use efficiency between larger and smaller producers [22].

Large-scale intensive, market-oriented farms rely completely on commercial concentrate feed [7, 24]. While average swine feed conversion rates in Vietnam are around 2.9 kg feed per kg weight gain, some companies have been able to achieve rates around 2.1 kg feed per kg weight gain [21]. These figures appear to approach those reported in a US pork industry analysis, which provided that feed conversion rates in 2013 were 2.66 and 2.50, for “conventional” finishing (the final stage in swine production) and wean-to-finish production, respectively [48].

There are several challenges associated with pig feed, however. Along with the growth of pork production and large-scale pig farming there is increased dependency

on imported ingredients for manufacturing pig feed [28]. Farmers also believe that the price of feed is excessive, and that feed merchants are deliberately keeping those prices high [27].

c) Antimicrobials, growth hormones and other additives

Animal health is mostly in the hands of the public sector, with a government-run veterinary office stationed in each of the 63 provinces responsible for slaughterhouse inspection, field activities, checkpoints, and drug retail outlets [7]. District-level veterinary stations vary in quality and extent of engagement [7]. Commune animal health workers comprise the core of field-level veterinary services; however, they have been criticized for being unreliable and inadequately supervised [7]. Private animal health services—veterinary practices and veterinary drug sellers—also exist in Vietnam [7]. The provinces have a list of registered drug stores, but most of them are staffed by personnel with uncertain qualifications [7]. Regarding extension services, in 2008 they were variable in quality and charged user fees which most farmers couldn’t afford; however, some private suppliers of extension services were emerging [25].

Livestock disease monitoring systems are very weak in Vietnam [26], and the use of veterinary inputs is poorly regulated, leading to a proliferation of low quality animal drugs [7]. Livestock products from Vietnam are not considered very safe so they are usually not imported by other countries [25]. In the Southeast Asia region in general, antibiotic use without supervision and veterinary advice is very common [26].

At the same time, use of feed additives has increased. As reported by a US-based market research company in 2015, the Vietnamese market for animal feed additives, which includes vitamins, antibiotics, antioxidants, amino acids, feed enzymes, and feed acidifiers, is projected to rise from 112 million USD in 2014 to 160 million USD by 2022 [49]. Feed additives are mostly imported, and foreign companies also dominate the production of feed additives in Vietnam, holding over 70% of the market share [49]. While the fastest growing element is feed acidifiers, the most imported additive is antibiotics, which accounted for over 34% of the 2014 total market revenue [49]. Factors behind this are increasing domestic probiotics production, inclination to use antibiotics as growth promoters, and concern about animal disease incidence [49].

8. More details on the study’s findings related to antibiotic resistance are provided in the subsection on antimicrobials below.

9. The 25 feed samples were “randomly collected from 25 different chicken farms,” according to the article. See Nguyen VT, Carrique-Mas JJ, Ngo TH, Ho HM, Ha TT, Campbell JI, et al. Prevalence and risk factors for carriage of antimicrobial-resistant *Escherichia coli* on household and small-scale chicken farms in the Mekong Delta of Vietnam. *J Antimicrob Chemother.* 2015;70(7):2150. However, it was not clear whether the 25 sampled chicken farms were randomly selected out of the 208 farms, how many of the 25 selected farms operated at the “household” versus “small” scale, and what proportion of the 25 selected farms used commercial feed.

The use of these additives, as well as other veterinary inputs, is described by type of livestock animal below.

Veterinary inputs and swine production

In the swine sector, animal health is a major challenge. A 2008 study found that three-quarters of 700 surveyed producers did not have access to extension services, a third did not have access to veterinary services, and four-fifths did not have access to credit [37]. Smallholder pig farmers used veterinary services more than large-scale pig farmers, a surprising result that researchers could not explain, while most pig farmers operating at all scales rarely used extension services [23]. Based on that same survey, another finding that was contrary to public perception was that larger-scale producers reported greater incidence of diseases like foot-and-mouth disease (a highly contagious viral disease that affects swine and cattle) and “blue ear” disease (porcine reproductive and respiratory syndrome) than smaller producers; however, classical swine fever was more common among smaller producers [37].

The FAO has noted that the problem of meat produced with veterinary drugs and containing antibiotic residues is “very rampant and difficult to regulate” [21, p. 109]. Antibiotics are misused in pig farming [50], and since the market for veterinary services and drugs is not monitored properly, there is low treatment effectiveness and risks to both veterinary and human health [7].

There have been some site-specific studies seeking to examine antibiotic use in greater detail. One survey conducted from 2009 to 2010 with 270 randomly selected pig and poultry farms in the Red River Delta found that large volumes of antibiotics were being used arbitrarily [51], and, overall, large-scale operations tended to use more antibiotics than small-scale ones [52]. At least ten classes of antibiotics represented by 45 different antibiotics were used in pig and poultry production for disease treatment, growth promotion, and prophylaxis, with 15 antibiotics being used in pig and poultry feed [51]. For prophylaxis and treatment, recommendations regarding dosage, withdrawal time, and length of treatment provided on labels and by drug manufacturers were disregarded [51]. Withdrawal times for antibiotics were only respected by about half of the respondents [51]. Antibiotic use without veterinary supervision was very frequent; it was unmethodical and unscientific, usually based on farmers’ experiences or advice from drug vendors after getting a description of the symptoms [51]. In terms of evaluating

the microorganism as a basis for choosing the appropriate drug, this was done 0%, 6.7%, and 13.3% of the time in farming households, semi-industrial farms, and industrial farms, respectively [52].¹⁰ Moreover, while some antibiotics are allowed by law to be used for growth promotion, results showed that both these and others that are not legally permitted were being used for growth promotion [51]. Half of those surveyed were interested in stopping antibiotic use and respecting pre-slaughter withdrawal times; the reported reasons for doing so were reducing costs and protecting consumers [52].

For pig production specifically, the survey revealed that the most commonly used antibiotics were from the aminoglycosides, tetracyclines, fenicol, beta-lactams, and fluoroquinolones groups, and although these were used to a greater extent for disease treatment than for prevention, the study still documented 25 different antibiotics being used for prophylaxis [51]. For growth promotion, chlortetracycline was the most commonly used drug [51]. Antibiotic growth promoters in pig production were used significantly more in industrial than semi-industrial pig farms, followed by household systems [51]. For therapeutic antibiotic use, there were no statistically significant differences among pig producers of different sizes [51]. Finally, for fattening pigs and piglets, farming households engaged in less prophylactic antibiotic use than industrial and semi-industrial production systems [51].

Veterinary inputs and poultry production

Like swine farming, poultry farming at all scales is also challenged by animal diseases. Free-range chicken production is considered problematic because of exposure to diseases carried by wild birds, but industrial production faces the challenges associated with concentrated production [53]. Nevertheless, the latter type of production is considered much more bio-secure and has been favored in policymaking in certain domains, such as highly pathogenic avian influenza (HPAI) control, where the focus has been on phasing out small-scale and free-range production [53]. A 2008 joint report by FAO, IFPRI, and other collaborators noted that even though policymaking around HPAI reflected a bias against small producers, there were no data to support the belief that they were at higher risk for HPAI than large-scale producers [10]. HPAI

10. Semi-industrial pig farms were those with at least 50 pigs or ten sows. Household farms operated at a smaller scale than this. However, no definition was provided for industrial farms. See Kim DP, Saegerman C, Douny C, Dinh TV, Xuan BH, Vu BD, et al. First survey on the use of antibiotics in pig and poultry production in the Red River Delta Region of Vietnam. *Food and Public Health*. 2013;3(5):247-56.

control measures have also included curtailing poultry operations, which has impacted the feed industry and foreign companies operating within Vietnam, as well as large-scale vaccination campaigns [10].

One 2010 study based on a sample of 270 chicken farms and veterinary agents in the suburbs of Hanoi characterized four different poultry production systems in terms of biosecurity as follows: backyard poultry production with low biosecurity; semi-commercial broiler production with low-to-moderate biosecurity; semi-commercial layer production with low-to-average biosecurity; and integrated poultry production with good biosecurity [14]. Researchers found that animal production, especially poultry production, at the small and semi-commercial scale, was considered risky in terms of animal disease [14]. In response to the HPAI outbreaks from 2003 to 2005, significant percentages of the flock were culled, the government instituted mandatory vaccination for farms with over 2,000 birds, small-scale and commercial farms were completely subsidized for the cost of vaccines, and vaccination campaigns were also carried out regionally for smaller farms [14].

In chicken farming in Vietnam, there is also uncontrolled and widespread antibiotic use. Some studies have suggested that foodborne pathogens have high levels of antibiotic resistance, and that isolates from chicken may be even more resistant than those from pigs [50]. The study of pig and poultry farms in the Red River Delta mentioned above found that 31 different antibiotics were used for disease prevention in poultry [51]. These included antibiotics from sulfonamides, beta-lactams, tetracyclines, aminoglycosides, ionophores, and the polymixin colistin, which were commonly used for disease prevention and, to a lesser extent, treatment [51]. For broilers, household farms used antibiotic growth promoters statistically significantly less than industrial and semi-industrial production systems [51].¹¹ For layers and breeding poultry, there was also statistically significantly less use of antibiotics for prophylactic purposes by household and semi-intensives farms as compared to industrial farms [51].

11. The study defined semi-industrial chicken farms as those with at least 200 birds, implying that household farms were those with fewer than 200 birds. However, the distinction between semi-industrial and industrial chicken production was not stated in the study. See Kim DP, Saegerman C, Douny C, Dinh TV, Xuan BH, Vu BD, et al. First survey on the use of antibiotics in pig and poultry production in the Red River Delta Region of Vietnam. *Food and Public Health*. 2013;3(5):247-56.

A 2012 to 2013 survey of 208 randomly selected chicken farms in the Mekong Delta found high levels of antimicrobial use—higher than Europe—and most of the time the purpose was prophylactic [50]. By use, 84% of the cases were for prophylaxis, 12% for therapy, and 3.8% for both prophylaxis and therapy [50]. In the sample, 123 farms (or 59%) reported using at least one antimicrobial; 71% of small- to medium-scale farms (201 to 2,000 birds) and 47% of household farms (10 to 200 birds) reported administering antimicrobials, and this difference was statistically significant [50]. Meat farmers used statistically significantly more antimicrobials per unit time than layer farms or dual purpose farms [50].

The study identified the use of 28 different antimicrobial compounds belonging to 10 classes, and the most widely used were polypeptides, tetracyclines, penicillins, and aminoglycosides [50]. Most administrations consisted of at least two classes of antimicrobials, with polypeptides plus penicillins, followed by tetracyclines plus macrolides as the most common combinations [50]. In 82% of occasions, formulations were administered in water; 9.5% in feed plus water; 4.2% in only feed; and 4.2% by injection [50]. An average of 24.9 mg and 5.21 mg of antimicrobials per chicken per week were used by household farms and small- to medium-scale farms, respectively, yielding an overall estimated total of 470.4 mg antimicrobials used to produce one meat chicken [50]. The most common source of antibiotics was drug sellers (56%), followed by district veterinarians (18%) [50].

Among this same sample, researchers also tested for antimicrobial resistance to 11 different antimicrobials in *E. coli* isolates obtained from the farms. They found a high prevalence of resistance to the most commonly used antimicrobials among the household farms and small-to-medium farms [47]. In particular, resistance to gentamicin, ciprofloxacin, and third-generation cephalosporins was detected on 97%, 92%, and 37% of the farms, respectively [47]. Of the 895 *E. coli* isolates tested, resistance to tetracycline, ampicillin, amoxicillin, gentamicin, ciprofloxacin, and third-generation cephalosporins was detected in 93.4%, 86.0%, 47.9%, 19.9%, 32.5%, and 3.2% of the isolates, respectively [47]. Moreover, multi-drug resistant (MDR) *E. coli* was found at all farms; 81.3% of the isolates were MDR [47].

Higher density of chickens was associated with both gentamicin resistance and MDR. There were 32% and 28% increases in the odds of isolating gentamicin-resistant or

MDR *E. coli*, respectively, for each unit increase in number of chickens per square meter [47]. In addition, the use of commercial feed was associated with increased risk of fluoroquinolone resistance and MDR, which was indicative of the fact that commercial poultry feed was commonly made with antimicrobials [47]. Twenty-five feed samples were randomly collected from a subset of 25 chicken farms, and all samples tested positive for antimicrobials [47].

Veterinary inputs and beef production

Cattle production in Vietnam faces the challenge of a lack of veterinary services, although there are some government policies to encourage vaccination and agricultural extension work [13]. However, we did not find detailed information about the state of animal health or use of veterinary inputs in cattle production.

d) Facilities for housing, slaughtering, and processing

Poultry housing, slaughtering, and processing

Housing facilities vary based on the system of production. In traditional backyard poultry production where indigenous poultry are raised, birds may be confined or kept free-range [15]. A study of 363 households farming indigenous chickens found that during the daytime 93% of chickens free-ranged and 7% were confined in shelters with roofs, while during the nighttime 92% were confined in shelters with a roof, 2% were confined in shelters without a roof, and 4% were not confined [15]. In semi-intensive poultry production, birds may be kept in enclosures or free-range, and their cages can be permanent or makeshift [9]. In intensive production, facilities are indoors, modernized, and mechanized, and include cage systems, watering and feeding systems, ventilation, lighting, and waste management [9, 10].

As of 2006, chicken density in the entire country was 459 birds per square km, with the Red River Delta by far the most densely populated (2764 birds per square km), followed by the North East (518 birds per square km) [12].¹² However, we did not find information about densities at which poultry are housed.

12. The source's authors did not specify whether they used total area, land area, or agricultural area as the denominators for these densities. However, from our attempts to reproduce these calculations, the figures are more consistent with interpreting the denominators as total area or land area.

Facilities for slaughtering and processing poultry also vary based on type of production. About half of industrial poultry produced get marketed through foreign-owned slaughterhouses [9]. However, a 2008 FAO report described poultry slaughtering facilities as generally small and old, with capacity to slaughter 300 to 500 heads daily, and in 2008 there were only 28 high-capacity model systems in Vietnam [11]. According to official statistics, in 2011 there were 173 poultry slaughterhouses, 141 poultry plus cattle slaughterhouses, 8,902 poultry slaughter points (facilities with capacity to slaughter fewer than 100 birds per day), and 3,646 poultry plus cattle slaughter points (facilities with capacity to slaughter fewer than 100 birds and ten heads of cattle/buffalo per day) [7].

Pig housing, slaughtering and processing

There was limited information about the facilities in which farmed pigs are housed. One 2007 study found that pigs were penned all the time in a sample of 64 small pig farms in North Vietnam [54]. Additionally, 19% of pens near towns and 37% of pens away from towns contained pigs of different types and ages, a practice that the researchers considered to hinder performance-oriented feeding [54].

For slaughtering, a 2008 survey of 700 pig producers found that in the lowland areas and urban areas slaughtering could occur at government or private slaughtering facilities; however, backyard slaughtering was also common, even though the government required pigs to be slaughtered at the private or public facilities [37]. On the other hand, in the upland areas, there was a lack of slaughtering facilities, so most slaughtering was done in pig traders' or butchers' backyards [37].

The government has promoted the upgrading and expansion of slaughterhouses [7]. A 2008 Department of Livestock Production survey revealed that there were 434 slaughterhouses, only 45% of which had licenses to operate, 35% had sanitary facilities, and 25% had running water [21]. In 2011, there were 561 pig slaughterhouses and 13,976 pig slaughter points (facilities with capacity to slaughter fewer than 20 pigs per day) [7]. A 2011 ACIAR-funded study reported 35 "industrial" slaughterhouses in Vietnam, with 22 of these located in the Red River Delta [2]. Large slaughterhouses are located mostly near urban areas [7].

In terms of processing, a 2014 CGIAR report documented increasing demand for processed pork meat, especially

in cities, leading large companies to invest in processing and more modern retail outlets [7]. There were 28 pork processing factories in Vietnam, according to a 2011 presentation by the Department of Livestock Production [7].

Cattle housing, slaughtering, and processing

There was limited information about cattle housing facilities. One 2010 study on 73 beef cattle producers in one province of northwestern Vietnam found that small farms, which generally kept two to four heads of cattle, either provided no shelters or only basic stables and sheds, while small huts were used as housing in medium-sized farms averaging nine heads of cattle [5]. In all five of the large-scale farms surveyed, which raised between 93 and 650 heads of cattle, stall-feeding was used and the animals were kept in purpose-built housing, separated into different groups based on sex and age [5].

Official government statistics from 2011 documented that there were 121 slaughterhouses for ruminants, 141 slaughterhouses for poultry plus cattle, 1,761 slaughter points for ruminants (facilities slaughtering fewer than ten heads per day), and 3,646 slaughter points for poultry plus cattle (facilities slaughtering fewer than ten heads of cattle and 100 birds per day) [7].

e) Land use and land acquisitions

There was limited information available about the use of agricultural land in Vietnam. The literature did document one characteristic of landholdings—their generally small size—and attributed that to domestic regulations. According to the 2006 agricultural census, 69% of the country's landholdings consisted of less than half a hectare of land, while 94% were less than two hectares [3]. Although Vietnamese authorities are now interfering less with land transfers, restrictions remain (e.g., on the permitted uses of land or on the recipients of land transfers) that serve as disincentives for agricultural investment [3]. There are also restrictions on the size of land that can be held by a given household [3]. Such restrictions, which may change in the future, have slowed down intensification and scaling up of livestock production [19].

We did not find any information about land acquisitions undertaken by Vietnamese entities outside of Vietnam.

5) Waste management

According to a 2014 CGIAR report, Vietnamese livestock farms of all sizes and types tend to manually separate solid and liquid parts of the animal waste [7]. Solid waste is composted and sometimes sold; other times, it is composted indoors or covered with plastic [7]. Solid chicken manure, for example, is collected and sold as a commodity in Vietnam, as in other countries in Asia [55]. A 2008 FAO source reported that in medium-sized pig farms, where pigs were raised on steel slats 40 to 50 cm above concrete floors, solid manure was scraped off of slats and floors and then sold; in large pig farms, manure was scraped off the floor once or twice per day, and pigs were hosed down thereafter [55].

However, the FAO also noted that pig farms of different sizes had difficulties coping with swine waste. They noted that there were no waste treatment facilities even in industrial-scale operations and very little awareness of laws on managing waste [21]. This was a particular problem for liquid manure, which is discharged into crop fields, ponds, canals, or rivers, and only pretreated on some occasions (for example, by being contained for a short time in lagoons) [7, 55]. Impacts from this include eutrophication and killing of fish in ponds [55]. The volume of water generated may be even higher during the hot season, when water is used both for cleaning operations and hosing down animals to cool them off. As one study by the PRISE research consortium notes, the liquid effluents deriving from these activities are hard to manage and store simply because of their sheer volume [56]. While wastewater can be useful in integrated pig-fish systems that recycle nutrients in livestock effluent as fish feed, there is a limit to how much effluent the fish ponds can absorb; in other systems, it is hard to put the effluent to use [56]. Moreover, there may be safety concerns with recycling wastewater, especially when inputs in animal production involve substantial antimicrobials, as described earlier. While the use of biogas digesters to ferment manure is well-known in Vietnam, gas production is low because the liquid manure has low dry matter content [55].

6) Transnational corporations

In the context of Vietnam's transition to a market economy, government policies have encouraged foreign investment, making it easier for foreign companies to enter into the country, and reducing trade barriers and regulations [6]. The government's promotion of foreign

investment to modernize livestock production has led transnational agribusinesses to acquire a significant presence in the country; they now command a substantial part of the market and are associated with the largest-scale operations. These companies dominate not only livestock farming, but also commercial breeding and animal feed production, as described previously in the section on inputs [7, 12].

The poultry sector, for example, reflects this development. Intensive poultry farming in Vietnam was initially promoted by foreign investors [9]. A 2006 USDA report described the largest poultry farms as being either joint ventures or wholly foreign-owned enterprises [13]. One 2007 study estimated that 45% to 50% of industrial poultry was eventually marketed through foreign-owned slaughterhouses [9]. As described in the discussion of vertical integration, multinational food companies also serve as integrators, engaging in contract farming with large poultry farms [10]. Foreign feed companies like CP, Japfa, Cargill, and Proconco are fully integrated and produce parent stock on their own commercial poultry breeding farms [12].

For swine production, foreign agribusinesses like CP, Dabaco, and Japfa also engage in contract farming [7, 38]. As in the poultry sector, farms affiliated with these entities tend to be large-scale and market-oriented, with 600 to 1,200, or even as many as 2,400 sows [21].

7) Regulation of livestock production

Government policies that support industrialization and scaling up

Government support for expanding the livestock sector has occurred within the context of Vietnam's transition to a market economy, which includes developments like more power for state-owned enterprises, easier entry into the country for foreign companies, strengthening of private property rights in rural areas, and fewer trade barriers and regulations [6]. The Vietnamese government is aware that demand is growing faster than supply of livestock products, so it is adopting policies that favor greater production by private registered companies or joint-stock companies, rather than small-scale/household farms, based on the idea that the former can achieve economies of scale [3, 25]. In this regard, the 2020 national livestock development plan promulgated in 2008 promotes industrialized livestock production and processing, so that operations are more integrated,

modernized, productive, and likely to yield higher-quality output [2, 4]. Its target is for large-scale intensive livestock farms to produce 70% of the country's meat and for industrial slaughtering to account for approximately 35% of the meat supply by 2020 [2].

Tools used to achieve these ends touch upon land, credit, tariff, and other policies [2] as well as animal health, artificial insemination, and forage production [13]. At the national level, one decree, Decree 80/2002/QĐ-TTg, encouraged contract farming as a way to improve product marketing [33]. However, the high initial investment required is a barrier to having more producers participate as contract farmers [21]. According to the FAO, as of 2011, contract farms only accounted for 10% of the total pig population in the country [21]. Thus, the government has tried to encourage intensive farming by providing access to long-term land leases and loans [21]. Much of the government's support has been focused on the pig sector [6]. As described by a 2006 USDA report, to support commercial swine production the government has reduced or eliminated land rents (the government owns most land and rents it long-term), and given better tax rates for commercial farms, large-scale slaughterhouses, and processing plants [13].

The government has also provided significant financial assistance consisting of direct subsidies for breeding farms and subsidized prices for commercial farms' purchase of breeding stock from state breeding farms [24]. In addition, as quality of animal-origin food products is a concern for both domestic consumers and export markets [4], certain policies for controlling animal disease, such as HPAI, have also attempted to phase out small-scale and extensive production [53]. In this regard, various cities in Vietnam have provided support for transitioning to semi-industrial and industrial poultry production, for example, through access to credit and technical assistance [57].

The extent of active government support for large-scale livestock production may render small producers less competitive. One 2009 study warns that subsidizing larger production units may not be wise because Vietnam is still in a transitional state, and small producers will not be sustainable in light of such subsidies [19].

Regulations or lack thereof of IFAP

Several sources criticized the lack of regulations or the under-enforcement of regulations related to food animal

production. Regulation of environmental impacts deriving from livestock farming mostly consists of the 1993 Law on Environmental

Protection and the 2004 Decree 67 on wastewater discharge [56]. Part of the national livestock development strategy includes mandating that production, slaughtering, and processing facilities have waste treatment systems and respect environmental protection [2].

One of the major problem areas described in the literature concerned the use of veterinary drugs in animal production. As described above, antibiotic use without veterinary supervision or adherence to guidelines on dosage is a serious challenge. As one 2013 study described, there have been alerts about veterinary antibiotic residues over the past few years, which have alarmed consumers; yet there is still no systematic monitoring or control strategy for antibiotic use in food animal production [51]. As a result, the quality of veterinary drugs is poor and their effectiveness is low [7]. Some policies do exist, such as a 1993 Animal Health Ordinance (Decree No. 93/CP) and a 2004 ordinance issued by the National Assembly on Veterinary Medicine, that address the management of veterinary drugs [2]. However, these have not been sufficient to control the problem of rampant antibiotic abuse.

Other norms and procedures are in place for food safety, but such policies are not implemented effectively [21]. One of the problems may be the fact that division of responsibilities among different government agencies are not clear, and health inspections by the Ministry of Health and veterinary hygiene inspection are limited [21]. As a 2014 CGIAR report describes, food safety is the responsibility of several ministries, but coordination among them is scant and the legal framework is complex and confusing [7].

Impacts of industrial food animal production

1) *Impacts on worker health*

Our landscape assessment did not produce any information on this topic.

2) *Impacts on surrounding communities and others*

A few sources found in our landscape assessment highlighted the consequences of intensified animal production on surrounding communities. Few of these studies, however, provided empirical evidence that these conse-

quences had in fact occurred. One 2003 study cited possible negative impacts, such as increased unemployment and impoverishment because of reduced rural employment opportunities as small producers ceased livestock production [58]. The concern is that smallholders would be unable to compete with large-scale, high-technology-equipped livestock farming [1]. There may also be increased economic risks because of reliance on imported genetics (including exotic breeds that may not be well adapted to local conditions), technologies, and feeds, resulting in vulnerability to price changes of inputs and outputs [58]. Other studies have warned of environmental and socio-economic costs (such as reduced biodiversity, soil contamination, atmospheric pollution, and water depletion), which in turn would affect public health [1, 2]. In this regard, industrial farms located near urban areas have been associated with human health and environmental concerns, such as bad odors and zoonotic disease risk [9].

3) *Impacts on natural resources*

We found several sources that commented on, but did not study *per se*, the impacts of industrial food animal production on natural resources. A 2003 study anticipated environmental harm deriving from animal waste and reduced biodiversity due to extinction of indigenous breeds [58]. Referring to the livestock revolution occurring in Southeast Asia in general, one 2014 study mentioned impacts consisting of atmospheric pollution and water depletion [2]. A 2011 paper by the researchers on an ACIAR project referred to concentrated and large-scale pollution, deriving from the generation of more animal waste than could be recycled naturally, as a result of concentrated and large-scale livestock production [2]. The connection was made between threats to soil, water, and air quality, on the one hand, and threats to public health on the other [2].

Regarding pig farming specifically, a CGIAR report stated that pollution was a bigger problem in suburban than in rural areas because the number of pigs was high and population density was greater [7]. Researchers reflecting on the implementation of an ACIAR-funded project on pig breeding and feeding in Vietnam stated that a challenge remaining after the project's implementation was pollution due to high concentration of pigs, which would cause bad smells, contaminate surface and groundwater, and thereby affect public health [17]. Additionally, a 2008

FAO report highlighted that pig farmers in Asia used water excessively to cool off pigs and clean buildings [55].

Public engagement with industrial food animal production

1) Transparency and access to information

We found a few sources that mentioned the lack of statistics on the number of contract farms in Vietnam [7, 39], and the absence of information about the impacts or contract farming [32].

2) Public awareness and attitudes

The information on public awareness that we found tended to focus on consumer preferences for fresh meat and indigenous meat animals versus processed meat products and exotic breeds. A 2007 research report from the FAO's Pro-Poor Livestock Policy Initiative documented that HPAI outbreaks had increased consumer awareness about certified food products [57]. In this regard, a 2008 FAO report on HPAI added that while consumers had a preference for local chickens, they were also willing to pay more for local chickens that had been certified as safe and healthy [10]. A more recent study using a sample of 923 randomly selected households in Hanoi found that consumers were willing to pay 10% to 15% more for chicken produced free-range and emphasizing safe production, processing, and transport [53]. However, this premium was not as high as the one paid for indigenous chicken varieties considered tastier [53]. Those consumers who were more willing to pay premiums tended to have higher education [53].

Regarding pork, there is also a preference for indigenous pork varieties because they are perceived to have better taste and consistency [25]. There has been a general preference for fresh meat and purchasing of meat at open markets, as well [2, 59]. Researchers have described the practice of buying fresh meat and not storing it for a long time as an advantage for the domestic pork sector, shielding it from international competition [28].

However, some consumers, particularly those with high-incomes, have been increasingly preferring processed meat products, such as frozen meat and ready-made meat products, and shopping in supermarkets instead of wet markets [13, 25]. At the same time, there is also growing public concern over the past several years about veterinary drug residues and antimicrobial resis-

tance related to animal-origin foods [7]. One 2011 report notes the "strongly increasing numbers" of food poisoning incidents due to chemicals, hormones, and antibiotics in meat and fish products, as well as pathogens and poor hygiene, over recent years [2, p. 8]. As described earlier in the subsections related to animal health and veterinary inputs used in livestock production, small producers are sometimes perceived to be associated with these problems, despite the lack of evidence to support that association.

3) Media interest in IFAP

Based on the media sources we found reporting on food animal production in Vietnam, it appears that there is interest in the activities of transnational agribusinesses in the country, especially in the feed and pork sectors. The focus has been on expansion of production capacity, rather than the impacts of livestock farming and feed production activities.

4) NGO or community campaigns, advocacy, and other efforts targeting IFAP

We did not find information about campaigns or other advocacy efforts targeting industrialized livestock production. There was one consultancy report written for the League for Pastoral Peoples and Endogenous Livestock Development, a German NGO, which used pig farming in Vietnam as one of its four case studies [39]. From this and other case studies, it drew the general conclusion that industrialization of livestock farming had a profound impact on smallholders, which could result in a "massive rural exodus" and fuel the creation of slums in the developing world [39].

5) Description of other civil society actors engaged in IFAP

Critical perspectives on industrialized food animal production came from a few academics and organizations. The focus was the impact of the livestock revolution on small-scale producers, rather than on environmental, public health, and animal welfare considerations associated with industrialization. Some researchers have cautioned that favoring large-scale producers over smallholders (for example, with subsidies and other policies) will result in the latter not being able to survive in the market [19]. One line of thinking is that achieving more competitiveness and greater economic efficiency doesn't

necessarily mean that small-scale producers should be replaced by large-scale ones [19]. Instead, the authors propose that the most economical option might be a combination of both small and large producers, given that Vietnam is in a “transitional” situation [19]. In this vein, a few researchers have argued that smallholder pig producers are not so disadvantaged compared to large-scale producers [29]. Rather than recommend scaling up to reduce transaction costs, they initially recommended that small pig producers join together in co-ops and associations to make things more efficient [37]. However, a later publication authored by this same group stated that “enlargement and modernization are obviously the way to go in the long-term” [37, p. 3]. Nevertheless, they still advocated for “[p]olicies that [would] enhance productivity across all producer types . . . rather than a targeted policy directive focusing on developing large, industrial farms” [37, p. 2].

Some of the researchers cited above have been associated with a project funded by the Australian Center for International Agricultural Research (which is part of the Australian government), titled “Improving competitiveness of pig producers in an adjusting Vietnam market,” in which IFPRI, Oxfam, ILRI, and the Center for Agricultural Policy, among other institutions, collaborated [2]. The project, which sought to assist smallholders through diversification and quality improvement, yielded various publications. Among them, one policy paper emphasized that the government of Vietnam should provide “neutral” support to both large- and small-scale farms, and recommended actions like credit and tax support for small producers, building infrastructure for producers of all scales, and upgrading facilities for slaughterhouses of all sizes [2]. The ACIAR has also sponsored introducing Australian pig breeds into Vietnam to compare their productivity to that of local breeds and to evaluate local-imported cross-breed performance [17]. The result of those efforts culminated in AusAID establishing five artificial insemination centers across Vietnam, to scale up the ACIAR project [17].

The FAO’s Pro-Poor Livestock Policy Initiative has also generated research that highlights the need for the industrialization process to be inclusive of smallholders and the poor [57]. A couple of these publications focus specifically on whether contract farming truly benefits small farmers, and conclude that formal contracts with agribusinesses do tend to exclude smallholders, but informal contract arrangements with cooperatives and

traders might be helpful for them [32, 34]. Researchers at IFPRI and ILRI have similarly questioned the extent to which contract farming is pro-poor, and have reached similar conclusions that formal contracting tends to exclude small-scale farmers but informal contracts can be more flexible and accommodate them [35].

However, rather than question the vertical integration or contract farming *per se*, the central issue in the reports we found was how to get smallholders involved. For example, a recent CGIAR report on the pig sector stated that small and medium farms, rather than large farms, would continue to dominate production, and therefore recommended strategies that “build on principles of vertical integration” [7, p. 120]. Their perspective was that smaller pig farmers should upgrade and modernize their production processes to improve the quality of their products [7]. Integration was seen as a way to increase local production, and thus the government should adopt measures to encourage large firms to serve as integrators and contract local farmers [7]. An IFPRI report similarly maintained that contract farming could help smallholders meet demand for quality and safe pork products, thereby helping them be more competitive [38].

Intensification was promoted to some extent, and questioned to a lesser extent than scaling up. One 2013 study, for example, examined how, over a decade, various ADB and IFAD-funded projects to improve fodder production had led to more cattle-fattening and stall-feeding operations [45]. All of the outcomes from these changes were described as positive. The PPLPI’s 2010 study on live-stock production found that intensive pig production in the Mekong was “superior” compared to traditional pig production, as determined by performance indicators such as shorter rearing periods, higher number of litters per sow and year, and higher weights of fattened pigs [16, p. 59]. That study, which spanned nine countries in South Asia and the Greater Mekong Sub-Region, conducted quantitative comparisons of production systems for poultry, cattle, and pig farming using metrics that did not have any environmental component, notwithstanding the recognition that disposal of animal manure was a major problem associated with intensified, commercial livestock production [16, p. 52-3].

We found one research consortium established in 2003, called PRISE (“Research consortium on risks associated with livestock intensification”), which was funded by the French government and included members, such as CI-

RAD (Agricultural Research Centre for International Development), NIAH (Vietnam's National Institute of Animal Husbandry), NIVR (Vietnam's National Institute of Veterinary Research), and Hanoi Agricultural University, among others.¹³ One paper presented at a NIAH-CIRAD workshop in 2002 offered the view that intensification should take place and needed to occur in order to satisfy demand for meat, but warned about the consequences of "inappropriate intensification," such as increased unemployment, impoverishment, economic risks, and pollution [58].

13. See <http://www.cirad.fr/en/content/download/3186/39824/.../4/.../25Initiatives-en.pdf>.

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