INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
IFPRI

WORKING PAPER NOVEMBER 2024

Medium-scale livestock farms in Asia's rapidly transforming food systems

Ayako Ebata and Ben Belton

CONTENTS

TABLES

FIGURES

ABSTRACT

Academic and policy debates on agriculture emphasize a bimodal typology of ‘small-scale’ and ‘large-scale’ farms. In this article, we draw attention to the role and distinct characteristics of medium-scale monogastric livestock farms in the Global South, drawing on an empirically grounded typology of scale that incorporates three linked components: (1) Social and economic organization of production; (2) Technological choice and environmental impacts, and; (3) Food system linkages and spillovers. We review national livestock sector policy documents from three Asian countries - Bangladesh, Myanmar, and Vietnam - with reference to the typology, and compare assumptions embedded in the policies with the characteristics of farm scale revealed by the typology. Our analysis indicates that current policy goals are not well aligned with the characteristics of medium-scale livestock farming in the region. This disconnect presents a missed opportunity to enhance the livestock sector’s contributions to rural economies, nutrition security, food safety, and environmental performance. We conclude with examples of how policies could maintain and enhance medium-scale monogastric livestock farms’ contributions to sustainable intensification, public health, and livelihoods.

Keywords: livestock farming; pigs; chickens; livelihoods; sustainable intensification; policy analysis; Asia

1. INTRODUCTION

Academic and policy debates in the Global South emphasize a bimodal typology of agriculture, comprised of 'small-scale' and 'large-scale' farming. Smallholder farmers are frequently assumed to be 'poor', while their farms are often seen as family enterprises that are 'traditional' in terms of technology, purchase few inputs, and are oriented to subsistence or local markets (Grace et al., 2017; FAO, 2009; Delgado et al., 2008; ILRI, 2007). Conversely, large-scale farms are often described as 'industrial' (Otte & Mcleod, 2004), 'very large' (Udo et al., 2016) and 'modern' (Van Boeckel et al., 2015), using sophisticated capital-intensive technologies, and serving export markets or 'modern retail' outlets (Thi Dien et al., 2023).

A growing body of empirical evidence suggests that the boundaries between smaller and larger farms are increasingly blurred. For instance, Neven et al. (2009), Jayne et al. (2019), Minten et al. (2020), Shonhe et al. (2020), and Van Hoyweghen et al. (2021) all provide evidence of the rise of commercially oriented medium-scale farms in sub-Saharan Africa. In Asia, similar tendencies have been observed for crops including rice (Reardon et al., 2014) and mangos Qanti et al. (2017), and 'small- and medium-scale commercial farms' have been identified as driving the rapid expansion of aquaculture in the region (Bush et al., 2019).

Medium-scale farms utilize a mix of family and hired labor, are highly integrated into factor, input, and output markets, and can span a broad spectrum of capital intensity and technological sophistication. The emergence of this class of farm is part of what Reardon et al. (2012) call "the quiet revolution" – the transformation of food systems in response to growing domestic demand for non-staple foods (Huynh et al., 2007; Philipsson et al., 2011; Swinnen, 2007), leading to the proliferation of increasingly commercial and specialized farms, and the concurrent evolution of supporting supply chains.

No study to date has focused on the characteristics of medium-scale livestock farms. In this working paper we do so, by advancing a typology of scale in pig and poultry farms, drawing primarily on experience from Asia. Animal sourced food (ASF) production has increased dramatically across Asia in the past 20-30 years in countries including Bangladesh (FAO, 2021), China (Gilbert et al., 2017; Liu et al., 2014), India (FAO, 2021), Myanmar (Belton et al., 2020), Thailand (Tisdell et al., 1998), Vietnam (Lucila and Lapar, 2014), as well as in some African countries such as Nigeria (Sanou et al., 2020). In East and Southeast Asia, this growth has been driven mainly by monogastric animals (pigs, chicken), and aquatic animals (e.g., fish, crustaceans), whereas chickens and aquatic animals dominate the growth of ASF supply in South Asia. Production of ruminants (cattle, sheep, goats, buffalo) in Asia has tended to increase much more slowly, or to decline (Edwards et al., 2019; Scott et al., 2023). These trends reflect high levels of demand for monogastric animals in the region relative to ruminants, linked to cultural preferences and price (Edwards et al., 2019), and their biological characteristics which have favored intensification of production and increased supply through the development of new breeds, feeds, and other technological advances (Bennett et al., 2018). As a result, pig and poultry farms in Asia now span a wide spectrum of technological sophistication and scale.

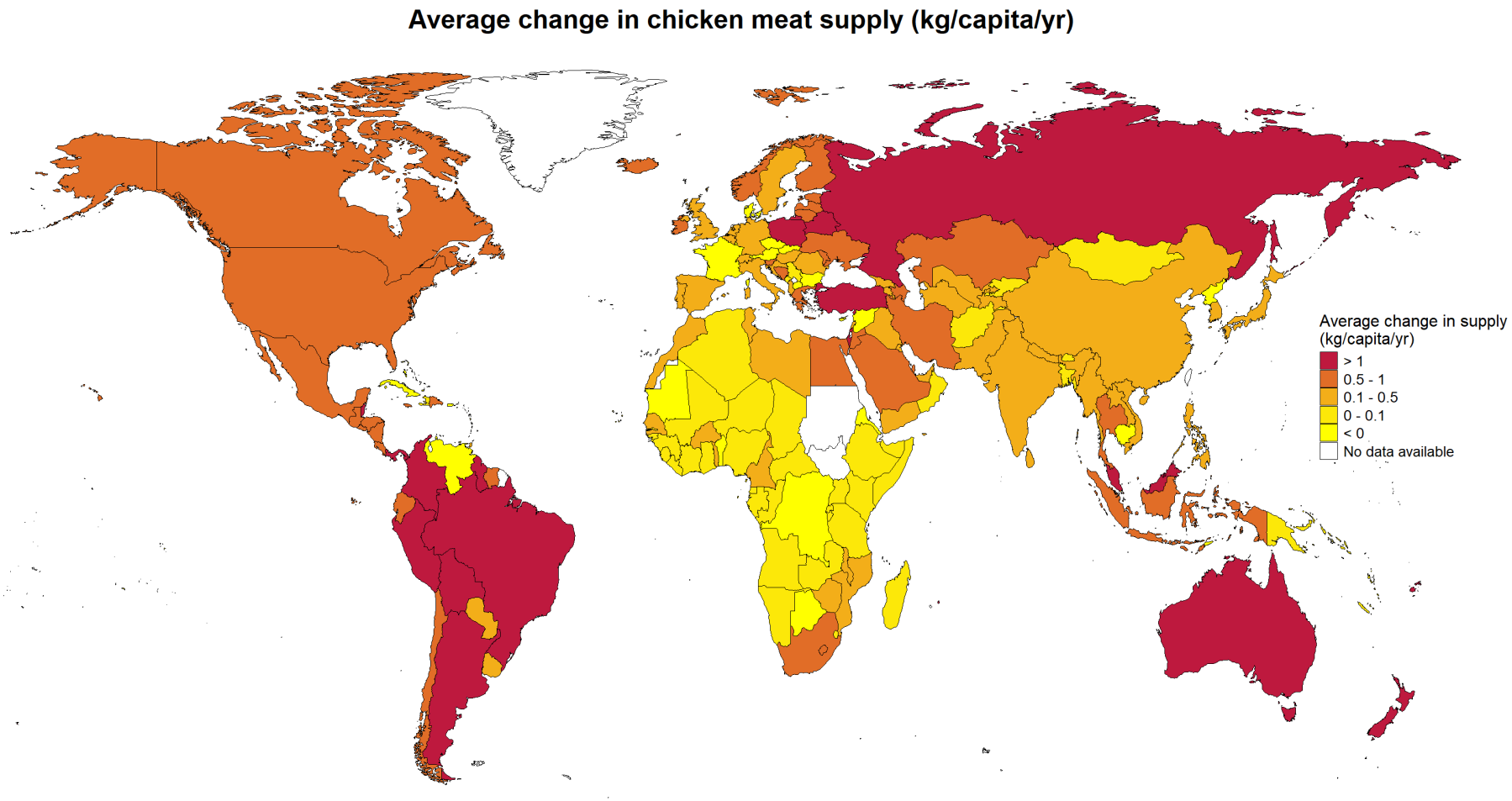
The growth rate of chicken and pig production in Southeast and South Asia has been less rapid than that of major industrial producers (e.g. USA, Canada, Australia, Russia, Brazil, Argentina and China), many of which are large exporters of these commodities (FAO,

2024). However, Figure 1 and Figure 2 highlight the rapid increase in non-traditional producers in Southeast Asia (e.g. Thailand, Indonesia and Malaysia for chicken; Vietnam, Thailand, Lao PDR, and Myanmar for pork). In South Asia, chicken production has grown recently from a very low historical base. While the supply increases per capita have been smaller than in other parts of Asia, they have been substantial in relative terms and large in aggregate given the population sizes of countries such as India and Bangladesh (Scudiero et al., 2023). Moreover, rapid rates of economic development and urbanization in these countries suggest potential for further acceleration of chicken meat and egg production.

As pigs and poultry in Asia are produced by farms spanning a wide spectrum of scale, this increase in supply involves not only large-scale industrial operations, but medium- and small-scale farms. This scenario makes it critical form a policy perspective to understand the dynamics of non-industrial commercial livestock farms. Based on literature review, empirical observation and policy analysis, we argue that current policy and research debates in much of Asia pay insufficient attention to medium-scale livestock producers. Inadequate recognition of these farms and their distinctive characteristics risks advancing policy goals and prescriptions that are poorly tailored to current realities. We add nuance to common assumptions in the literature by analyzing the continuum of scale among livestock producers, including those falling between the small-scale and industrial farms on which the literature and policy debates are focused, and address the implications for livestock policy.

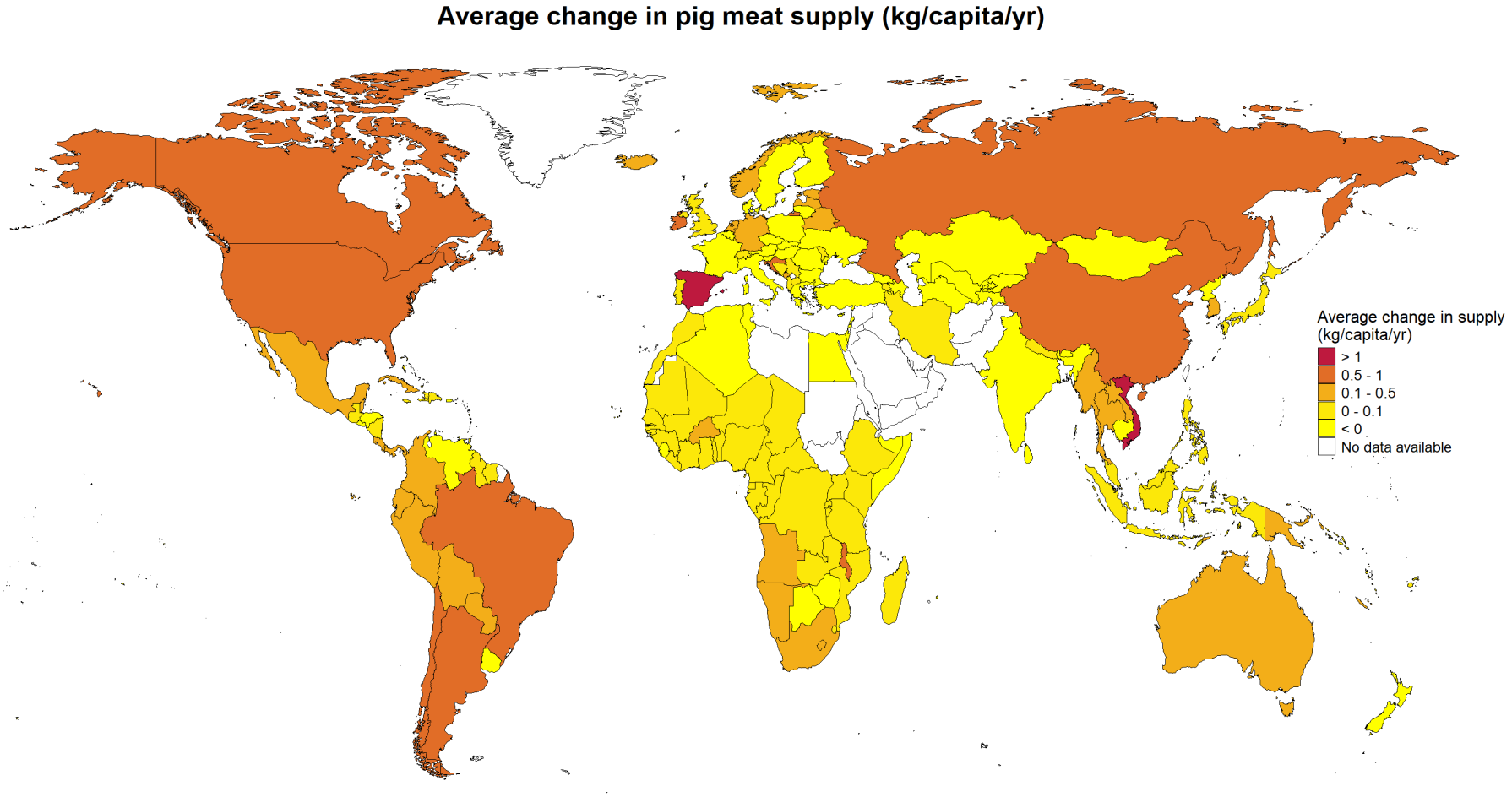
The rest of the paper is structured as follows. In section 2, we present a typology of scale in Asian monogastric livestock farming based on insights drawn from recent research. We then analyze the nature of policy tools for the sector, using examples drawn from policy documents from Bangladesh, Myanmar, and Vietnam. Section 4 concludes by comparing the visions represented in these policies with the realities of medium-scale livestock husbandry in the region, and discusses the implications for livestock policy in low- and middle-income countries (LMICs).

Figure 1: Annual change in chicken meat supply, kg per capita, 2000-2022



Source: FAOSTAT (2024) and authors' interpretation

Figure 2: Annual change in pig meat supply, kg per capita, 2000-2022



Source: FAOSTAT (2024) and authors' interpretation

2. TYPOLOGY OF LIVESTOCK FARM SCALE

Table 1 presents a scale-based typology of monogastric livestock production in the Global South, informed by Johnson (2006) and Belton, Haque and Little (2012). The table content draws from the authors' research and field observations in countries including Myanmar, Vietnam, Bangladesh, and Thailand, and from the literature.

We specifically consider the implications of scale of production in three linked areas: (1) social and economic organization; (2) technology use and associated environmental impacts; (3) linkages with other dimensions of the food system, including markets, governance, and economic spillovers. These characteristics exist along a broad continuum, and some exceptions will exist. Nevertheless, we contend that the typology helps focus attention on the characteristics of livestock farm scale, situating it in relation to the broader food system, and facilitating a comparative evaluation of approaches to livestock sector policy in Asia. In following subsections, we elaborate on farm characteristics pertaining to each area of the typology.

2.1 Social and economic organization

Based on their social relations of production and production logics, small-, medium-, and industrial-scale forms of monogastric livestock farming can be considered to correspond with, respectively, peasant, petty commodity production, and capitalist modes of production (c.f. Belton, Haque and Little (2012)).

Traditional small-scale monogastric livestock production is relatively insulated from factor and output markets, and thus has the characteristics of a peasant mode production (Ellis, 1993). Producers depend entirely on their own unpaid family labor, use little or no purchased feed or purchased stock (using kitchen waste and own-farm cop processing residues, and obtaining animals from reproduction on-farm), and often sell only a portion of the animals or animal products produced (McDermott et al., 2010). Raising monogastric animals on a small-scale uses limited space, and is usually practiced close to the homestead on land that is inherited, rather than rented or purchased. Little capital investment is required because the number and value of animals produced is small, so raising animals typically accounts for only a small part of a more diverse livelihood portfolio (Ebata, MacGregor, Loevinsohn, & Win, 2020). In addition to supporting subsistence consumption of ASF, small-scale livestock production functions as a form of household savings (Tucker et al., 2022a).

Medium-scale livestock producers engage in petty commodity production, operating at a scale that offers the possibility of generating a surplus, and typically deploying a mix of family and hired labor. Members of the farm household may supervise workers employed for various activities and participate in some or all these activities themselves (Belton et al., 2020). Medium-scale farms often require substantial investment in specialized assets such as farm buildings, electrical transformers, generators, or farm vehicles. This capital is most often obtained by reinvesting savings from livestock farming, other agricultural enterprises, and non-farm income sources, but may also be obtained in part through informal loans (e.g., family members), formal credit providers (banks), or input suppliers (e.g., Belton et al. 2020). Significant areas of land may be needed, and these are often rented or purchased.

Medium-scale livestock farms are highly integrated into input and output markets. Few animals or animal products are retained for own consumption. A high degree of market integration equates to a high level of horizontal integration with other specialist enterprises; usually a mix of small and medium enterprises (SMEs) and larger companies, including veterinarians, feed manufacturers and suppliers, livestock traders, and slaughterhouses, on whose services medium sized farms depend (Ebata, 2022).

Medium-scale farming is often among the most important activities in the livelihood portfolios of the households involved. High levels of capital investment and the use of hired labor create possibilities for profit, expanded reproduction and accumulation (Belton et al., 2012). However, the household-based nature of farming operations means that partial withdrawal from the market by pausing or scaling back operations due to unfavorable market conditions may remain a possibility and an important risk-reducing strategy (e.g., Fang et al. (2021)).

Industrial-scale livestock farms are formal capitalist enterprises (Schneider, 2017). They employ manual workers and staff occupying managerial and technical roles. They may be horizontally integrated with other specialized businesses, or vertically integrated (e.g., through investments in feed milling, grandparent stock farms, food processing operations, and retail or food service outlets) (Thi Dien et al., 2023). Vertically integrated livestock companies may outsource part of their production activities via contract farming arrangements with medium-scale farms, supplying inputs and technical expertise and buying back animals (Thi Dien et al., 2023).

Industrial farms are completely integrated into factor markets, markets for intermediate inputs, and output markets, and are subject to the logic of accumulation, which demands continual reinvestment of profits in the acquisition of additional capital or technology (Wood, 2012). Levels of capital investment can range from large to extremely large, and may be financed by reinvestment profit from own farms and allied businesses, or through formal financial markets (Schneider & Sharma, 2014).

2.2 Technology and environmental impacts

Technological choices are closely linked to scale of production and associated production logics and capital intensity. Scale and technological choice in turn strongly influence the environmental risks and impacts associated with livestock production.

Scale of production is reflected in herd or flock size. This can range from individual animals up to tens of pigs and hundreds of birds at the upper end of the small-scale distribution. Medium-scale farms in turn might house several tens or hundreds of pigs or thousands of birds (Belton et al., 2020), while industrial-scale operations may contain thousands of pigs or tens or hundreds of thousands of birds (Luu et al., 2021).

Small farms often use local breeds obtained from on-farm reproduction or sourced from nearby farms. These breeds may be slow growing and have low meat yields when processed, but be well-adapted to foraging or consuming diets based mainly on low cost, locally available wastes and by-products such as kitchen scraps or broken rice (Hennessey et al., 2021; Thi Dien et al., 2023). Medium-scale farms typically raise fast-growing, high yielding improved breeds, purchased from commercial hatcheries or breeding farms. These breeds demonstrate optimal growth rates when fed commercially manufactured nutritionally complete feeds. Medium sized poultry farms are almost exclusively reliant on improved breeds and formulated feeds, whereas medium-scale pig farms may also make use of local

breeds or hybrids and supplement commercial diets with cheaper farm-made feeds (Belton et al., 2020). Industrial farms use only improved breeds and formulated feeds and are often vertically integrated with feed milling and hatcheries, sometimes with proprietary genetic improvement programs (Chatterjee & Rajkumar, 2015).

Production density (the number of animals raised per unit area) and productivity (biomass of animals produced per unit area over a fixed time) rises sharply from small-scale, through medium- to industrial-scale. Progressively higher levels of capital investment demand higher production densities and shorter production cycles to increase productivity and recover investments. The use of mechanization and automation (e.g., automatic watering and feeding systems, or automatic egg collection systems) in livestock farming increases with scale and intensity (Asche et al., 2018).

The design of production units also evolves with scale and capital intensity, from open or semi-open systems (e.g., scavenging backyard poultry, fenced enclosures), to simple buildings with rudimentary bio-security (e.g., bamboo poultry houses with external netting to prevent entry of wild birds that could be vectors of disease), to completely sealed, climate controlled, bio-secure facilities (FAO et al., 2010a).

Table 1: Scale-based typology of monogastric livestock production in the Global South

	Characteristics	Small	Medium	Industrial
Social & economic organization	Mode of production	Peasant	Petty commodity production	Capitalist
	Labor	Family	Hired + family	Hired + managerial/specialized
	Capital intensity	Low	Medium to high	High to very high
	Source of capital	Own farm	Farm and non-farm (informal)	Formal financial markets, non-farm
	Land ownership	Inherited, occupied	Inherited, rented, purchased	Rented, purchased
	Market integration	Subsistence/partial	Very high (up- and down-stream)	Total
	Economic integration	Endogenous (household)	Horizontal (specialized enterprises)	Horizontal - Vertical
	Livelihood function	Small part of livelihood portfolio	Major part of livelihood portfolio	N/A
Technology & environmental impact	Herd size	Individuals, 10s	100s, 1000s	10,000s – 100,000s
	Breeds	Local, own stock	Improved, purchased	Improved, own lines
	Feeds	Farm & household wastes	Formulated feeds, purchased	Formulated feeds, own manufacture
	Production intensity/yields	Extensive/low	Semi-intensive to intensive/moderate to high	Intensive to super-intensive/high to very high
	Mechanization/automation	None	Limited	High
	Production system/bio-security	Open/low	Semi-closed/low-moderate	Closed/high
	Antibiotic use	Low	Moderate-high	High
	Infectious diseases	Risk of disease spread due to low bio-security	Risk of disease spread due to low bio-security	Risk of emerging novel diseases
	Production efficiency (e.g., CO^2/kg)	Low	Moderate	High
	Local environmental footprint	Low-moderate	Moderate-high	Moderate-high
	Economic risk	Low	Moderate-high	Moderate-low
Food system linkages & spillovers	Production geography	Mostly rural	Mostly peri-urban	Peri-urban
	Market geography	Household, village, urban centers	Urban centers	Urban centers, export
	Food environment	Household, hawker, wet market	Wet market	Modern retail, wet market
	Production & consumption linkages	Low	High	Moderate
	Leakages	Low	Moderate	High
	Governance & regulation (on-farm)	Customary/limited public	Variable/weakly enforced public	Formalized, public and private
	Governance & regulation (value chain)	Limited public	Variable/weakly enforced public	Variable, public and private
	Policy focus	Subsistence, household food security & income	…. Largely missing….	Modernization, growth, food safety, bio-security
	Continuum:			

Antibiotic use is often lowest among traditional extensive small-scale farms while medium-scale farms are often encouraged to apply prophylactic and therapeutic use of antibiotics because of risk of disease outbreaks due to the high density of animals stocked and relatively poor bio-security (Parkhi et al., 2023; Tucker et al., 2022b). The routine inclusion of antibiotics as an ingredient in many animal feeds as a growth promoter further compounds this tendency (Coyne et al., 2019). Similar incentives apply to industrial scale farms, though higher levels of bio-security, vaccination, and – in some cases – targeting of more highly regulated export markets or modern retail chains and compliance with national standards may reduce or regulate antibiotic use (Heft-Neal et al., 2008).

Intensive livestock farming operations tend to utilize feed resources more efficiently than more extensive production systems (McDermott et al., 2010). For example, improvements in breeding, feed formulation, and husbandry have led to progressively lower CO_2 emissions per ton of poultry produced over time (Pelletier et al., 2014), although corresponding increases in production volumes may still result in larger absolute impacts despite improvements in efficiency per unit of output. In contrast, the local environmental impacts of small-scale production (e.g., water pollution, unpleasant odors) are typically lower, and point source pollution and associated externalities can become highly problematic for industrial-scale facilities producing large quantities of manure (Delgado et al., 2008).

Finally, capital intensity, production density, and vulnerability to disease equate to low levels of financial risk for small-scale producers, moderate to high for medium-scale farms (which have made relatively large investments and face significant disease risks), and moderate-low for industrial scale facilities, which face a high level of potential impact from disease outbreaks given the huge investments made, but are also able to invest in bio-security measures that limit exposure to such risk (Ebata, MacGregor, Loevinsohn, & Win, 2020).

2.3. Food system linkages and spillovers

Small-scale farms are predominantly rural, although ‘backyard’ farms may also exist in urban areas. The low numbers of animals marketed per small rural farm, and high transaction costs associated with marketing small quantities, mean that products from these farms are sold primarily in village markets or nearby towns. Rural brokers may also aggregate higher value products such as pigs and local breeds of chicken, for distribution to urban markets (Ebata, 2022; Hennessey et al., 2021; Thi Dien et al., 2023).

In contrast, medium-scale and industrial-scale pig and poultry farms tend to cluster in peri-urban zones close to cities where the specialized inputs and services that they require are available, and where consumers’ incomes and purchasing power are higher than in rural areas, minimizing costs of sourcing inputs and onward distribution of animals for sale (Belton & Fang, 2022). Animals traded into urban wholesale markets may also flow outward to smaller cities and rural areas (Thi Dien et al., 2023).

Links to downstream retail food environments reflect these market geographies. Small farms consume their products or may sell to local consumers, either directly or via traders or wet markets (Ebata et al., 2020). Products from medium sized farms, who find it difficult to comply with traceability requirements or standards, are sold primarily through domestic wet markets (Ebata, 2022). Industrial-scale farms are formal enterprises, capable of compliance with standards such as international HACCP and traceability requirements (Trienekens & Zuurbier, 2008). They may also supply domestic wet markets but are the main suppliers to modern retail (i.e. domestic supermarkets and formal food service outlets)

and export markets, which tend to require compliance with food safety and traceability standards from suppliers (Thi Dien et al., 2023).

Medium-scale farms are generally dependent on intermediaries to market their products, whereas industrial-scale operations are often at least partially vertically integrated and may supply larger retail buyers directly. The largest of these (e.g., the Thai company CP) may also incorporate processing and value addition, and operate their own retail outlets (Thi Dien et al., 2023).

Production and consumption linkages (economic multipliers associated with the acquisition of locally traded production inputs and consumption goods procured by farms) and leakages (transfer of farm profits to locations outside the area where they were generated) (Haggblade et al., 2007) may be low for small livestock farms, which utilize few inputs (including labor) and services and generate little profit. Medium sized farms may generate larger production, consumption, and employment linkages via expenditure on locally available inputs and services and hiring workers. As many medium sized farms are owner-operated, farm profits are often used to fund consumption expenditure on locally traded items such as food, transport, or construction (Filipski & Belton, 2018).

In contrast, industrial farms, especially if vertically integrated, may manufacture production inputs (e.g., from own feed milling operations) or source them directly from distant locations. Because of scale economies and automation, industrial farms may create fewer employment linkages than medium-scale farms, per area of land (Filipski & Belton, 2018). Profits from large-scale farms are likely to be repatriated to absentee owners or shareholders located in urban areas or overseas, or spent on high value items (e.g., cars) that are not traded in the vicinity of the farm, resulting in high levels of economic leakages (Haggblade et al., 2007).

The reach and depth of formal farm-level governance and regulation mechanisms varies across countries and farm scales. Governance and regulation of small-scale livestock production is predominantly informal with limited government oversight (Vorley, 2013). Formal regulation tends to increase in proportion to farm size but the breadth of coverage and stringency of enforcement or regulations can vary from country to country, and is sometimes weakly enforced (Lam et al., 2019).

3. ANALYSIS OF EXISTING POLICIES

In this section, we examine livestock development policies from three Asian countries, Myanmar, Vietnam, and Bangladesh, for which national livestock policies are available. Specifically, we review the Bangladesh *National Livestock Development Policy* (Government of Bangladesh, 2007); Vietnam's *Animal Husbandry Development Strategy* 2021-2030 and Vision for 2045 (Government of Vietnam, 2020); and Myanmar's *National Action Plan for Poverty Alleviation and Rural Development through Agriculture* (NAPA) (Government of Myanmar, 2016). Analysis of these documents helps to reveal the underlying assumptions guiding policymakers in LMICs with respect to livestock sector development goals.

Key elements of the visions or strategies for each country's respective livestock sector, as expressed in the three documents, and the policy tools proposed to address them are synthesized in Table 2. We expand on this analysis in the text below, structured with reference to the three pillars presented in Table 1.

Table 2: Policy tools per visions for livestock sector development

Livestock sector visions	Policy tools	Countries*
Social and economic organization		
Better organized animal marketing and commercialization	• Collective actions by smallholder farmers. • Better information access regarding commodity prices for smallholder farmers.	BD
	• Vertical integration along animal value chains. • Private investment to centralize animal trading.	VN
Technology and environmental impact		
Improving veterinary, public health and environmental impact of livestock farms; improving farm productivity	• Promotion of cross-bred animal species, between high-productivity exotic breeds and high-resilience indigenous breeds.	VN, BD, MM
	• Branding of indigenous breeds for export markets.	VN
Increasing the quantity, quality and stability of animal feed supply.	• Monitoring and reducing antimicrobial use in animal feed.	VN, BD
	• Producing 70% of commercial feed domestically.	VN
Controlling infectious diseases; improving farm productivity; reducing environmental footprints	• Improving the capacity of public sector animal healthcare providers and public disease control capacity.	MM
	• Facilitating private sector engagement in providing veterinary healthcare to farmers, research and innovation, and improving the quality of farm inputs	VN, BD
	• Strengthening community-based veterinary services. • Disease monitoring and control, including trans-boundary diseases.	BD
	• Monitoring and controlling animal production and farm management by the private sector. • Providing extension programs for closed loop animal husbandry practice and circular economy and disease monitoring. • Produce 100% of meat from concentrated industrial slaughterhouses. • Converting animal waste into organic fertilizer.	VN
Food systems linkages and spillovers		
Modern and industrialized livestock value chains	• Provide tax incentives to private investors and private companies to establish modern facilities for farms, slaughter, processing and retail. • Minimize risks of such investment through government-sponsored insurance.	VN

*Countries: Vietnam (VN); Bangladesh (BD); and Myanmar (MM)

3.1. Social and economic organization

Myanmar's NAPA and Bangladesh's Livestock Policy emphasize the livelihood aspects of the sector, thereby aiming to tailor policies to support small-scale livestock farmers. The documents emphasize that small-scale farms are central to production of poultry and (in Myanmar) pigs, and are operated mainly with family labor. Smallholders are thought to have limited access to land, which prevents them from taking advantage of lower interest rates offered by formal loan providers (p.20, Myanmar). Keeping small livestock, particularly pigs and poultry, is noted as an important way for landless or land-constrained people in Myanmar to earn income, as they can be raised on a limited area of land. In both Myanmar and Bangladesh, most farms are assumed to raise livestock at low intensity, with limited capital

investment. As a result, both countries' policies focus on supporting small-scale livestock farmers to increase their incomes, and thereby improving livelihood opportunities from the livestock sector.

In contrast, Vietnam's policy logic is driven by the desire to modernize and industrialize livestock production, trade, slaughter, and processing. While Vietnam's policy document is not explicit in its understanding of the structure of the existing livestock sector, its vision is driven by the aspiration to increase the scale of existing pig and poultry farms. To do so, the policy actively supports private investment to develop livestock farms, breeding facilities and concentrated slaughterhouses in government-designated zones outside residential areas. Their key strategy is to encourage investors and companies to establish highly capital-intensive animal farms, slaughter and processing facilities through tax incentives (p.6), and to provide insurance to minimize risks through government budget support (p.6).

In terms of livestock marketing, Myanmar's NAPA and Bangladesh's policy suggest that pigs and poultry products are marketed through a network of traders to both rural and urban domestic markets. Both policy documents mention the oligopolistic nature of the markets that smallholder farmers participate in, suggesting that traders can exercise their market power to reduce farm-gate prices. In Bangladesh, fostering collective action by farmers and reducing information asymmetry regarding market prices for poultry is suggested as a remedy to help farmers benefit from market participation. In Vietnam, the policy supports the vertical integration of animal supply chains and encourages private companies to develop a centralized system for trading animal products through, for example, controlled wholesale markets, an auction system and electronic trading platforms (p.6).

3.2. Technology and environmental impact

Policy documents from Vietnam and Bangladesh emphasize the need to reduce public health risks and environmental externalities from the livestock sector, while Myanmar's policy focuses on improving farm productivity. All three countries produce a mixture of indigenous native animal breeds and imported exotic breeds. Policy documents tend to represent indigenous breeds as low in productivity and commonly raised by small-scale farmers, yet resilient to the local climatic and environmental conditions. Conversely, exotic breeds are presented as highly productive but vulnerable to disease and environmental stress. As a result, all three documents recognize the potential to achieve high productivity and resilience by cross-breeding native and exotic animals. Vietnam encourages the branding of indigenous breeds for the high-end and export markets.

While none of the three documents is explicit about farm sizes in their countries, both Vietnam and Bangladesh express a commitment to scaling up farm production. Vietnam's policy document aims to produce 70% and 60% of pigs and chickens, respectively, in industrialized farms by 2030. Bangladesh does not make such an explicit claim, but encourages the conversion of small-scale poultry farms into large commercially-oriented operations.

Myanmar's NAPA suggests that smallholders do not utilize commercial animal feed, and rely mainly on crop-residues and household wastes (p. 22), whereas commercial farmers use purchased animal feeds. Bangladesh cites feed shortages as "one of the single most important obstacles to livestock development" (p.13). The poor quality of available feeds is also said to hamper productivity gains. Bangladesh and Vietnam both emphasize the role of government in monitoring and reducing antimicrobial use in animal feed. Vietnam's policy aims to achieve 70% self-sufficiency in concentrated animal feed production by 2030 (p.4).

Control of infectious diseases, thereby improving farm productivity, is closely linked to the availability and quality of veterinary healthcare. Myanmar's NAPA assumes that veterinary healthcare is provided to small-scale farmers by Community Animal Health Workers (CAHWs, public sector veterinary assistants) who provide vaccination and treatment, but acknowledges that small commercial farms have limited access to veterinary expertise and learn about treatment and farm management techniques "on the job (p.19)". In contrast, commercial farms are said to receive veterinary health care from trained veterinarians, mainly – if not exclusively – through the private sector (p.25) and to have access to information on appropriate bio-security, optimal feeding practices, market dynamics and animal health. Such farms are considered to have access to government services such as laboratory-based disease diagnostics for infectious diseases (p.21). As a result, the main policy tool for improving smallholder productivity is investing in the capacity of CAHWs and public disease control capabilities (p.46).

Vietnam and Bangladesh's policy documents recognize the active role of the private sector without referring to their outreach to smallholder or large-scale farmers. As a result, policies aim to facilitate private sector engagement in veterinary healthcare provision (p.12, Bangladesh), research and innovation, and improving the quality of farm inputs (p.8, Vietnam). The state's role is formulated as providing public goods and support to marginalized actors through, for instance, strengthening community-based veterinary services (Bangladesh), targeting agricultural extension programs for "closed loop animal husbandry practice and circular economy" in response to public health and environmental concerns (p.7, Vietnam), and disease monitoring and control (including trans-boundary diseases) (p.12, Bangladesh).

While the environmental footprint of livestock production is scarcely mentioned in Myanmar's NAPA, Vietnam's policy is explicit about controlling environmental aspects of animal production. The suggested tool is to produce 100% of livestock and poultry meat from concentrated and industrial slaughterhouses (p.5). The document also refers to waste treatment technologies to convert animal waste into organic fertilizer (p.8) and provision of extension services for closed loop animal husbandry practices and a circular economy (p.7). Similar to Vietnam, Bangladesh mentions the need to improve environmental protection of poultry farms where antibiotics in feeds pose public health threats (p.9). Specifically in relation to the poultry sector, the document indicates that "commercial poultry farms" (p.9) have an urgent need to improve their environmental footprint.

3.3. Food system linkages and spillovers

Farm linkages to non-farm value chain segments and the broader food system receive limited attention in the policy documents reviewed. This may be because Myanmar and Bangladesh's policy documents are concerned mainly with livestock in the context of rural development. The lack of emphasis on off-farm segments of the value chain may also reflect the perception that smallholders are weakly integrated into markets.

Vietnam is the only country to discuss strategies for developing the livestock sector that extend beyond the farm. Vietnam's vision is to develop modernized transport and concentrated slaughter premises for all domestic animals by 2030. This is to ensure disease prevention, food safety, environmental management, and animal welfare. Similarly, Vietnam's policy is explicit about promoting trade-marked animal products and strengthening vertical linkages along animal supply chains (p.6).

Vietnam's strategy encourages collaboration with the private sector in research related to animal husbandry and veterinary medicine (p.8). The policy positions the state's role as facilitating businesses

to conduct quality control and “safety supervision” by themselves (p.11), whilst improving public capacity to monitor and control animal production and farm management standards implemented by the private sector. In other words, the strategy emphasizes the need for government to work closely with the private sector and delegate specific tasks related to livestock production and commerce, while managing their actions within the realm of public interests.

4. POLICY IMPLICATIONS AND CONCLUSIONS

In this concluding section, we synthesize and discuss the implications of our analysis of farm scale and selected policy measures across Asia. We focus on three areas where we have identified gaps between representations of livestock farming in policy debates and the reality ‘on the ground’, namely: (1) Access to veterinary healthcare; (2) Capital investment and sustainable intensification; and (3) Livelihoods.

The assumption that small-scale farms rely predominantly on the public sector for veterinary health services leads policymakers to advocate for investing in the public veterinary system. This notion is prominent in academic literature. For example, Alawneh et al. (2014) show that small-scale pig farmers in the Philippines generally accessed veterinary healthcare through the public system while commercial farms utilized private veterinarians. Similarly, in Thailand and China, the larger the farms are, the more likely they are to hire on-farm veterinarians (Lekagul et al., 2021; McOrist et al., 2011). However, as our analysis shows, and as documented in the literature, small- and medium-scale farmers use a combination of both (Alawneh et al., 2014; Gizaw et al., 2021; Lekagul et al., 2021) and sometimes rely more heavily on advice and care from the private sector (Hallenberg et al., 2020). Therefore, instead of focusing exclusively on the public veterinary healthcare, policy makers could facilitate improved access to veterinary healthcare for farmers of all scales through both private and public channels and specialize in effective monitoring and control of the quality of care provided by the private sector.

Similarly, the dichotomous understanding of farming scales encourages policymakers to seek to attract private sector investment in industrial-scale animal farms and downstream activities in supply chains, particularly in Vietnam. However, our analysis suggests that medium-scale farms have access to significant capital, and interest in and capabilities to improve on-farm bio-security, technical efficiency, and productivity. Indeed, commercial livestock farming requires capital investment: to improve animal housing, purchase improved breeds, and market animals (FAO et al., 2010b; Jabbar et al., 2002). For example, Dercon (2004) shows that Ethiopian households invest between 20 and 40 percent of their annual income to market their livestock. Facilitating further capital investment by medium-scale farms would require, for instance, lifting barriers to access formal loans and supporting efforts to formalize farm status, rather than aiming to attract larger private investors and businesses through subsidies and tax breaks.

The livelihood contributions of small-scale livestock farming are central to policy priorities in Myanmar and Bangladesh. The benefits of livestock keeping – including income and nutrition security (Randolph et al., 2007) – especially for vulnerable groups such as women (Kristjanson et al., 2014) are well documented in the literature. Earnings from production of animal source foods are often higher than from crop farming and can be used to support the costs of children’s education and/or healthcare (Thys et al., 2016), providing families with opportunities to escape from poverty.

While the policy documents we reviewed recognize these aspects, their strategies to enhance livelihoods remain vague and often refer to farm industrialization, strengthening vertical integration and improving export potential. As our analysis shows, these measures are more likely to lead to leakage of economic benefits from rural areas and their concentration among few hands located in urban centers as well as encourage diets linked to non-communicable diseases (Queenan et al., 2022). An alternative, and potentially more equitable approach would be to invest in fostering medium-scale farms with greater potential to create growth linkages via their demand for locally traded goods and services, and through labor markets.

In summary, our paper problematizes that the policy documents reviewed and academic debates maintain a largely dichotomous understanding of scale in livestock farming and supply chains. As a result, policy visions and tools are not well adjusted to addressing the rapidly changing face of livestock production. We argue that this is a missed opportunity for public policies to support the transformation of the livestock sector in the region and beyond. Both large- and small-scale farms are associated with social and environmental challenges such as malnutrition (e.g. obesity), infectious diseases (Liverani et al., 2013), and pollution (Lander et al., 2020; Schneider, 2017; Woldegebriel et al., 2017). When appropriately supported, medium-scale farms can help improve the social, economic, and environmental performance and sustainability of the livestock sector in LMICs. In order to do so, policy and academic communities need to recognize the distinct characteristics of the medium-scale farms and tailor policies to their realities.

ABOUT THE AUTHORS

Ayako Ebata is a research fellow with the Health and Nutrition, and Business, Markets and State clusters at the Institute of Development Studies, UK, based in the Netherlands

Ben Belton is a research fellow in the Development Strategies and Governance Unit of IFPRI and an associate professor in the Department of Agricultural, Food, and Resource Economics at Michigan State University, based in Bangladesh

ACKNOWLEDGMENTS

The authors thank Durjoy Dey (IFPRI Bangladesh) for his GIS and editing contributions.

Funding for this work was provided by The Zoonoses and Emerging Livestock Systems (ZELS) scheme (BB/L018934/1) by Biotechnology and Biological Sciences Research Council, Economic and Social Sciences Research Council, Medical Re-search Council, Natural Environment Research Council, Defence Science and Technology Laboratory, and the Department for International Development of the United Kingdom; The UKRI GCRF One Health Poultry Hub (Grant No. B/S011269/1), one of twelve interdisciplinary research hubs funded under the UK government's Grand Challenge Research Fund Interdisciplinary Research Hub initiative; The Myanmar Agricultural Policy Support Activity (MAPSA) led by the International Food Policy Research Institute in partnership with Michigan State University. Funding support for MAPSA was provided by the United States Agency of International Development (USAID), and the Livelihoods and Food Security Fund (LIFT).

This publication has been prepared as an output of The CGIAR Initiative on Securing the Food Systems of Asian Mega - Deltas for Climate and Livelihood Resilience (INIT-18), which is carried out with support from funders through their contributions to the CGIAR Trust Fund. For details, please visit https://www.cgiar.org/funders/

REFERENCES

Alawneh, J. I., Barnes, T. S., Parke, C., Lapuz, E., David, E., Basinang, V., Baluyut, A., Villar, E., Lopez, E. L., & Blackall, P. J. (2014). Description of the pig production systems, biosecurity practices and herd health providers in two provinces with high swine density in the Philippines. *Preventive Veterinary Medicine*, *114*(2), 73–87. https://doi.org/10.1016/j.prevetmed.2014.01.020

Asche, F., Cojocaru, A. L., & Roth, B. (2018). The development of large scale aquaculture production: A comparison of the supply chains for chicken and salmon. *Aquaculture*. https://doi.org/10.1016/j.aquaculture.2016.10.031

Belton, B., Cho, A., Payongayong, E., Mahrt, K., & Abaidoo, E. (2020). Commercial poultry and pig farming in Yangon's peri-urban zone. In *FSP Research Paper* (174).

Belton, B., & Fang, P. (2022). *Livestock, capture fisheries, and aquaculture in Myanmar: Status and recent*.

Belton, B., Haque, M. M., & Little, D. C. (2012). Does Size Matter? Reassessing the Relationship between Aquaculture and Poverty in Bangladesh. *Journal of Development Studies*. https://doi.org/10.1080/00220388.2011.638049

Bennett, C. E., Thomas, R., Williams, M., Zalasiewicz, J., Edgeworth, M., Miller, H., Coles, B., Foster, A., Burton, E. J., & Marume, U. (2018). The broiler chicken as a signal of a human reconfigured biosphere. *Royal Society Open Science*, *5*(12). https://doi.org/10.1098/RSOS.180325

Bush, S. R., Belton, B., Little, D. C., & Islam, M. S. (2019). Emerging trends in aquaculture value chain research. *Aquaculture*, *498*, 428–434. https://doi.org/10.1016/J.AQUACULTURE.2018.08.077

Chatterjee, R. N., & Rajkumar, U. (2015). An overview of poultry production in India. *Indian Journal of Animal Health*, *54*(2), 89–108.

Coyne, L., Arief, R., Benigno, C., Giang, V. N., Huong, L. Q., Jeamsripong, S., Kalpravidh, W., McGrane, J., Padungtod, P., Patrick, I., Schoonman, L., Setyawan, E., Sukarno, A. H., Srisamran, J., Ngoc, P. T., & Rushton, J. (2019). Characterizing antimicrobial use in the livestock sector in three south east asian countries (Indonesia, thailand, and vietnam). *Antibiotics*. https://doi.org/10.3390/antibiotics8010033

Delgado, C. L., Narrod, C. A., Tiongco, M. M., de Camargo Barros, G. S. A., Catelo, M. A., Costales, A., Mehta, R., Naranong, V., Poapongsakorn, N., Sharma, V. P., & de Zen, S. (2008). Determinants and implications of the growing scale of livestock farms in four fast-growing developing countries. *Research Report of the International Food Policy Research Institute*. https://doi.org/10.2139/ssrn.1275538

Dercon, S. (2004). Growth and shocks: Evidence from rural Ethiopia. *Journal of Development Economics*, *74*(2), 309–329. https://doi.org/10.1016/j.jdeveco.2004.01.001

Ebata, A. (2022). Social embeddedness of pig value chains in Myanmar and its implications for food and nutrition security. *Food Security 2022*, 1–12. https://doi.org/10.1007/S12571-022-01278-9

Ebata, A., MacGregor, H., Loevinsohn, M., & Win, K. S. (2020). Why behaviours do not change: structural constraints that influence household decisions to control pig diseases in Myanmar. *Preventive Veterinary Medicine*, *183*, 105138. https://doi.org/10.1016/j.prevetmed.2020.105138

Ebata, A., MacGregor, H., Loevinsohn, M., Win, K. S., & Tucker, A. W. (2020). Value Chain Governance, Power and Negative Externalities: What Influences Efforts to Control Pig Diseases in Myanmar? *European Journal of Development Research*, *32*(3), 759–780. https://doi.org/10.1057/s41287-019-00239-x

Edwards, P., Zhang, W., Belton, B., & Little, D. C. (2019). Misunderstandings, myths and mantras in aquaculture: Its contribution to world food supplies has been systematically over reported. *Marine Policy*, *106*, 103547. https://doi.org/10.1016/J.MARPOL.2019.103547

Ellis, F. (1993). Peasant economics: farm households and agrarian development. Second edition. *Peasant Economics: Farm Households and Agrarian Development. Second Edition*.

Fang, P., Belton, B., Zhang, X., & Ei Win, H. (2021). Impacts of COVID-19 on Myanmar's chicken and egg sector, with implications for the sustainable development goals. *Agricultural Systems*, *190*, 103094. https://doi.org/10.1016/J.AGSY.2021.103094

FAO. (2009). *Livestock keepers: guardians of biodiversity*.

FAO. (2021). *FAOSTAT*. http://faostat.fao.org/beta/en/#home

FAO. (2024). *FAOSTAT*. http://faostat.fao.org/beta/en/#home

FAO, OIE, & World Bank. (2010a). Good practices for biosecurity in the pig sector - Issues and options in developing and transition countries. In *FAO Animal Production and Health Paper No. 169* (169).

FAO, OIE, & World Bank. (2010b). Good practices for biosecurity in the pig sector - Issues and options in developing and transition countries. In *FAO Animal Production and Health Paper No. 169* (169). http://www.fao.org/3/a-i1435e.pdf

Filipski, M., & Belton, B. (2018). Give a Man a Fishpond: Modeling the Impacts of Aquaculture in the Rural Economy. *World Development*. https://doi.org/10.1016/j.worlddev.2018.05.023

Gilbert, M., Xiao, X., & Robinson, T. P. (2017). Intensifying poultry production systems and the emergence of avian influenza in China: A 'One Health/Ecohealth' epitome. *Archives of Public Health*, *75*(1), 48. https://doi.org/10.1186/s13690-017-0218-4

Gizaw, S., Woldehanna, M., Anteneh, H., Ayledo, G., Awol, F., Gebreyohannes, G., Gebremedhin, B., & Wieland, B. (2021). Animal Health Service Delivery in Crop-Livestock and Pastoral Systems in Ethiopia. *Frontiers in Veterinary Science*, *8*, 601878. https://doi.org/10.3389/fvets.2021.601878

Government of Bangladesh. (2007). *National livestock development policy*.

Government of Myanmar. (2016). *Livestock production, extension and applied research* (2; Formulation and Operationalization of National Action Plan for Poverty Alleviation and Rural Development through Agriculture (NAPA)).

Government of Vietnam. (2020). *Decision: Approving animal husbandry development strategy for 2021 - 2030 and vision for 2045*.

Haggblade, S., Hazell, P. B. R., & Dorosh, P. A. (2007). Sectoral Growth Linkages between Agriculture and the Rural Nonfarm Economy. *Transforming the Rural Nonfarm Economy: Opportunities and Threats in the Developing World*, *February 2015*, 141–182.

Hallenberg, G. S., Jiwakanon, J., Angkititrakul, S., Kang-Air, S., Osbjer, K., Lunha, K., Sunde, M., Järhult, J. D., van Boeckel, T. P., Rich, K. M., & Magnusson, U. (2020). Antibiotic use in pig farms at different levels of intensification—Farmers' practices in northeastern Thailand. *PLoS ONE*, *15*(12 December). https://doi.org/10.1371/journal.pone.0243099

Heft-Neal, S., Otte, J., Pupphavessa, W., Roland-Holst, D., Sudsawasd, S., & Zilberman, D. (2008). *Supply chain auditing for poultry production in Thailand* (Pro-Poor Livestock Policy Initiative Research Report).

Hennessey, M., Fournié, G., Hoque, M. A., Biswas, P. K., Alarcon, P., Ebata, A., Mahmud, R., Hasan, M., & Barnett, T. (2021). Intensification of fragility: Poultry production and distribution in Bangladesh and its implications for disease risk. *Preventive Veterinary Medicine*, *191*, 105367. https://doi.org/10.1016/j.prevetmed.2021.105367

Huynh, T. T. T., Aarnink, A. J. A., Drucker, A., & Verstegen, M. W. A. (2007). Pig Production in Cambodia, Laos, Philippines, and Vietnam: A Review. *Asian Journal of Agriculture and Development*, *4*(1), 70–90.

Jabbar, M. A., Ehui, S. K., & von Kaufmann, R. (2002). Supply and demand for livestock credit in sub-Saharan Africa: Lessons for designing new credit schemes. *World Development*, *30*(6), 1029–1042. https://doi.org/10.1016/S0305-750X(02)00021-9

Jayne, T. S., Muyanga, M., Wineman, A., Ghebru, H., Stevens, C., Stickler, M., Chapoto, A., Anseeuw, W., van der Westhuizen, D., & Nyange, D. (2019). Are medium-scale farms driving agricultural transformation in sub-Saharan Africa? *Agricultural Economics*, *50*(S1), 75–95. https://doi.org/10.1111/agec.12535

Johnson, D. S. (2006). Category, narrative, and value in the governance of small-scale fisheries. *Marine Policy*. https://doi.org/10.1016/j.marpol.2006.01.002

Kristjanson, P., Waters-Bayer, A., Johnson, N., Tipilda, A., Njuki, J., Baltenweck, I., Grace, D., & MacMillan, S. (2014). Livestock and Women's Livelihoods. In *Gender in Agriculture* (pp. 209–233). Springer Netherlands. https://doi.org/10.1007/978-94-017-8616-4_9

Lam, Y., Fry, J. P., & Nachman, K. E. (2019). Applying an environmental public health lens to the industrialization of food animal production in ten low- A nd middle-income countries. *Globalization and Health*. https://doi.org/10.1186/s12992-019-0479-5

Lander, B., Schneider, M., & Brunson, K. (2020). A History of Pigs in China: From Curious Omnivores to Industrial Pork. *Journal of Asian Studies*, *79*(4), 865–889. https://doi.org/10.1017/S0021911820000054

Lekagul, A., Tangcharoensathien, V., Liverani, M., Mills, A., Rushton, J., & Yeung, S. (2021). Understanding antibiotic use for pig farming in Thailand: a qualitative study. *Antimicrobial Resistance and Infection Control*, *10*(1), 1–11. https://doi.org/10.1186/s13756-020-00865-9

Liu, Q., Cao, L., & Zhu, X. Q. (2014). Major emerging and re-emerging zoonoses in China: A matter of global health and socioeconomic development for 1.3 billion. In *International Journal of Infectious Diseases* (Vol. 25, pp. 65–72). https://doi.org/10.1016/j.ijid.2014.04.003

Liverani, M., Waage, J., Barnett, T., Pfeiffer, D. U., Rushton, J., Rudge, J. W., Loevinsohn, M. E., Scoones, I., Smith, R. D., Cooper, B. S., White, L. J., Goh, S., Horby, P., Wren, B., Gundogdu, O., Woods, A., & Coker, R. J. (2013). Understanding and managing zoonotic risk in the new livestock industries. In *Environmental Health Perspectives* (Vol. 121, Issue 8, pp. 873–877). https://doi.org/10.1289/ehp.1206001

Lucila, M., & Lapar, A. (2014). *Review of the Pig Sector in Vietnam*.

Luu, Q. H., Nguyen, T. L. A., Pham, T. N., Vo, N. G., & Padungtod, P. (2021). Antimicrobial use in household, semi-industrialized, and industrialized pig and poultry farms in Viet Nam. *Preventive Veterinary Medicine*, *189*, 105292. https://doi.org/10.1016/J.PREVETMED.2021.105292

McDermott, J. J., Staal, S. J., Freeman, H. A., Herrero, M., & Van de Steeg, J. A. (2010). Sustaining intensification of smallholder livestock systems in the tropics. *Livestock Science*, *130*, 95–109.

McOrist, S., Khampee, K., & Guo, A. (2011). Modern pig farming in the People's Republic of China: Growth and veterinary challenges. *OIE Revue Scientifique et Technique*, *30*(3), 961–968. https://doi.org/10.20506/rst.30.3.2091

Minten, B., Mohammed, B., & Tamru, S. (2020). Emerging Medium-Scale Tenant Farming, Gig Economies, and the COVID-19 Disruption: The Case of Commercial Vegetable Clusters in Ethiopia. *European Journal of Development Research*, *32*(5), 1402–1429. https://doi.org/10.1057/s41287-020-00315-7

Neven, D., Odera, M. M., Reardon, T., & Wang, H. (2009). Kenyan Supermarkets, Emerging Middle-Class Horticultural Farmers, and Employment Impacts on the Rural Poor. *Agrifood Industry Transformation and Small Farmers in Developing Countries*, *37*(11), 1802–1811.

Otte, M. J., & Mcleod, R. (2004). *Transboundary Animal Diseases: Assessment of socio-economic impacts and institutional responses*.

Parkhi, C. M., Liverpool-Tasie, L. S. O., & Reardon, T. (2023). Do smaller chicken farms use more antibiotics? Evidence of antibiotic diffusion from Nigeria. *Agribusiness*. https://doi.org/10.1002/agr.21770

Pelletier, N., Ibarburu, M., & Xin, H. (2014). Comparison of the environmental footprint of the egg industry in the United States in 1960 and 2010. *Poultry Science*, *93*(2), 241–255. https://doi.org/10.3382/PS.2013-03390

Philipsson, J., Kosgey, I. S., Amimo, J., Okeyo, A. M., Ojango, J. M., & Mbuku, S. M. (2011). Institutional and organizational frameworks for dairy and beef cattle recording in Kenya: a review and opportunities for improvement. *Animal Genetic Resources*, *48*, 1–11. https://doi.org/10.1017/s2078633610001220

Qanti, S. R., Reardon, T., & Iswariyadi, A. (2017). Triangle of Linkages among Modernising Markets, Sprayer–traders, and Mango-farming Intensification in Indonesia. *Https://Doi.Org/10.1080/00074918.2017.1299923*, *53*(2), 187–208. https://doi.org/10.1080/00074918.2017.1299923

Queenan, K., Cuevas, S., Mabhaudhi, T., Chimonyo, M., Shankar, B., Slotow, R., & Häsler, B. (2022). A food systems approach and qualitative system dynamics model to reveal policy issues within the commercial broiler chicken system in South Africa. *PLoS ONE*, *17*(6 June). https://doi.org/10.1371/journal.pone.0270756

Randolph, T. F., Schelling, E., Grace, D., Nicholson, C. F., Leroy, J. L., Cole, D. C., Demment, M. W., Omore, A., Zinsstag, J., & Ruel, M. (2007). Role of livestock in human nutrition and health for poverty reduction in developing countries. *Journal of Animal Science*, *85*(11), 2788–2800. https://doi.org/10.2527/jas.2007-0467

Reardon, T., Chen, K., Minten, B., & Adriano, L. (2012). *The Quiet Revolution in Staple Food Value Chains Enter the Dragon, the Elephant, and the Tiger The Quiet Revolution in Staple Food Value Chains: Enter the Dragon, the Elephant, and the Tiger Printed on recycled paper Printed in the Philippines*.

Reardon, T., Chen, K. Z., Minten, B., Adriano, L., Dao, T. A., Wang, J., & Gupta, S. Das. (2014). The quiet revolution in Asia's rice value chains. *Annals of the New York Academy of Sciences*, *1331*(1), 106–118. https://doi.org/10.1111/nyas.12391

Sanou, A., Liverpool-Tasie, L. S. O., & Kerr, J. M. (2020). Threshold investment and firm viability: Evidence from commercial poultry farms in Nigeria. *Agribusiness*, *36*(3), 422–439. https://doi.org/10.1002/agr.21639

Schneider, M. (2017). Wasting the rural: Meat, manure, and the politics of agro-industrialization in contemporary China. *Geoforum*, *78*, 89–97. https://doi.org/10.1016/j.geoforum.2015.12.001

Schneider, M., & Sharma, S. (2014). *China's Pork Miracle? Agribusiness and Development in China's Pork Industry*. Institute for Agriculture and Trade Policy.

Scott, J. M., Belton, · Ben, Mahrt, K., Thilsted, S. H., & Bogard, J. R. (2023). *Food systems transformation, animal-source foods consumption, inequality, and nutrition in Myanmar*. *15*, 1345–1364. https://doi.org/10.1007/s12571-023-01380-6

Scudiero, L., Mehroosh Tak, ·, Alarcón, P., & Shankar, · Bhavani. (2023). *Understanding household and food system determinants of chicken and egg consumption in India*. *15*, 1231–1254. https://doi.org/10.1007/s12571-023-01375-3

Shonhe, T., Scoones, I., & Murimbarimba, F. (2020). Medium-scale commercial agriculture in Zimbabwe: the experience of A2 resettlement farms. *The Journal of Modern African Studies*, *58*(4), 601–626. https://doi.org/10.1017/S0022278X20000385

Swinnen, J. F. M. (2007). Global supply chains, standards and the poor: How the globalization of food systems and standards affects rural development and poverty. In *Global Supply Chains, Standards and the Poor: How the Globalization of Food Systems and Standards Affects Rural Development and Poverty* (Issue March). CABI. https://doi.org/10.1111/j.1467-8276.2009.01331_2.x

Thi Dien, N., Thi Minh Khue, N., Ebata, A., Fournié, G., Huyen, L. T. T., Van Dai, N., Tuan, H. A., Duc, D. Van, Thi Thanh Hoa, P., Van Duy, N., Ton, V. D., & Alarcon, P. (2023). Mapping chicken production and distribution networks in Vietnam: An analysis of socio-economic factors and their epidemiological significances. *Preventive Veterinary Medicine*, *214*, 167–5877. https://doi.org/10.1016/j.prevetmed.2023.105906

Thys, S., Mwape, K. E., Lefèvre, P., Dorny, P., Phiri, A. M., Marcotty, T., Phiri, I. K., & Gabriël, S. (2016). Why pigs are free-roaming: Communities' perceptions, knowledge and practices regarding pig management and taeniosis/cysticercosis in a Taenia solium endemic rural area in Eastern Zambia. *Veterinary Parasitology*, *225*, 33–42. https://doi.org/10.1016/j.vetpar.2016.05.029

Tisdell, C. A., Kehren, T. C., & Murphy, T. D. (1998). The pig and poultry industries in Thailand: development, trade and commerce. *Sasin Journal of Management*, *4*, 1–18.

Trienekens, J., & Zuurbier, P. (2008). Quality and safety standards in the food insutry, developments and challenges. *International Journal of Production Economics*, *113*, 107–122.

Tucker, A. W., MacGregor, H., Ebata, A., & Hoa, N. T. (2022a). *Pig meat and food safety in Myanmar: evidence to support practice*.

Tucker, A. W., MacGregor, H., Ebata, A., & Hoa, N. T. (2022b). *Taking Myanmar's AMR National Action Plan forward*. https://doi.org/10.19088/IDS.2022.060

Udo, H., Weiler, V., Modupeore, O., Viets, T., & Oosting, S. (2016). Intensification to reduce the carbon footprint of smallholder milk production: Fact or fiction? *Outlook on Agriculture*, *45*(1), 33–38. https://doi.org/10.5367/oa.2016.0229

Van Boeckel, T. P., Brower, C., Gilbert, M., Grenfell, B. T., Levin, S. A., Robinson, T. P., Teillant, A., & Laxminarayan, R. (2015). Global trends in antimicrobial use in food animals. *Proceedings of the National Academy of Sciences of the United States of America*, *112*(18), 5649–5654. https://doi.org/10.1073/pnas.1503141112

Van Hoyweghen, K., Fabry, A., Feyaerts, H., Wade, I., & Maertens, M. (2021). Resilience of global and local value chains to the Covid-19 pandemic: Survey evidence from vegetable value chains in Senegal. *Agricultural Economics*, *January*, 1–18. https://doi.org/10.1111/agec.12627

Vorley, B. (2013). *Meeting small-scale farmers in their markets: understanding and improving the institutions and governance of informal agri-food trade*.

Woldegebriel, D., Udo, H., Viets, T., van der Harst, E., & Potting, J. (2017). Environmental impact of milk production across an intensification gradient in Ethiopia. *Livestock Science*, *206*(April), 28–36. https://doi.org/10.1016/j.livsci.2017.10.005

Wood, E. M. (2012). Peasants and the market imperative: The origins of capitalism. In *Peasants and Globalization: Political Economy, Rural Transformation and the Agrarian Question*. https://doi.org/10.4324/9780203891834-4

Funding for this work was provided by Biotechnology and Biological Sciences Research Council, Economic and Social Sciences Research Council, Medical Re-search Council, Natural Environment Research Council, Defence Science and Technology Laboratory, and the Department for International Development of the United Kingdom; The UKRI GCRF One Health Poultry Hub; and the Myanmar Agricultural Policy Support Activity (MAPSA). This publication has been prepared as an output of The CGIAR Initiative on Securing the Food Systems of Asian Mega - Deltas for Climate and Livelihood Resilience (INIT-18), and has not been independently peer reviewed. Any opinions expressed here belong to the authors and are not necessarily representative of or endorsed by IFPRI.

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

A world free of hunger and malnutrition

IFPRI is a CGIAR Research Center

1201 Eye Street, NW, Washington, DC 20005 USA | T. +1-202-862-5600 | F. +1-202-862-5606 | Email: ifpri@cgiar.org | www.ifpri.org | www.ifpri.info