THE HIDDEN HEALTH IMPACTS OF INDUSTRIAL LIVESTOCK SYSTEMS

Transforming Livestock Systems for Better Human, Animal and Planetary Health

WORLD ANIMAL PROTECTION

TASTING THE FUTURE

Sustainable Food Systems Consultancy

CONTENTS

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Cover photo: Chicken farm. Credit: branislavpudar / Shutterstock.com

FOREWORD

It's past time that the hidden impacts of factory farming were laid bare. Factory farming is the cornerstone of a dangerous industrial food system that profits from the suffering of billions of cruelly farmed animals each year. The system imposes serious public and environmental health impacts that undermine our nutrition and food safety, lead to an onslaught of disease and superbugs, health hazards for workers, and environmental pollution, climate change and habitat destruction.

A handful of multi-national companies are consolidating their stranglehold on the global industrial food system as demand for meat and dairy continues to grow, and governments turn a blind eye or in some cases support and promote the destruction.

Governments ignore the health consequences of factory farming at our peril. Swine flu and bird flu are just two examples of diseases that started on factory farms and have caused devastating human health impacts. We're living through the worst pandemic in 100 years but there's worse to come as wildlife habitats are cut down to make room for factory farming, risking disease spread between wild and farmed animals, and to humans.

The World Health Organisation warns we are facing a superbug health crisis. Factory farming is the major culprit as farmed animals are indiscriminately dosed with antibiotics to prop up a cruel system, leading to superbugs that jump to humans and kill.

People are suffering from obesity and chronic illness at record rates, made worse by the 'cheap meat at all costs' mentality of factory farming. At the same time, hundreds of millions of people face hunger. As cruel factory farming grows around the world, more and more land is used to grow crops to feed farmed animals, not humans. Food security is undermined.

It's a dangerous paradox where experts implore that action this decade is vital to prevent irreversible damage to our planet and climate, yet governments continue to support the growth of factory farming in a misguided belief it will bring nutrition, food safety and security.

Nothing could be further from the truth. We must make fundamental changes in the way in which we grow, trade, and consume our food.

For a truly sustainable, equitable and food-secure future, we need governments to urgently impose a moratorium on factory farms. They must support the transition to a humane and sustainable food system where factory farming is a thing of the past.

The fallout on our health from the explosion of factory farming will disproportionately hit people in low-and-middle-income countries. Rather than global companies industrialising livestock production systems around the world, governments must support humane and sustainable, localised food supply chains. Benefits will flow to local communities and farmers, not big multinational companies.

Countries with high per capita meat and dairy consumption must lead the transition to a predominantly plant-based food system globally, with far fewer farmed animals produced in humane and sustainable conditions.

Let's start the journey now to end factory farming and safeguard our health and the health of our planet.

Image: An intensive egg farm in South India, where over 300,000 hens are crammed into cages. Their cage is an example of a "battery cage", which is used worldwide to farm hens for egg production: here are up to eight hens in a single cage, meaning there isn´t enough space for them to spread their wings. Credit: Amy Jones / Moving Animals

EXECUTIVE SUMMARY

This report unveils the true hidden health impacts and costs of industrial livestock systems, which damage our health through multiple and interconnected pathways of impact. They make us ill, drive climate change and biodiversity loss, and cause suffering to billions of farmed animals each year. On the surface, meat, fish, and dairy products produced using factory farming systems may appear cheap but the fact is they cost trillions of dollars in poor health and ecological damage annually – these true 'external costs' are being picked up by taxpayers, citizens, rural communities, smallholder farmers, fishers, pastoralists, future generations and other disadvantaged groups.

This report highlights how industrial livestock systems make us sick through five interrelated pathways of impact including:

1. **Unhealthy diets and food insecurity** – The health impacts of unhealthy diets and excessive meat consumption contributes to malnutrition in all its forms including obesity (leading to non-communicable diseases) and food insecurity (hunger and micronutrient deficiencies).

2. **Zoonotic pathogens and antimicrobial resistance (AMR)** – Factory farms, characterised by substandard husbandry practices and poor animal welfare, drive the increased use of antimicrobials, and are connected to the emergence of AMR and a range of zoonotic pathogens.

3. **Unsafe and adulterated foods** – The health impacts of unsafe and adulterated food include illnesses arising from consumption of livestock derived foods containing food safety hazards including pathogens, chemicals, and toxicants.

4. **Environmental contamination and degradation** – People are exposed to health impacts from environments contaminated by livestock production and processing, including pollution of soil, air, and water.

5. **Occupational hazards** – These include a range of physical and mental health impacts in the workplace affecting livestock factory farmers, agricultural workers supplying feedstocks, aquaculture, abattoir, meat processing and packaging workers, livestock/meat distributors and people selling livestock foods within the marketplace.

The report includes a regional synthesis of these health impacts highlighting how Asia and Africa are the new frontiers of the growth of factory farming over the next decade, with global health risks posed by industrial livestock systems expected to significantly increase in the years to come.

The report identifies nine systemic shifts that will required to transform our livestock systems towards those that are regenerative and restorative, improving the health and well-being of people, planet, and animals. These include a shift in mindsets; a shift to true costs and pricing; a shift to a just transition; a shift in power and influence; a shift in trade; a shift to higher animal welfare standards; a shift to regenerative and agroecological systems; a shift to sustainable and healthy diets; and a shift to a One Health, One Welfare Approach.

To achieve the paradigm shift required, the report outlines ten recommendations for government action:

1. Recognise the inter-connected public health and planetary impacts of industrialised farming systems and commit to stopping the support for factory farms.

2. Ensure fiscal policies, including taxation and social policy and programs, research, and infrastructure investments, align to reflect the true health, sustainability, and animal welfare costs of livestock production systems.

3. Establish national plans to support a just transition away from industrialised livestock production towards agroecological systems that produce sustainable plant-based foods and fewer farmed animals in high welfare environments.

4. Ensure integrated, participatory, transparent, and rights-based approaches to governance and policymaking at all levels across the livestock system.

5. Introduce trade policy incentives that facilitate shorter livestock derived food (LDF) value chains and that support agroecological, regenerative and pastoral LDFs.

6. Meet the Farms Initiative Responsible Minimum Standards (FARMS) animal welfare requirements for production or procurement as a minimum.

7. End subsidies and policy support for unhealthy and unjust industrial livestock systems and redirect these to support regenerative, agroecological and pastoralist systems that deliver better human, animal, and planetary health outcomes.

8. Commit to a moratorium on factory farming within National Climate actions plans (known as Nationally Determined Contributions (NDCs)) in recognition of factory farming's climate impacts.

9. Promote humane, healthy, and sustainable diets, including those that support an average global reduction in meat and dairy consumption and production of 50% by 2040, through the provision of healthy eating advice and other financial incentives.

10. Develop national One Health, One Welfare action plans and national antimicrobial resistance (AMR) plans that recognise the health impacts of industrialised livestock and restrict its growth.

GLOSSARY AND LIST OF ABBREVIATIONS

Glosary

Agroecology – Agroecology is a holistic and integrated approach that simultaneously applies ecological and social concepts and principles to the design and management of sustainable agriculture and food systems. It seeks to optimize the interactions between plants, animals, humans, and the environment while also addressing the need for socially equitable food systems within which people can exercise choice over what they eat and how and where it is produced[1].

Antimicrobial resistance (AMR) – AMR occurs when bacteria, viruses, fungi, and parasites change over time and no longer respond to medicines making infections harder to treat and increasing the risk of disease spread, severe illness and death. As a result, the medicines become ineffective and infections persist in the body, increasing the risk of spread to others. Antimicrobials - including antibiotics, antivirals, antifungals and antiparasitics - are medicines used to prevent and treat infections in humans and animals. Antibiotic overuse, particularly within industrial livestock systems, is a key driver of AMR[2].

Animal welfare – Animal welfare describes the state of the animal in terms of their physical condition (health, growth, and functioning), their mental state (feelings of pleasure, happiness, pain, or frustration) and their ability to live naturally (to perform their full range of behaviour). The Five Domains model is a framework for assessing animal welfare. Domains 1 to 4 (nutrition, physical environment, health, behavioural interactions) contribute to the animals' individual experience, which is described by domain 5: mental states[3].

Carbon dioxide equivalent – A metric measure used to compare the emissions from various greenhouse gases by converting amounts of other gases (methane, nitrous oxides etc.) to the equivalent amount of carbon dioxide with the same global warming potential.

Climate change – A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is, in addition to natural climate variability, observed over comparable time periods.

Concentrated animal feeding operations (CAFOs) – The USA terminology for 'Factory Farms'. Defined as a form of intensive animal agriculture where animals are contained or confined for more than 45 days in 12 months, in an area that does not produce vegetation, and meets size thresholds[4]. CAFOs can have considerable impacts on the environment because greater stocking density and are directly associated with increased feed and manure production per unit of area. Resulting nutrient flows can cause pollution to air, soil, and water.

Ecosystem health – Is oriented towards preserving the functions of ecosystems, even though the system may be considerably altered because of human actions. A healthy ecosystem is one that is intact in its physical, chemical, and biological components and their interrelationships, such that it is resilient to withstand change and stressors. An ecosystem is composed of animal communities, other organisms and the physical environment in which they live.

Ecosystem services – These are benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on earth[5].

Factory farming – Farming practices that do not acknowledge the sentience and welfare of animals, and where negative animal welfare, environmental and labour impacts are significant yet not factored into the costs of production. The business model is characterised by concentrated and highly corporatized management, production efficiency and process control, monocultures, high production volumes, and a strong focus on cost minimisation. These systems are associated with damaging human and planetary health impacts.

Food environments – These refer to the physical, economic, political, and socio-cultural context in which citizens engage with food systems to make their decisions about acquiring, preparing, and consuming food.

Food safety – An assurance that food will not cause adverse health effects to the citizen/consumer when it is prepared and/or eaten according to its intended use. It is a shared responsibility among all stakeholders.

Food security – Food security exists when all people, at all times, have physical, economic and social access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life.

Food systems – Food systems gather all the elements (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to the production, gathering, processing, marketing, distribution, preparation, consumption and disposal of food, and the output of these activities, including health, socio-economic, animal welfare, and environmental outcomes.

Just transition – A just transition away from an industrial livestock system involves supporting those who stand to lose economically – be they countries, regions, farmers, farm workers, communities, workers, or citizens – to ensure decent livelihoods, access to nutrition, and fair and equitable terms of trade.

Health – Health is a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity. The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, religion, political belief, economic or social condition.

High animal welfare – These are animals that experience a 'Good Life', defined as animals that experience mostly positive experiences and emotions as defined by the Five Domains model as a framework for assessing animal welfare.

Healthy and sustainable diets – Healthy and sustainable diets are dietary patterns that are of adequate quantity and quality to achieve optimal growth and development of all individuals and support functioning and physical, mental, and social wellbeing at all life stages and physiological needs; they are also ones that are culturally appropriate, accessible, affordable and minimise negative environmental, social, and economic impacts.

Industrial livestock systems – These systems are complex, globally interconnected value chains supporting high levels of production of livestock derived foods as cheaply as possible. Activities include crops fed to livestock/fish, factory farming, fish farming, abattoirs, meat processing and packaging, transportation of livestock, marketing and retail, meat consumption and the degree to which livestock derived foods are wasted.

Livestock derived foods (LDFs) – LDFs include all products from domesticated animals; farmed fish are included in this definition for the purpose of this report. In nutrition terms, they are traditionally classified into the food groups of meat, fish, eggs, milk or dairy and their derivative products.

Monocropping – Monocropping is the practice of growing a single crop year after year on the same land and in the absence of any form of crop rotation. Popular monocropping crops used as animal feeds include corn, soybeans, and wheat.

Noncommunicable diseases (NCDs) – Also known as chronic diseases, these tend to be of long duration and are the result of a combination of genetic, physiological, environmental and behavioural factors. The main types of NCDs are cardiovascular diseases (such as heart attacks and stroke), cancers, chronic respiratory diseases (such as chronic obstructive pulmonary disease and asthma) and diabetes. Modifiable behaviours, such as unhealthy diets, increase the risk of NCDs[6].

One Health – 'One Health' is a collaborative, multisectoral, and trans-disciplinary approach, working at local, regional, national, and global levels, to achieve optimal health and well-being outcomes recognizing the interconnections between people, animals, plants, and their shared environment[1]. It is an approach that recognises that human health and animal health are interdependent and bound to the health of the ecosystems in which they exist.

One Welfare – 'One Welfare' extends the approach of (and partially overlaps) the One Health approach. A One Welfare approach promotes the direct and indirect links of animal welfare to human welfare and environmentally friendly animal-keeping systems. One welfare serves to highlight the interconnections between animal welfare, human wellbeing, and the environment. It fosters interdisciplinary collaboration to improve human and animal welfare internationally. One welfare also helps to promote key global objectives such as supporting food security, sustainability, reducing human suffering and improving productivity within the farming sector through a better understanding of the value of high welfare standards[8].

Pastoralism – Pastoralism is a livelihood system based on extensive livestock production.

Planetary health – The achievement of the highest attainable standard of health, wellbeing, and equity worldwide through judicious attention to the human systems—political, economic, and social—that shape the future of humanity and the Earth's natural systems that define the safe environmental limits within which humanity can flourish[9].

Regenerative agriculture - Describes farming and grazing practices that, among other benefits, reverse climate change by rebuilding soil organic matter and restoring degraded soil biodiversity – resulting in both carbon drawdown and improvement to the water cycle[10].

Silvopastoral systems - An agroforestry land use system in which trees or shrubs are grown and animals graze or browse.

Humane and sustainable food systems - Food systems that ensure food security and nutrition for all in such a way that the economic, social, and environmental bases to generate food security and nutrition of future generations are not compromised. Animals farmed within the system live good lives where positive experiences and welfare dominate over negative experiences.

True cost accounting - A practice that accounts for all external costs of food systems, from production through to consumption. This includes the environmental, social, and economic-generated costs caused by foods.

Unhealthy diets - Unhealthy diets include those of insufficient quantity and quality of nutrients and are a driver of hunger, micronutrient deficiency and undernutrition. They include excessive intake of food and beverages high in fat, especially saturated and trans-fats, sugars, and salt and/or sodium.

Zoonoses - Diseases and infections that are naturally transmitted between vertebrate animals and humans. A zoonotic agent may be a bacterium, a virus, a fungus, or other communicable disease agent.

List of abbreviations

AMR	Antimicrobial Resistance
CAFOs	Concentrated Animal Feed Operations
COVID-19	Coronavirus Disease
DALYs	Disability-Adjusted Life Years
EDCs	Endocrine Disrupting Chemicals
EU	European Union
FAO	Food and Agriculture Organization
FBSDGs	Food Based Sustainable Dietary Guidelines
GDP	Gross Domestic Product
GHGs	Greenhouse Gas Emissions
ILO	International Labour Organisation
ILRI	International Livestock Research Institute
LDFs	Livestock Derived Foods
LMICs	Low- and Middle-Income Countries
LPS	Land-based Production Systems
NCDs	Non-Communicable Diseases
NDCs	Nationally Determined Contributions
OECD	Organisation for Economic Co-operation and Development
SARS	Severe Acute Respiratory Syndrome
SDGs	Sustainable Development Goals
TCA	True Cost Accounting
UN	United Nations
UNEP	United Nations Environment Programme
UNICEF	United Nations Children's Fund
UK	United Kingdom
USA	United States of America
USD	United States Dollars
VAT	Value Added Tax
WAP	World Animal Protection
WFP	United Nations World Food Programme
WHO	World Health Organization
WTO	World Trade Organization

Image: Mother pigs in individual cages are unable to move, turn around or socialize during their pregnancy. Credit: World Animal Protection / Emi Kondo

1. INTRODUCTION: INDUSTRIAL LIVESTOCK SYSTEMS AND HEALTH IN CONTEXT

1.1 Background

We live in the era of factory farming. Over 80 billion farmed animals are produced annually with an estimated 70% of farmed animals raised and slaughtered within industrialised systems, including 99% of all US farmed animals[11]. These industrial livestock systems make us sick, drive climate change and biodiversity loss and cause suffering to billions of farmed animals. With a human population that is projected to surpass 9.7 billion people by 2050[12], combined with a growing demand for meat and dairy, particularly across Asia and Africa, the spread of industrial livestock systems around the world will significantly increase the risks to public health in the years to come.

This report is based on stakeholder interviews and desk-based research and identifies the most damaging human, animal, and planetary health impacts of industrial livestock-systems. It explores the opportunities to transform extractive industrial livestock systems towards regenerative and restorative livestock systems. Nine systemic shifts and a set of ten policy recommendations are identified to support this transformation.

The report acknowledges that not all livestock systems are bad for health. High animal welfare, low-impact, extensive and smallholder livestock systems, including pastoralism, silvopastoral and agroecological livestock systems, provide a valuable source of nutrition and livelihoods for many of the poorest communities across the world. They can also improve human, animal, and planetary health.

Your comments, engagement, and feedback on this report are welcome.

1.2 A word on scope and definitions

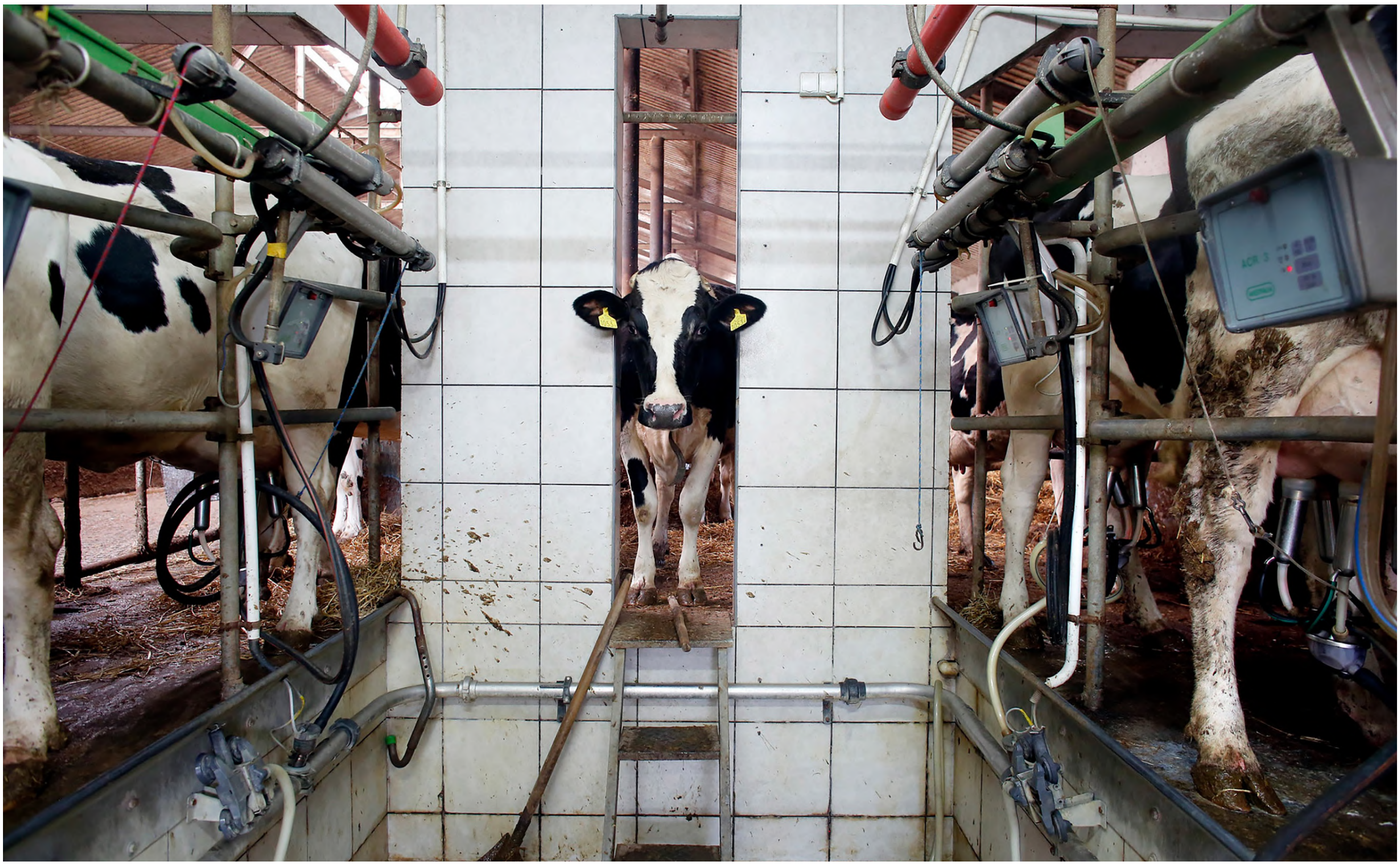
The following terms are used frequently throughout this report and therefore a more detailed explanation of these is provided:

Industrial Livestock Systems – These systems are complex, globally interconnected value chains, supporting high levels of production of livestock derived foods (LDFs) as cheaply as possible. Activities include the growing of crops to feed livestock/fish, factory farming, fish farming, abattoirs, meat processing and packaging, transportation of livestock, marketing and retail, meat consumption and the degree to which LDFs are wasted. They are characterised by practices which focus on profit over health and do not acknowledge the sentience and welfare of animals, and where the negative animal welfare, environmental and/or labour impacts are significant yet not factored into the costs of production. The business model is characterised by concentrated and highly corporatized management, production efficiency and process control, high production volumes, and a strong focus on cost minimisation.

Factory Farms – Also known as a Concentrated Animal Feeding Operations (CAFOs) in North America, they cover the farming (production) activities within an industrial livestock system. Factory farms are systems of rearing livestock using highly intensive methods, by which poultry, pigs, or cattle are confined indoors, in large numbers, under strictly controlled conditions. These farms tend to be fewer in number but larger, with more animals per holding in enclosed, climate-controlled buildings, with more automation and minimal labour. All or most of the feed comes from outside the farm and is concentrated feed whose price relies on global markets. The farm is typically *'vertically integrated'* where a company owns two or more functions in the supply chain, for example the production of feed, production of animals and the supply of antibiotics. These farming practices do not acknowledge the sentience and welfare of animals and create significant health and environmental impacts.

This report focuses on domesticated livestock species such as cattle, pigs, poultry, sheep, goats, and farmed fish (aquaculture). Wild caught animals, including wild caught fish are not in scope.

Image: Steel barriers, concrete floors, tiled walls and push-button technology make up the habitat of the modern day dairy herd. Credit: We Animals Media / Andrew Skowron



1.3 A snapshot on the global livestock sector and its impacts

Industrialisation outpacing population growth

Meat production is 470% higher in 2018 than it was 50 years ago, having increased from 70 million tons annually to more than 330 million tons off the back of industrialisation. Fish farming also grew rapidly during this period, with a 50-fold increase from 2 million tons to over 100 million tons per year[13]. Industrialisation has outpaced population growth: within this same period, the global population doubled.

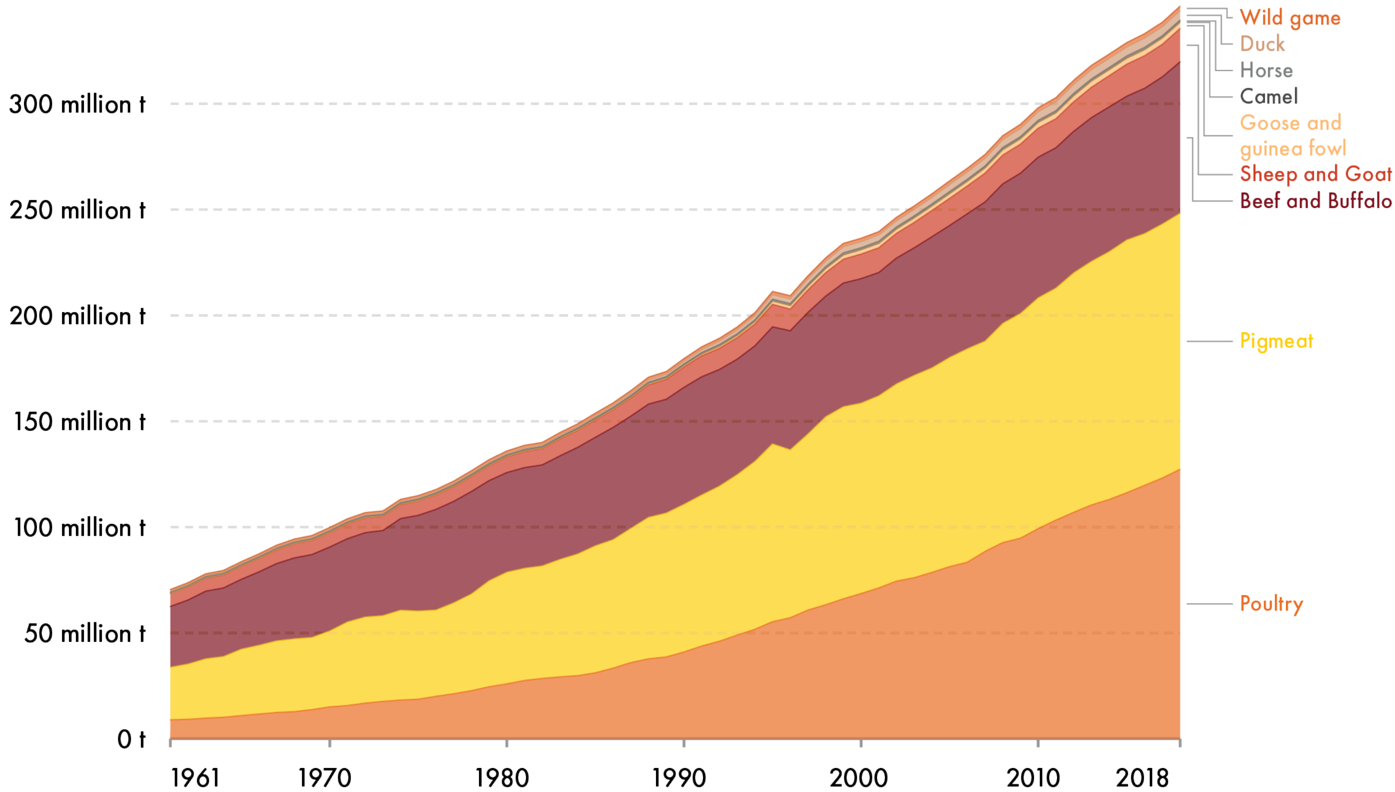


Figure 1 - Global meat production by livestock type 1961 – 2018[14].

As a global average, per capita meat consumption has doubled in the last 30 years[15]. Meat consumption correlates with high income countries, with the largest per capita meat consumption in 2019 in the United States (USA - 101kg), Australia (90kg), Israel (90kg), Argentina (88kg), Chile(81kg), Brazil (79kg), New Zealand (75kg), Canada (70kg), and the United Kingdom (61.5kg)[16]. The most substantial increases in meat consumption, close to 2 kg/capita/year, were observed in countries such as Russia, Vietnam, and Peru. The most populous country, China, which consumes almost one-third of the world's meat, accounted for one third of growth over the last 20 years, even though its per capita consumption (46kg) is still less than half that of the USA.

In 2018, 80 billion animals each year were killed for meat including an estimated 69 billion chickens; 1.5 billion pigs; 656 million turkeys; 574 million sheep; 479 million goats; and 302 million cattle[17]. In addition, 80 million tons of farmed fish was consumed[18].

Strong growth in poultry within LMICs

Global livestock production continues to increase year-on-year as the industrialized model of livestock and fish production spreads to many low-and-middle-income countries (LMICs), especially in Asia, with poultry accounting for an increasingly large share of meat production globally. The global livestock sector has grown to the extent that farmed poultry represent 70% of all live birds, with wild birds representing only 30% of the global bird population[19].

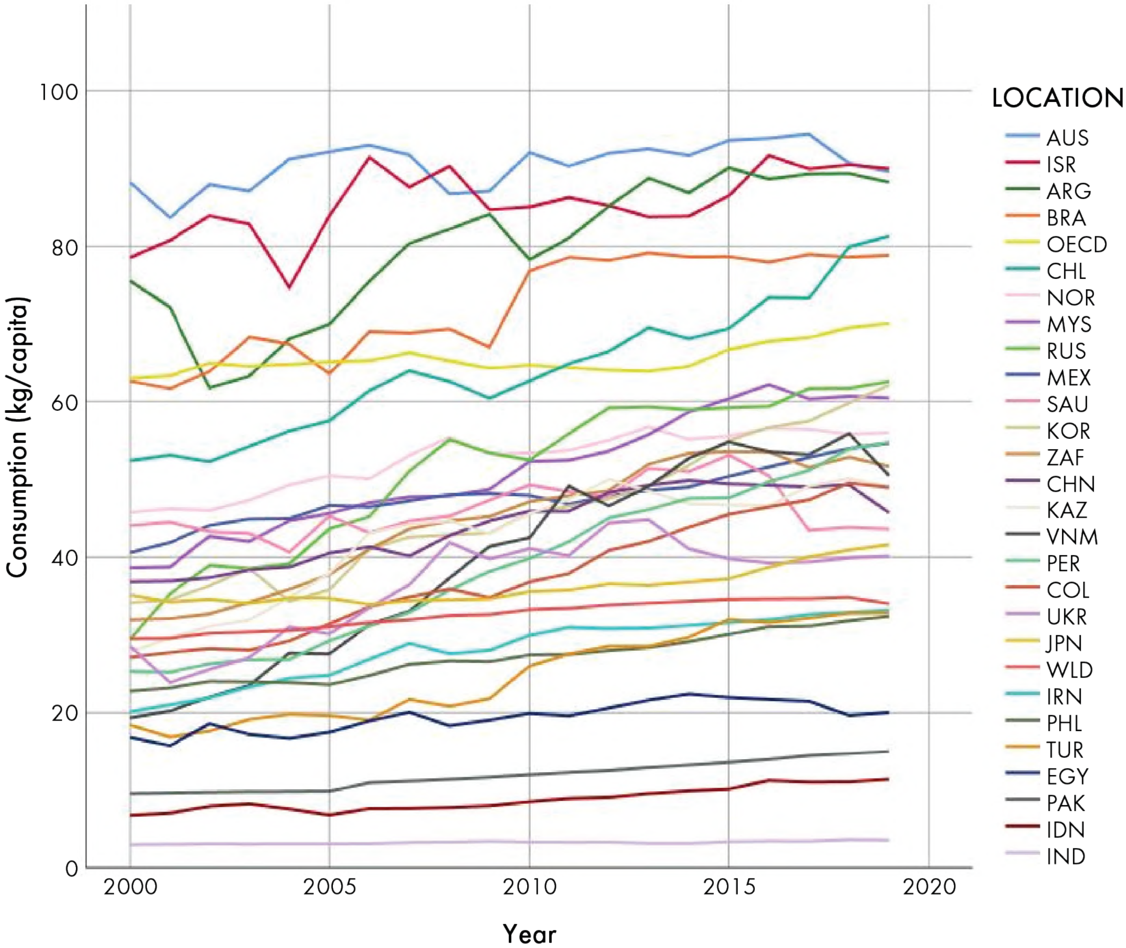


Figure 2 - **Total meat consumption over time (years) in countries with increasing consumption**

The latest FAO/OECD Agricultural Outlook[20] forecasts production of beef, pork, poultry, and sheep meat is projected to grow 5.9%, 13.1%, 17.8% and 15.7% respectively by 2030. Poultry meat is expected to represent 41% of all the protein from meat sources in 2030. Meat consumption is projected to grow by 30% in Africa (from a low base), 18% in the Asia and Pacific region, and 12% in the Latin American region; the projected increase in meat consumption is 0.4% in Europe and 9% in North America.

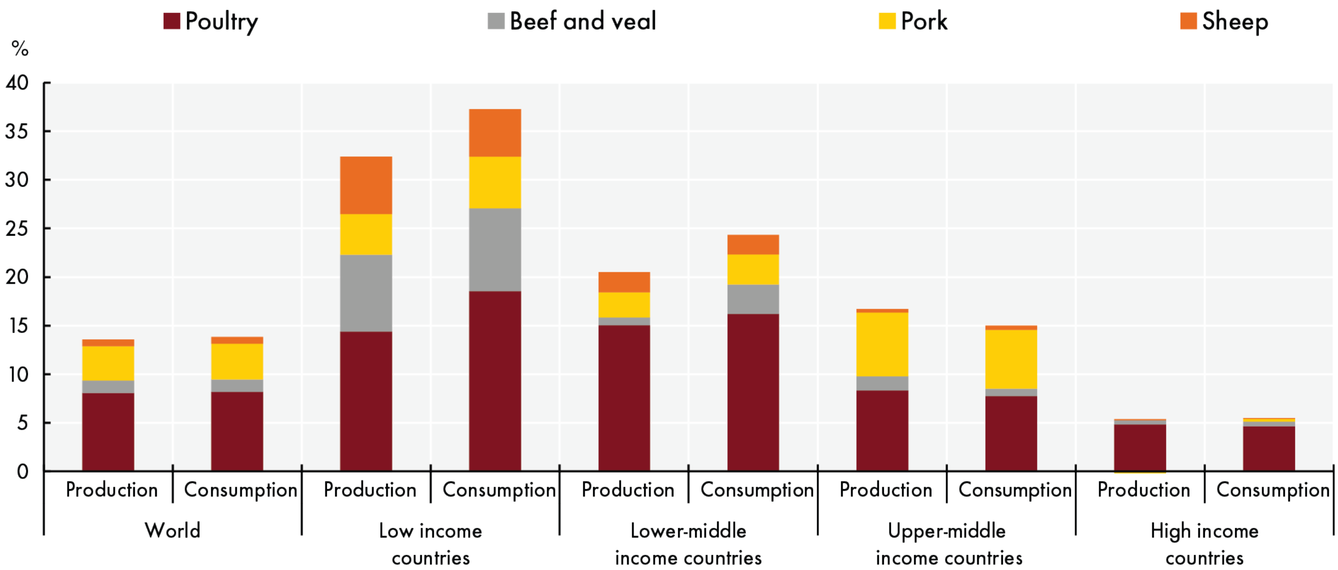


Figure 3 - Forecast growth in poultry, beef and veal, pork and sheep production and consumption 2021 – 2030[21].

Import and export hot spots

Just a few countries and regions with large land masses are the major meat and dairy exporting regions: the USA and Canada; the European Union (EU); Brazil and Argentina; and Australia and New Zealand. Surplus production from these regions is exported. Just six countries (the US, the EU, Brazil, Argentina, Australia, and China) account for nearly 68% of global beef production. Five (not considering China) are responsible for over 55% of world beef production, with the USA producing the largest quantity. Just three countries (Brazil, Australia, and the USA) account for nearly half (46.5%) of global exports and adding India's buffalo meat exports brings the total to 65% of global exports. For pork, China, the EU, and the USA produce 80% of the world total with the EU, the USA, Canada, and Brazil responsible for over 90% of world exports. Only four countries – the USA, China, Japan, and Mexico – account for nearly 60% of world pork imports. A similar situation exists for factory farmed poultry, with the USA, Brazil, the EU, and China accounting for 61% of global chicken production. Brazil, USA, EU, and Thailand account for 81% of world exports. The USA, EU, China, and New Zealand account for 52% of global dairy production. The EU, USA, and New Zealand account for nearly 80% of skim milk powder exports while New Zealand produces 68% of whole milk powder exports[22].

Growth in the consumption of farmed fish within Asia

Aquaculture contributes a growing share of protein for the global population[23]. Global aquaculture production has more than tripled in the last 20 years from 34 million tons in 1997 to 112 million tons in 2017. Aquatic animals now provide 20% of animal protein to the human diet for over 40% of the world. World aquaculture production of farmed aquatic animals is dominated by Asia, with an 89% share in the last two decades. China alone represents 35% of global production with significant growth within India, Indonesia, Vietnam, Bangladesh, Egypt, Norway, and Chile. Fish production is forecast to grow by an additional 80% by 2050 with countries such as Brazil, Ghana, India, Mexico, and Nigeria doubling the quantity of fish they consume over the same period[24].

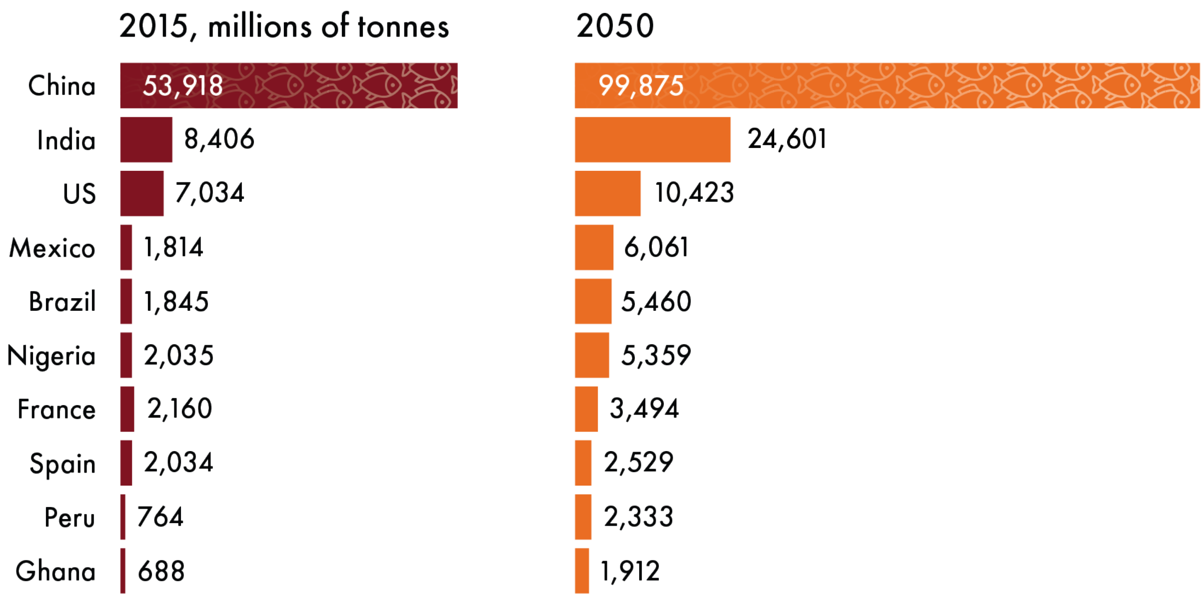


Figure 4 - Countries which are forecast to experience growth in the production of farmed fish between 2015 and 2050

Industrial systems impacting food security and livelihoods

Industrial livestock systems are replacing traditional forms of livestock production in many LMICs. This has direct impacts on livelihoods: the UN estimates that livestock contributes to the livelihoods of about 1.7 billion poor people and 70% of those employed in the sector are women[25]. Traditional and nature friendly forms of animal husbandry (e.g., pastoral or agropastoral systems), give people in LMICs access to LDFs which provide an important source of nutrients, family income, transport, fuel, and fertilizer inputs (manure) for crop production on mixed farms. As a result, the sector plays a major part in reducing poverty, improving resilience as well as combating food insecurity and malnutrition[26].

Industrial systems impacting planetary health

Industrial livestock systems impact on planetary health through the production of Greenhouse Gases (GHGs), the pollution of water courses and the destruction of wildlife and their habitats, costing the equivalent of United States Dollars (USD) 3 trillion each year, according to some estimates[27].

Climate change

Food and agriculture are estimated to contribute approximately 27% of global human made GHGs[28]. The major impacts come from industrial livestock systems and land-use change (e.g., clearing forests for factory farmed animal feeds such as soya), with fertilisers, pesticides, manure, farming and land-use change together contributing as much as around 24% of global GHGs[29]. Livestock systems account for 57% of all food system emissions[30]. Industrial livestock production is the largest global source of methane and nitrous oxide – two particularly potent GHGs. Very high calorie diets are common in high-income countries and are associated with high total per capita greenhouse gas emissions due to high carbon intensity and high intake of LDFs[31].

Factory farming requires large amounts of energy to function: in animal feed production, heating, lighting, and ventilation. Industrial livestock systems contribute 32% of global methane emissions. Because methane is a key ingredient in the formation of ground-level ozone (smog), a powerful climate forcer and dangerous air pollutant, a 45% reduction in methane emissions would prevent 260,000 premature deaths, 775,000 asthma-related hospital visits, 73 billion hours of lost labour from extreme heat, and 25 million tons of crop losses annually[32].

Feed production and processing, including the expansion of feed crops into forests, are the largest contributors to GHG emissions associated with LDFs, followed by enteric fermentation by ruminants (Figure 4).

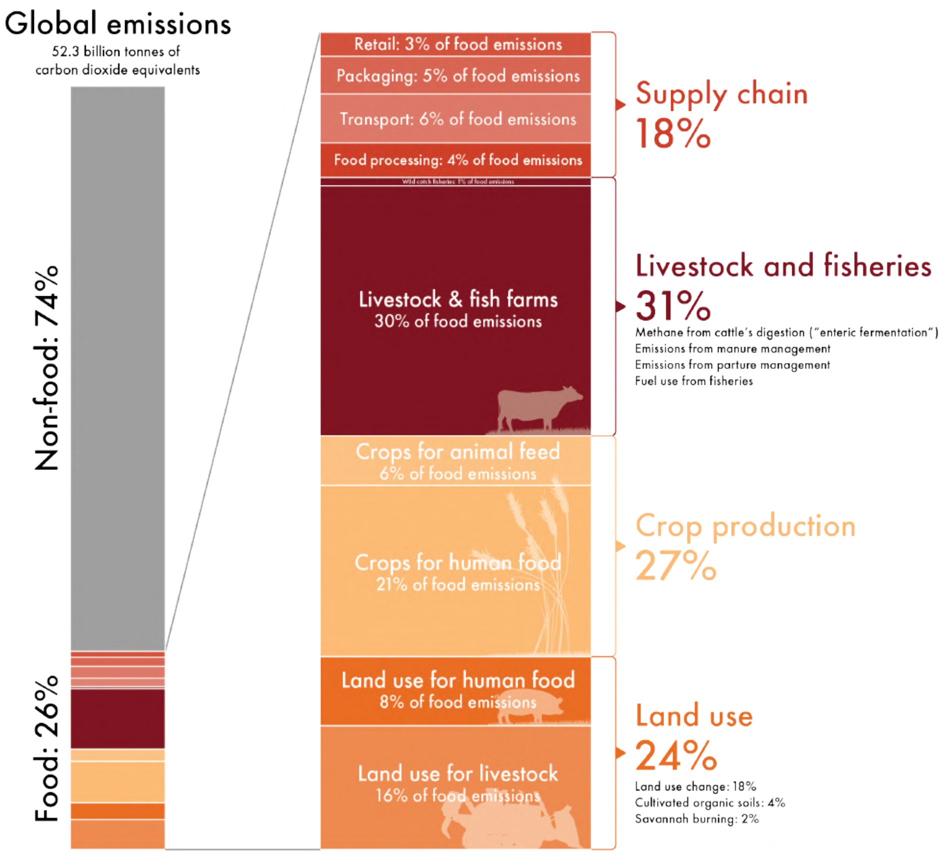


Figure 5 - **Global Greenhouse Gas emissions from food production including the emissions associated with animal agriculture[33].**

Livestock reared using more agroecological, pastoral, regenerative and agroforestry methods, within more extensive grazing systems, can play an important role in mitigation the impacts of climate change[34]. These systems are discussed in more detail within section 3.

Between 2030 and 2050, climate change is expected to cause approximately 250,000 additional deaths per year, from malnutrition, malaria, diarrhoea, and heat stress. The direct damage costs to health are estimated to be between USD 2-4 billion/year by 2030[35]. Humanitarian funding requirements after climate-related disasters could increase from between USD 3.5-12 billion to USD 20 billion annually by 2030[36].

Within 10 years, the livestock sector will account for almost half (49%) of the world's emissions budget for 1.5°C by 2030 and 80% by 2050[37], leading to catastrophic levels of global heating. To meet the goals of the Paris agreement and the SDGs, a rapid and substantial reduction in factory farming and average per capita meat consumption, will be required.

Land-use change and biodiversity loss

The shift towards industrialised animal farming systems creates significant demand for grain and other plant proteins as feed for animals, which would otherwise have been fed to humans. 77% of soya is used in animal feed for factory farmed animals (two thirds of which goes to poultry and pigs)[38], driving deforestation and biodiversity loss in the Amazon for example.

Food production is the primary cause of biodiversity loss, the loss of native livestock breeds[39] and the loss of Indigenous Peoples lands globally[40]. 30% of global biodiversity loss is linked to industrial livestock production[41], driven by livestock's role in deforestation and land conversion, overgrazing and degradation of grasslands, and desertification.

Biodiversity is declining globally at rates unprecedented in human history, with over 1 million species threatened with extinction[42] because of human activities. The WWF Living Planet Index (2018)[43] reveals that global populations of fish, birds, mammals, amphibians, and reptiles decreased by 60% globally between 1970 and 2014. In addition, untold billions of sentient animals die because of habitat destruction. According to WWF, an area 1.5 times the size of the EU would be saved from agricultural production if the amount of animal products eaten globally was reduced to meet national nutritional guidelines[44].

Furthermore, significant freshwater and marine biodiversity loss is attributed to the production of fertilizers and manures used by or produced within the industrial livestock sector. The abundance of populations monitored in freshwater and marine systems has fallen by 83% and 36% respectively between 1970 and 2014[45]. In Europe for example, the use of nitrogen in fertilisers has had a significant impact on freshwater habitats with concentrations and depositions continuing to exceed safe limits and thresholds[46].

Image: Factory farms use a lot of resources, considering the land for infrastructure, also water sources, monocrop land for animal feeding and contamination of soil and water around farms locations. Credit: World Animal Protection

Image: Water downstream from a pig farm in Thailand. Credit: World Animal Protection

Water quality

Industrial livestock systems use a significant amount of water with agriculture accounting for 70% of freshwater withdrawals globally[47]. The production of beef, pork and chicken respectively uses around nine, four and three times as much water as plant-based products[48], such as cereals, although these estimates can be considerably higher under more intensive production systems[49].

Intensive livestock systems are often associated with higher incidences of water pollution. Water pollution due to animal waste is a common problem in both developed and developing nations with many countries in Europe, USA, Canada, China, India, and New Zealand experiencing major environmental degradation due to water pollution via animal waste. In China for example, a pollution census from the Chinese government found livestock farming was responsible for 44% more water pollution than other industrial operations[50].

In the last 20 years, because of the industrialisation of livestock production, a new class of agricultural pollutants has emerged in the form of veterinary medicines (antibiotics, vaccines, and growth promoters), which move from farms through water to ecosystems and drinking-water sources. The high content of nitrogen and other nutrients in manure runoff can also lead to *dead zones* in downstream waterways and seas, where an overgrowth of algae consumes all the oxygen. In 2021 the dead zone in the Gulf of Mexico, created by runoff from manure and other agricultural fertilizer in the Mississippi floodplain, is now more than 6,300 square miles[51], negatively impacting on the incomes and livelihoods of fisherfolk who fish in the region.

Food waste and loss

Industrial livestock systems involve feeding huge amounts of food that could be consumed by people, to animals confined in inhumane, unhealthy, and unsustainable conditions. One third off all cereals and soya is used to feed livestock. Pigs and poultry are some of nature's great foragers and recyclers and where food waste cannot be reduced, they could be the perfect recipients of food waste which would otherwise end up in landfill. Returning animals to the land on mixed regenerative/agroecological, high animal welfare farms where they can forage and turn food waste into eggs and meat would be one solution to the food waste problem. According to WWF up to 40% of the fish landed in the world is not consumed directly by people[52] – it's used mostly as feed for farmed fish and other livestock. Eliminating fishmeal as a feedstock would reduce the pressure on over exploited seas.

1.4 The decade of action

We are at a critical juncture for delivery and action for health of people, planet, and animals. Over the course of the next decade, up to 2030 and beyond, there are several key global conventions and agreements that provide an opportunity to help shape policies that can shift us away from inhumane, unhealthy, and unsustainable industrial livestock systems. In 2015, UN Member States endorsed the 2030 Agenda for Sustainable Development[53], which identified 17 Sustainable Development Goals (SDGs) as well as the Paris Agreement on Climate Change[54]. We are also mid-way through the UN Decade of Action on Nutrition (2016 – 2025), a commitment United Nations Member States to undertake 10 years of sustained and coherent implementation of policies, programs, and increased investments to eliminate malnutrition in all its forms. The decade for action presents an unprecedented opportunity for universal and integrated change – it will be impossible to meet the SDGs, address malnutrition in all its forms, or prevent catastrophic global heating, without a fundamental shift away from damaging industrial livestock systems.

1.5 Impacts of COVID-19 and building forward better livestock systems

As the COVID-19 pandemic continues across the world, with over 5 million recorded deaths (November 2021), its' devastating impacts are being felt in nearly all countries of the globe. Whilst COVID-19 is believed to have originated from wildlife and live animal markets, the large-scale conversion of forests for agriculture and the industrialisation of livestock production, is increasing interactions between wildlife, livestock, and humans. This in turn is leading to the emergence of a range of zoonotic diseases (Section 2.2) increasing our vulnerability to future health threats[55]. According to the UN, there are several factors driving increased zoonotic emergence including intensified livestock production, antimicrobial resistance, climate change and the illegal wildlife trade[56].

As governments start to put economic stimulus packages and policies in place to support recovery, there is now a unique opportunity to build forward a humane, sustainable, and healthy food system that improve the welfare of animals and focus on planetary health, that will ultimately reduce future zoonotic risk and result in better health human health outcomes.

Figure 6 - **Factors driving zoonotic emergence[57].**

Image: Pregnant mother pigs live in cramped, barren cages where they cannot move or turn around. Credit: World Animal Protection

2. THE HEALTH IMPACTS OF INDUSTRIAL LIVESTOCK SYSTEMS

This section focusses on the negative health impacts of industrial livestock systems and builds on health impact pathways identified in two previous reports including *'Unravelling the Food-Health Nexus'* (IPES Food, 2017) [1] and a subsequent 2021 World Health Organisation (WHO) report entitled *'Food Systems Delivering Better Health'*[1]. In summary, the health impacts identified are:

1. Unhealthy diets and food insecurity
2. Zoonotic pathogens and Antimicrobial Resistance (AMR)
3. Unsafe and adulterated foods
4. Environmental contamination and degradation
5. Occupational hazards

For each of the health pathways described examples of the impacts that result from industrial livestock systems are provided. A more detailed analysis of specific regional trends and health impacts of industrial livestock systems are covered in Appendix 1.

2.1 Unhealthy diets and food insecurity

Industrial livestock systems lead to unhealthy diets or food insecurity and therefore contribute to malnutrition in all its forms (obesity, overweight and diet related non-communicable diseases (NCDs), and undernutrition (stunting, wasting (low weight for height) and micronutrient deficiencies). An increase in the availability of inexpensive high calorie LDFs has often displaced a diversity of more traditional, local, nutritious, and healthier foods within many parts of the world.

Malnutrition – The Double Burden of Hunger and Obesity

It is estimated that between 720 and 811 million people in the world faced hunger in 2020 because of conflict, food insecurity, climate shocks and economic turbulence[60]. The prevalence of undernourishment climbed from 8.4% in 2019 to 9.9% because of the COVID-19 pandemic.[61] Many LMICs are now facing a 'double burden'[62] of malnutrition and are having to confront undernutrition, whilst also experiencing overweight, obesity and diet-related NCDs. Sub-optimal diets are estimated to be responsible for 20% of premature mortality worldwide[63] as well as for 20% of all Daily Adjusted Life Years (DALYs. i.e., the number of years lost to ill-health, disability, or early death)[64]. Among children under 5 years of age,144 million are stunted and 47 million are wasted. A child that has been stunted at an early age has a higher risk of obesity and NCDs later in life[65].

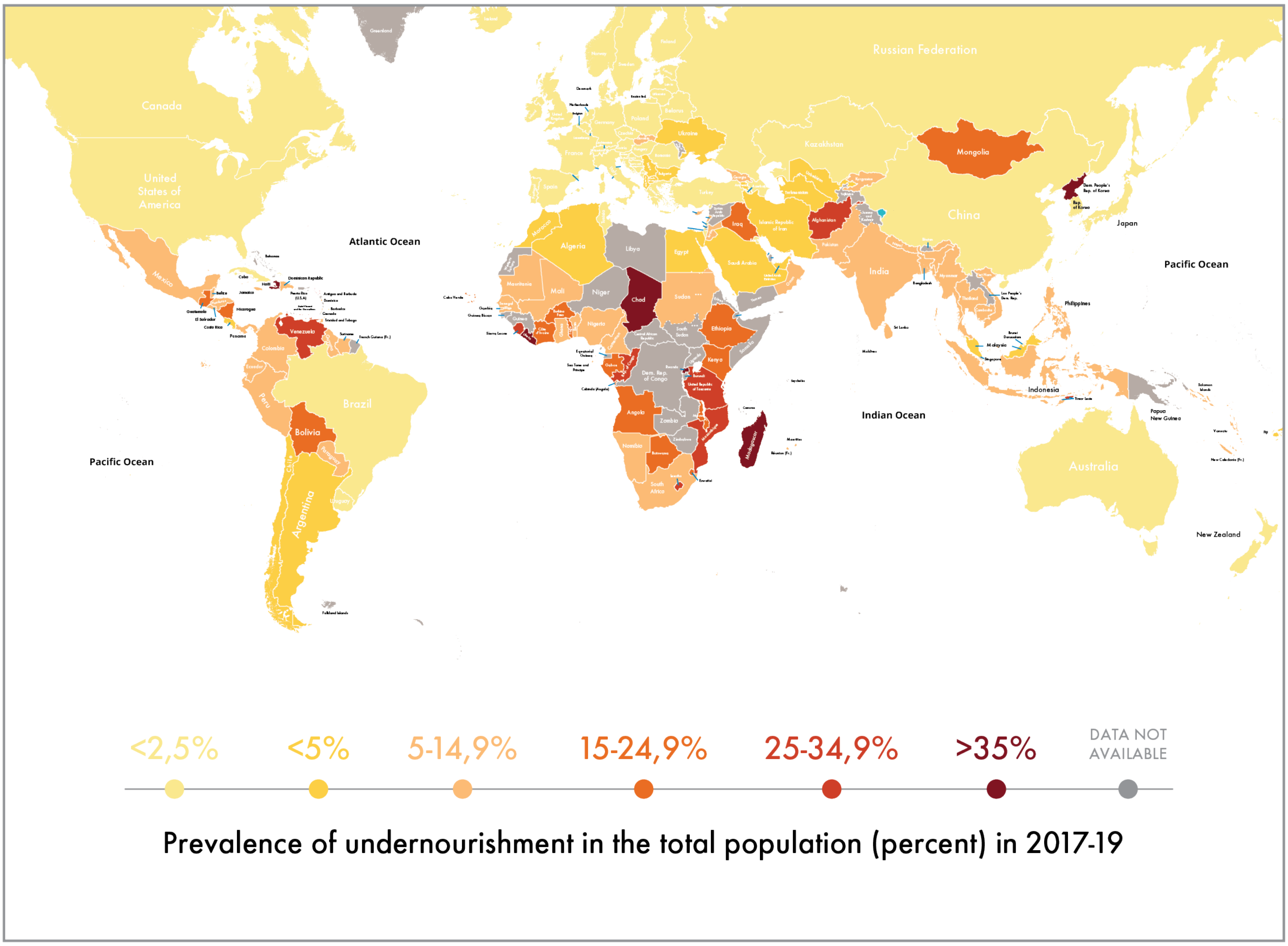


Figure 7 - World Food Programme Hunger Map 2020 depicts the prevalence of undernourishment in the population of each country in 2017 - 2019[66].

Globally obesity has nearly tripled since 1975. There are now 677.6 million obese adults and 1 in 3 people are now overweight[67], including 38 million children under the age of five[68]. Obesity is one of the leading causes of NCDs (such as diabetes, heart disease, stroke, and cancer) which are responsible for 41 million of the world's 57 million total deaths (71%) – diets containing excessive LDFs and too few fruits and vegetables are one of the four leading risk factors of these NCDs[69].

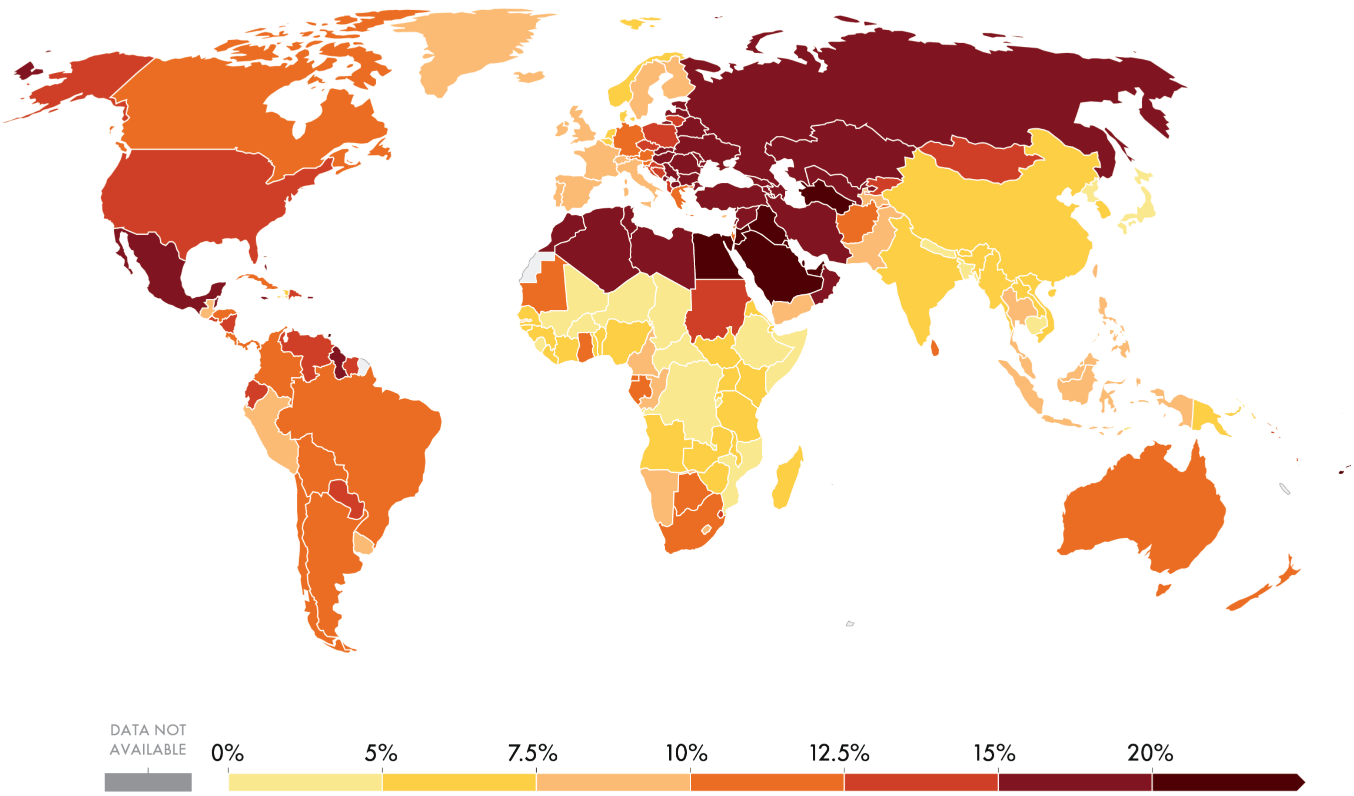


Figure 8 - Share of deaths attributed to obesity in 2017 with poor diets as a leading risk factor[70].

Excess calories (energy intake) are the most important dietary factor in relation to weight gain and the development of obesity, the result of an increase in the intake of energy-dense foods that are high in fats and sugars[71]. Obesity can also result in a range of psychological effects, such as depression, impaired body image, low self-esteem, eating disorders, stress, and poor quality of life[72]. In one study it was estimated that businesses lose an estimated USD 8–38 billion per year (equivalent to 0.2–0.9% of Gross Domestic Product (GDP) from reduced worker productivity due to employees being underweight, and USD 4–27 billion per year (0.1–0.6% of GDP) due to obesity[73].

The annual global economic costs of obesity are estimated at USD 2 trillion, representing 2·8% of the world's gross domestic product[74]. The WHO estimates the direct costs of diabetes at more than USD 827 billion per year, globally and this is set to reach USD 2.5 trillion by 2030[75]. Diet related risks also monopolize large portions of many national health-care budgets. For example, the UK National Health Service spent £6.1 billion on overweight and obesity-related ill-health in 2015 where the overall cost of obesity to wider society is estimated at £27 billion. Between 2020 – 2020 it is estimated that an average of 8·4% of healthcare expenditure in OECD member countries will be spent treating obesity-related NCDs, equivalent to USD 311 billion per year[76].

Humane, healthy, and sustainable diets contain a diversity of nutrient-rich foods, consisting of vegetables, fruits, whole grains, legumes, nuts, and unsaturated oils, with lower amounts of white meat, fish and dairy, red meat, processed meat, added sugar, refined grains, and starchy vegetables, helping to protect against malnutrition in all its forms.

The overconsumption of meat has been linked with increased risk of diseases such as coronary heart disease, and several forms of cancer[77,78], and an increasing body of literature shows that more plant-based eating is associated with benefits for health[79]. Long-term consumption of increasing amounts of red meat and particularly of processed meat is associated with an increased risk of total mortality, cardiovascular disease, colorectal cancer, and type 2 diabetes[80]. The World Health Organisation (WHO) International Agency for Research on Cancer also classifies processed meat as carcinogenic to humans because of an association with colorectal cancer, and red meat as probably carcinogenic to humans[81].

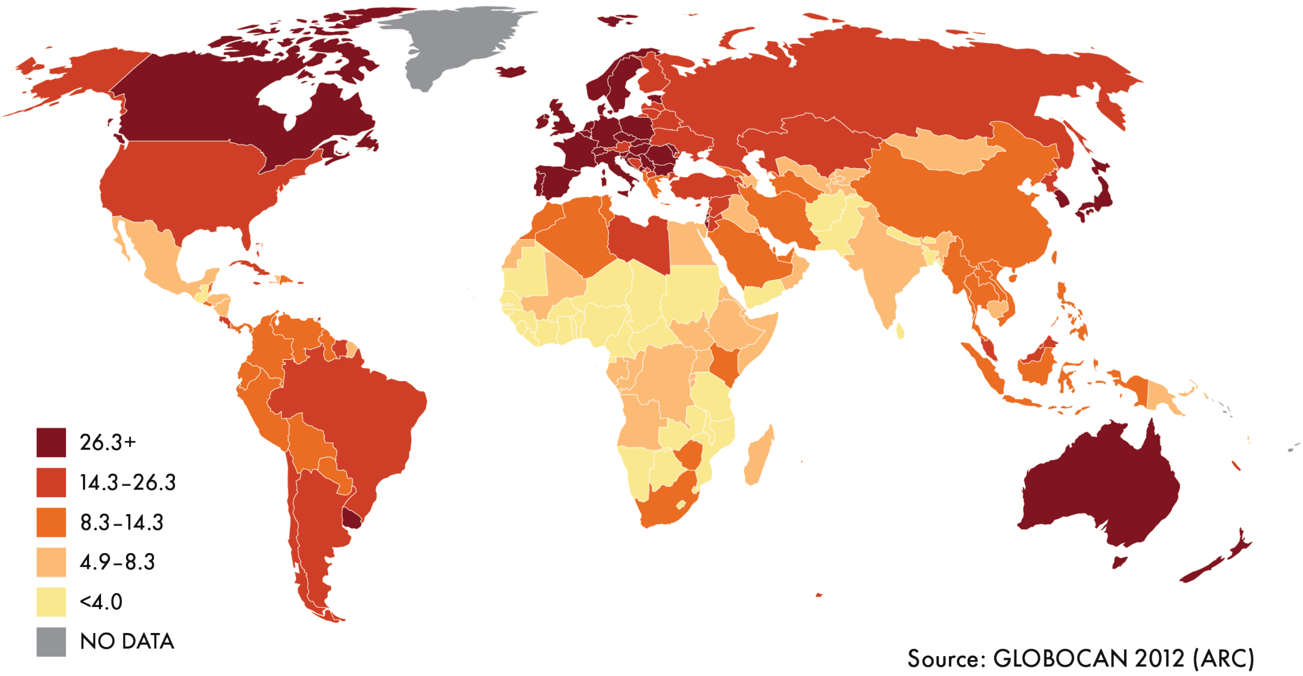


Figure 9 - **Estimated age-standardised incidence rate of colorectal cancer in 2012[82].**

A focus on efficiency and the industrialisation of livestock systems has seen an increase in the availability of inexpensive high calorie LDFs, at the expense of dietary diversity and often displacing indigenous and healthier foods. 700 million people in LMICs are dependent on traditional farming methods that use extensive, mixed, or pastoral systems, rearing a few cows, pigs, goats, sheep, chickens, or camels, providing them with their main source of protein and micronutrients (e.g., iron, zinc, and Vitamin B_{12})[83]. The rapid rise in factory farming and industrial livestock systems, which is forecast to take place within many of these LMICs over the next decade, threatens to replace these traditional systems, which in turn could increase malnourishment as a result.

FINLAND USES PLANT-BASED DIETS TO REVERSE DIET RELATED DISEASES

In 1972, an international team of academics identified a public-health crisis in the Eastern province of Finland–North Karelia–middle-aged men were dying of heart attacks at the highest known rates in the world. Diets that contained high levels of meat and dairy were identified as one of the risk factors contributing to coronary heart disease, high cholesterol and blood pressure and type 2 diabetes. A community-based nutrition programme was established which aimed to reduce cholesterol level among the North Karelian population with a focus on reductions in consumption of saturated fats and increases in dietary fibres. Specific measures included reductions in dairy (butter, full fat milks etc), meat and increases in consumption of whole grains, vegetables, roots, berries, and fruits.

The project included a combination of large-scale public health campaigns (via both official channels and mass media), food industry regulations, updated dietary guidelines and diet counselling training for frontline healthcare professionals. The project resulted in a successful joined-up national public health programme which led to an 80% drop in mortality from diet-related cardiovascular disease[84].

Food insecurity

The FAO defines food security as *''a situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life''*[85]. Access to humane and sustainably reared livestock will play a key role in ensuring food security, particularly within LMICs, by providing food, employment, and income. Significant reductions in LDFS will correspondingly be required in countries where there is an over-consumption of LDFs, particular in North America, Europe, South America, and Australasia. The use of crops and arable land for intensive livestock production indirectly places rich meat and dairy consumers in competition for calories with those who need them most. Continuing along the path of livestock industrialisation and the westernisation of human diets will have dramatic consequences on land use globally which will make food security more challenging in areas which are already food insecure, including parts of Africa, Asia, and Latin America.

Image: Tractor spraying pesticides on a soybean field. Credit: iStock.com / fotokostic

2.2 Zoonotic pathogens and antimicrobial resistance (AMR)

Factory farms, characterised by substandard husbandry practices and poor animal welfare, drive the increased use of antimicrobials, and are connected to the emergence of AMR alongside a range of zoonotic pathogens, diminishing animal health, exacerbating the human health crisis, and contributing to the ecological crisis[86]. Zoonotic pathogens and AMR are increasing as a direct result of the growth in industrial livestock systems and pose one of the most significant threats to human health across the globe.

Zoonoses

A zoonosis is an infectious disease that is transmitted from animals (farmed or wild) to humans. Zoonotic pathogens may be bacterial, viral, or parasitic and can affect humans through direct contact between humans and farmed animals or through food, water, vectors (mosquitoes, flies, ticks, fleas etc.) or indirectly through the contamination of the wider environment (water, surfaces, soils etc). An estimated 60% of known infectious diseases and up to 75% of new or emerging infectious diseases are zoonotic in origin[87]. Many of the most recent pandemics, such as avian flu and swine flu, are associated with intensive poultry and pig production systems with poor animal welfare and animal husbandry standards[88].

Driven by global demand for cheap animal foods, the industrialisation of animal production has resulted in a focus on fewer and more genetically similar productive livestock breeds. The transition from subsistence and extensive to more commercial and intensive factory farming systems has resulted in the greatest zoonotic spill overs, because of higher livestock stocking densities, poor hygiene, lower animal welfare standards, and genetically similar breeds with less resilience to disease. Factory farming of pigs, for example, promoted transmission of swine flu due to a lack of physical distancing between animals[89]. Moreover, as livestock population densities increase, more natural habitats are converted into farmland (for grazing or animal feed), which in turn reduces biodiversity and, thus, the ability of ecosystems to provide crucial functions, such as disease regulation or dilution[90].

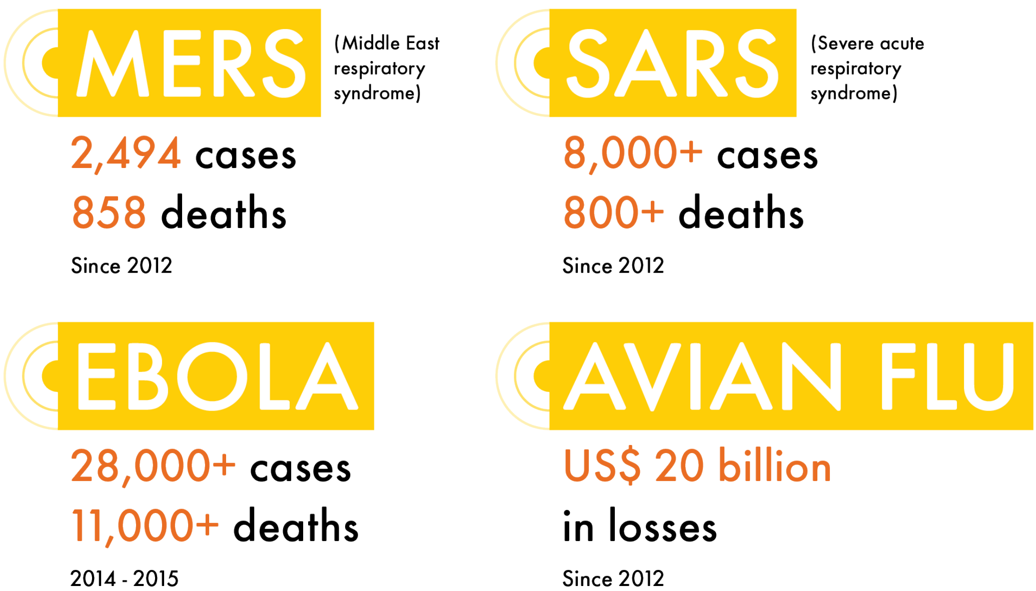


Figure 10 - **Recent Zoonoses and their health and economic impacts[91].**

There is a significant potential threat to human health from the transmission of zoonotic diseases from wildlife into livestock populations, with intensive livestock production systems accelerating the spread[92]. For example, cases of the novel febrile encephalitis, Nipah virus, emerged amongst pig farmers in Malaysia in 1998. The industrialisation of mango and pig production within the area are believed to have provided a pathway for the virus, circulating in fruit bats, to infect an intensively managed commercial pig population which subsequently spread to other farms[93].

Zoonoses are responsible for 2.5 billion cases of human illness and 2.7 million human deaths worldwide each year[94]. Zoonotic diseases are particularly prevalent among the poorest and most marginalised populations who live in proximity with their animals or who are dependent on livestock for their livelihoods. About 70% of the world's 1.4 billion people living in extreme poverty live close to livestock or fresh markets where diseases spread easily. Global efforts to manage diseases originating in animals and prevent loss of human life cost an estimated USD 120 billion globally between 1995 and 2008[95]. The International Monetary Fund (IMF) estimates that the COVID 19 pandemic will cost the global economy USD 9 trillion over the next two years[96]. Recent outbreaks of African Swine Fever have had huge a huge economic cost to key emerging markets in Asia. In 2019 half of China's pig herd (~220 million heads) was lost, while in Vietnam more than 20% of its herd (~6 million) were culled resulting in an estimated economic loss of 0.8% GDP[97] and 0.4%-1.5% GDP[98] in China and Vietnam respectively.

Climate change, and changing land-use patterns, are expanding the range of many zoonotic diseases[99] - as the planet heats up, infectious diseases that were once confined to warmer latitudes are slowly expanding their range. For example, rising temperatures with changes in rainfall patterns in Eastern Africa, have resulted in increasing populations of Aedes mosquitoes and associated outbreaks of Rift Valley fever[100]. The African continent has been identified as a likely hotspot for new zoonotic disease emergence[101]- with the world's fastest-growing human population, expanding settlements and accelerated levels of deforestation increasing encounters between people, livestock, and wildlife.

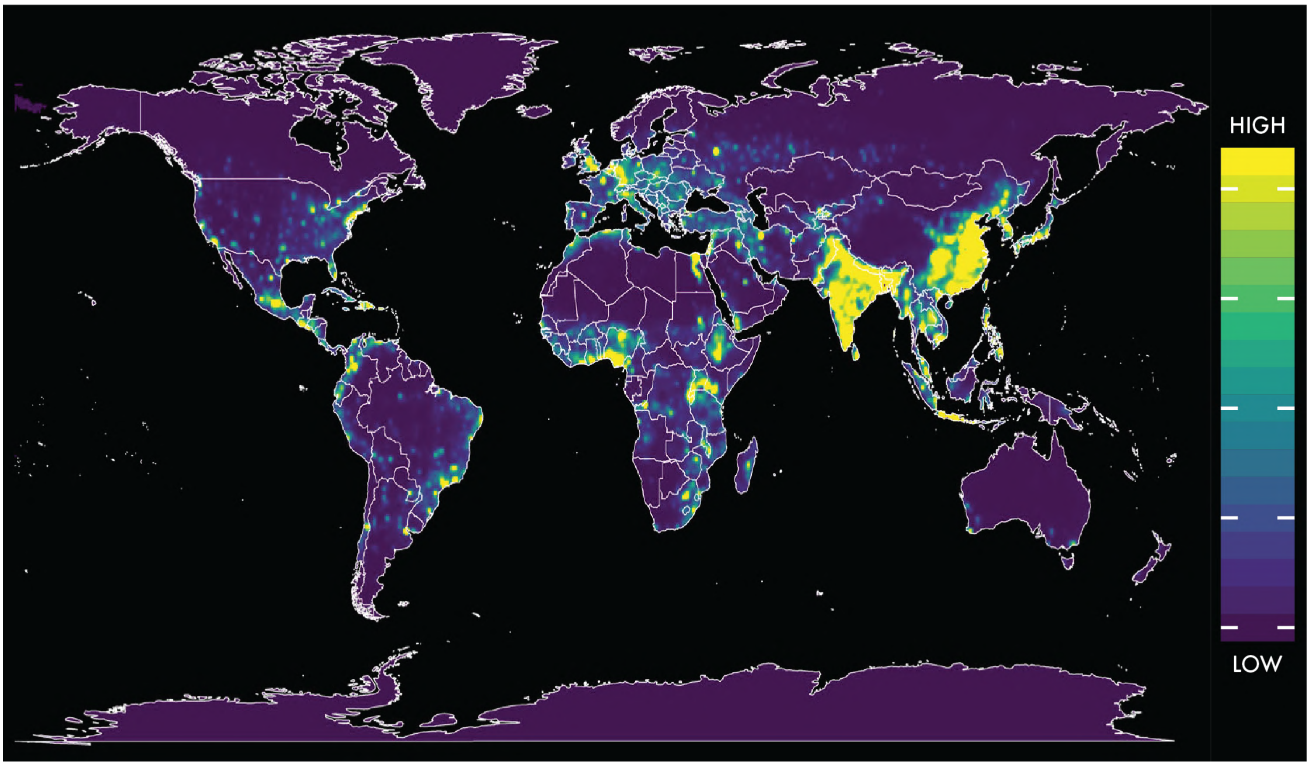


Figure 11 - **Global hotspot map of estimated risk in zoonotic disease emergence[102].**

THE DEVASTATING IMPACTS OF AVIAN INFLUENZA IN ASIA

Avian influenza is the most common form of influenza. It coexists with its host species - wild birds. Poultry factory farms, with birds kept in intensive, crammed and inhumane conditions, results in the rapid spread of any outbreak killing whole flocks within days.

The first avian influenza H5N1 outbreak in humans was recorded in Hong Kong in 1997, and since then the disease has spread with several new variants emerging. The primary risk factor for humans is exposure to infected live or dead poultry, contaminated environments such as live-bird markets, and intermediate hosts such as domesticated pigs. Early in 2021, India begun culling tens of thousands of poultry birds after avian influenza was detected in ducks, crows, and wild geese in at least a dozen locations across the country. In June 2021 China recorded its first human case of infection with a rare strain of bird flu known as H10N3. With a fatality rate for humans up to 60%, avian influenzas continue to be of significant concern for health agencies around the world.

Antimicrobial resistance

AMR is a major global health and development threat and declared one of the top 10 global public health threats facing humanity[103]. Resistance to drugs occurs when bacteria, viruses, fungi, and parasites change over time due to the exposure to antimicrobials and no longer respond to medicines, making infections harder to treat and increasing the risk of disease spread, severe illness and death. The increasing industrialization of livestock farming, poor husbandry standards within factory farms, high stocking densities and low associated levels of animal health and welfare, result in the global increase in farm antibiotic use. It has been estimated that 73% of all antibiotics are now used within the livestock sector[104], which will continue to rise as the demand for LDFs increases, especially in LMICs.

In 2010, the five countries with the largest shares of global antimicrobial consumption in food animal production were China (23%), the USA (13%), Brazil (9%), India (3%), and Germany (3%), countries associated with the greatest concentrations of factory farms. A positive association between a large farm size and antibiotic use has also been reported from various regions in the world, including Thailand, China, Nigeria, and the Netherlands[105]. Antibiotic use in livestock is predicted to grow significantly by 2030 with the highest growth rates predicted within LMICs including Myanmar (205%), Indonesia (202%), Nigeria (163%), Peru (160%), and Vietnam (157%)[106].

As LMICs are expected to shift to more industrial livestock systems, total antibiotics use in animal agriculture is set to increase by 11.5% from 2017 to 2030, from over 93,000 tonnes to over 104,000 tonnes[107]. The overuse of antibiotics can also drive food insecurity and reduce farmers' incomes, the result of higher mortality and morbidity within antibiotic resistant animals.

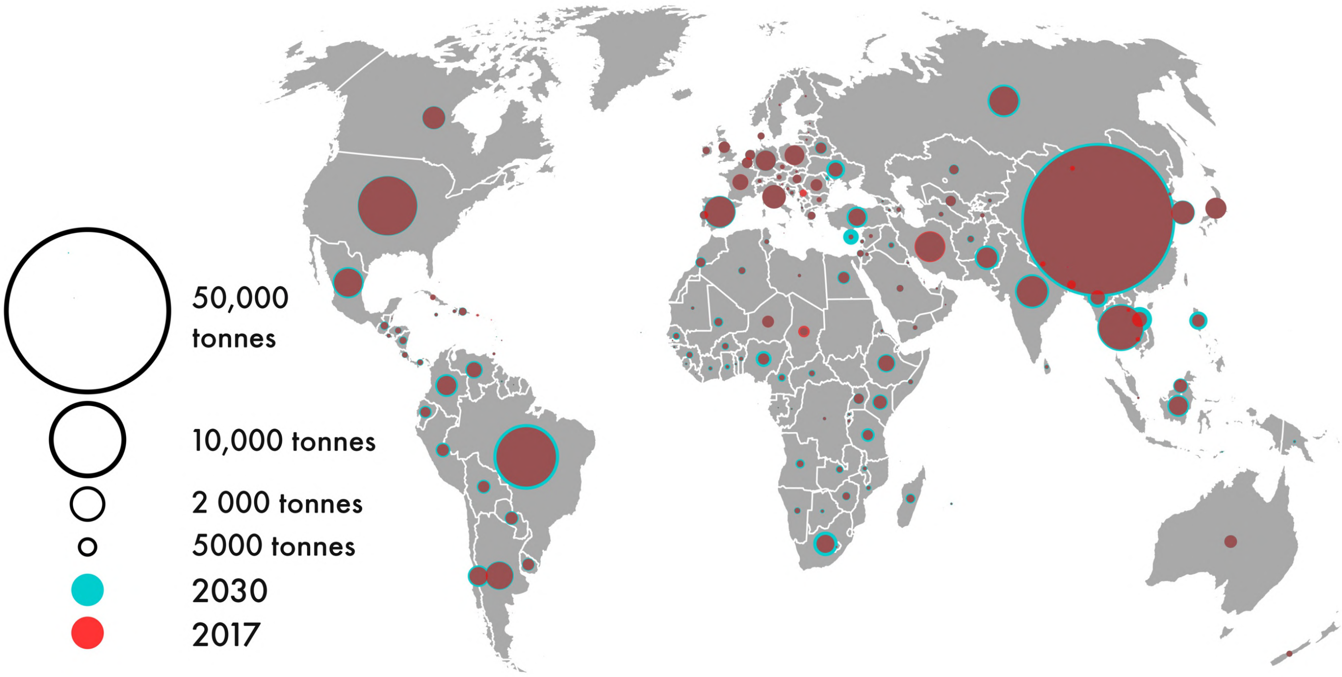


Figure 12 - **Antimicrobial consumption per country in 2017 and 2030. The size of the circles corresponds to the amounts of antimicrobials used. Dark red circles correspond to the amounts used in 2017, and the outer blue ring corresponds to the projected increase in consumption in 2030. Growth in forecast consumption is strongly correlated to the forecast expansion of factory farms, particularly within China, India, SE Asia, Brazil, and North America [108].**

The use of antimicrobials to promote growth and to routinely prevent disease in groups of animals, without addressing the underlying animal welfare and husbandry practices that can prevent ill health, is contributing to the development and spread of AMR[109]. These antibiotics are then excreted from treated livestock/fisheries and end up in the wider environment contaminating soils, water courses and seas, thereby contributing to the selection of resistant strains of bacteria infecting humans. The misuse of antimicrobials in livestock and the resultant increase in AMR in animal pathogens can eventually lead to untreatable infections in animals, thereby reducing output and negatively affecting livelihoods of livestock keepers[110]. An investigation by World Animal Protection (WAP) across four countries (Thailand, USA, Canada, and Spain) found that pig factory farms are discharging significant quantities of pig waste (manure and urine), containing significant quantities of antibiotic resistance genes and superbugs, into public waterways and the wider environment in all four countries sampled[111]. In another USA study, which looked at contamination of water courses downstream of pig factory farms in North Carolina, WAP found at least one antibiotic resistance gene in 100% of all water samples tested and 3 resistant genes in 92% of samples tested[112].

The aquaculture sector is also a significant and growing contributor to the AMR reservoir through the administration of group treatment (therapeutic and prophylactic use) in farmed fish to prevent diseases and boost growth rates[113]. AMR in aquatic animals destined for human consumption is seldom documented. Today, the aquaculture industry is experiencing rapid growth, and aquatic animals are now the fastest-growing food animal sector globally. Global antimicrobial consumption in aquaculture is concentrated in the Asia-Pacific region, at more than 93%, with China alone contributing 57.9% of global consumption in 2017[114]. Elevated levels of multi-drug resistance (33%) are already present in farmed aquatic animals intended for human consumption within Asia, which also revealed that hotspots of AMR correspond to those areas experiencing rapid aquaculture growth. Freshwater hotspots of multi-drug resistance were identified along Asia's major river systems; marine water hotspots were in North-eastern and Southern China and coastal India on the Arabian Sea and Bay of Bengal between India and Sri Lanka[115].

Prior to updated research released in January 2022, it was thought that at least 700,000 people die each year due to drug-resistant diseases[116]. Further, if no action is taken, that drug resistant infections could cause 10 million deaths a year by 2050[117]. New research based on 2019 data now estimates the death toll from drug-resistant diseases at 1.27 million each year[118]. Furthermore, AMR generates a burden on the health care system through secondary effects. These effects happen when the procedures that utilize antibiotics, which are essential to decrease the risk of any infection after surgery, cannot be successfully carried out due to the prevalence of AMR[119]. AMR may make performing organ transplants, chemotherapy, and other routine procedures too risky as they expose patients to different infections, against which, antibiotics may no longer be effective[120].

By 2030, shocks due to antimicrobial resistance could cost the world up to USD 3.4 trillion a year and force an additional 24 million people into extreme poverty[121]. **It is estimated that by 2050 AMR infections will be the leading cause of death globally with a total economic cost of USD 100 trillion, with the overwhelming burden placed on low and middle-income countries[122].** The World Bank warns that AMR will induce a possible 11% loss to livestock production in low-income countries by 2050[123] resulting in devasting economic and livelihoods impacts particularly for those smaller traditional livestock farmers.

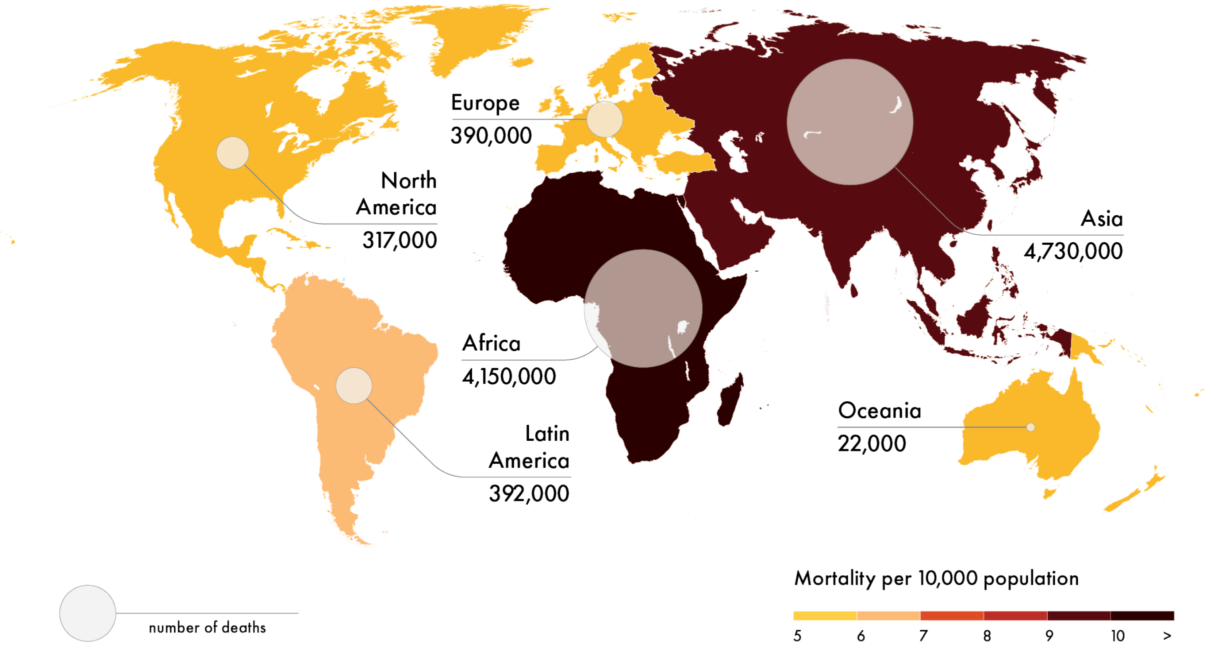


Figure 13 - **Forecast deaths each year from AMR in 2050[124].**

Apart from the US, Europe and Thailand, data highlighting the economic burden of AMR within most other countries is missing. Despite this missing data, the economic impact of AMR on health care systems across the globe, is set to grow significantly over the next 35 years if no effective action is promptly put in place.

BANNING COLISTIN AS A GROWTH PROMOTOR

In 2017 China banned the use of Colistin as a feed additive in Chinese agriculture – the result was a decline in colistin resistance in both animals and humans in China, as well as a drop in human carriage of the MCR-1 mobile colistin-resistance gene. The emergence of this gene, which was first discovered in *Escherichia coli* bacteria from Chinese pigs and Chinese hospital patients was the result of widespread use of the drug as a growth promoter in Chinese livestock.

To date seven countries - Argentina, Brazil, China, India, Japan, Malaysia, and Thailand, have agreed to ban or have implemented a ban on the use of colistin as a feed additive for animal growth promotion. Much more needs to be done on a worldwide ban on the use of colistin and other antibiotics as animal feed additives with many countries still regularly using antibiotics as growth promoters.

2.3 Unsafe and adulterated foods

Unsafe and adulterated food include illnesses arising from the ingestion of LDFs containing food safety hazards such as pathogens, chemicals, and toxicants. Examples of LDF safety hazards that may cause foodborne illnesses include a variety of bacteria and viruses. In addition, parasites (e.g., tapeworms such as *Taenia Solium*), viruses (e.g., Norovirus infections) and chemical hazards associated with factory farming such as veterinary drug residues and chemicals (e.g., dioxins) or environmental pollutants (nitrates, heavy metals) can also be the source of unsafe and adulterated foods.

Food-borne diseases (FBDs)

FBDs are infectious or toxic in nature and caused by bacteria, viruses, parasites, or chemical substances, usually through contaminated LDFs or water and air contaminated by factory farming operations. The move towards industrial livestock systems across the world has exacerbated the risk posed by FBDs. Factory farming systems, with animals housed in proximity, induce metabolic and psychological stresses[125] increasing the opportunities and susceptibility of these populations for the transmission of FBDs. To mitigate the health impacts of FBDs, industrial livestock systems have been heavily reliant on antimicrobials for prophylactic, treatment, and growth promotion. The homogenization of livestock breeds and the lack of genetic diversity within livestock systems has also been a significant factor resulting in the increasing susceptibility to outbreaks of animal diseases. For example, Porcine Reproductive and Respiratory Syndrome virus, is a major disease burden to the global pork sector and has led to exacerbated losses within genetically homogenous herds as compared to herds with a wider genetic pool[126].

WHO estimates that 31 global hazards caused 600 million foodborne illnesses (1 in 10 of the global population) and 420,000 deaths in 2010[127], equating to 550 DALYs per 100,000 people. Pathogens in LDFs are estimated to account for 35% of all FBDs, most notably: non-typhoidal *Salmonella enterica, Campylobacter* species, strains of *Escherichia coli*, and *Listeria monocytogenes*[128]. Driven by the increasing demand for LDFs, the burden of the FBDs falls on the poor in LMICs, who mostly obtain their animal-source foods from informal, traditional markets. For example, informal and traditional markets, which supply 85–95% of food needs in sub-Saharan Africa, and the poorly regulated slaughter, processing and retail practises associated with them, can result in extensive microbial contamination of products[129]. Diarrhoeal diseases are the most common illnesses resulting from the consumption of contaminated food, causing 550 million people to fall ill and 230,000 deaths every year[130].

The health impacts of FBDs have significant economic consequences for those affected, including smallholder farmers, small businesses, vulnerable groups, the poorest and for the healthcare system[131]. In the USA estimates suggest that the total annual health-related cost of foodborne illness may be as high as USD 90 billion[132]. The International Livestock Research Institute (ILRI) suggest that FBDs cost poorer countries USD 110 billion a year in lost productivity and medical expenses[133]. One estimate suggested that the total productivity loss associated with FBD in LMICs is estimated at USD 95.2 billion. In Africa alone, it is estimated the productivity losses associated with unsafe foods were USD 20 billion in 2016, and the cost of treating these illnesses were an additional USD 3.5 billion[134].

Salmonella is one of the most common foodborne pathogens that affect millions of people annually. Poor sanitary practices allow Salmonella, which live in the intestinal tracts of infected livestock, to contaminate meat or animal products during slaughter or processing. Contamination occurs at higher rates on factory farms because crowded and unclean living conditions increase the likelihood of transmission between animals. Poultry, meat products, and eggs are the food sources most identified as responsible for outbreaks of salmonellosis although the microorganism has also been found in other foodstuffs and is often found in animal faecal matter contaminating with the potential to contaminate soils and water sources. Symptoms include fever, headache, nausea, vomiting, abdominal pain and diarrhoea and on occasion death. In 2017 salmonella enterocolitis resulted in 95·1 million cases, 50,771 deaths and 3·10 million DALYs[135].

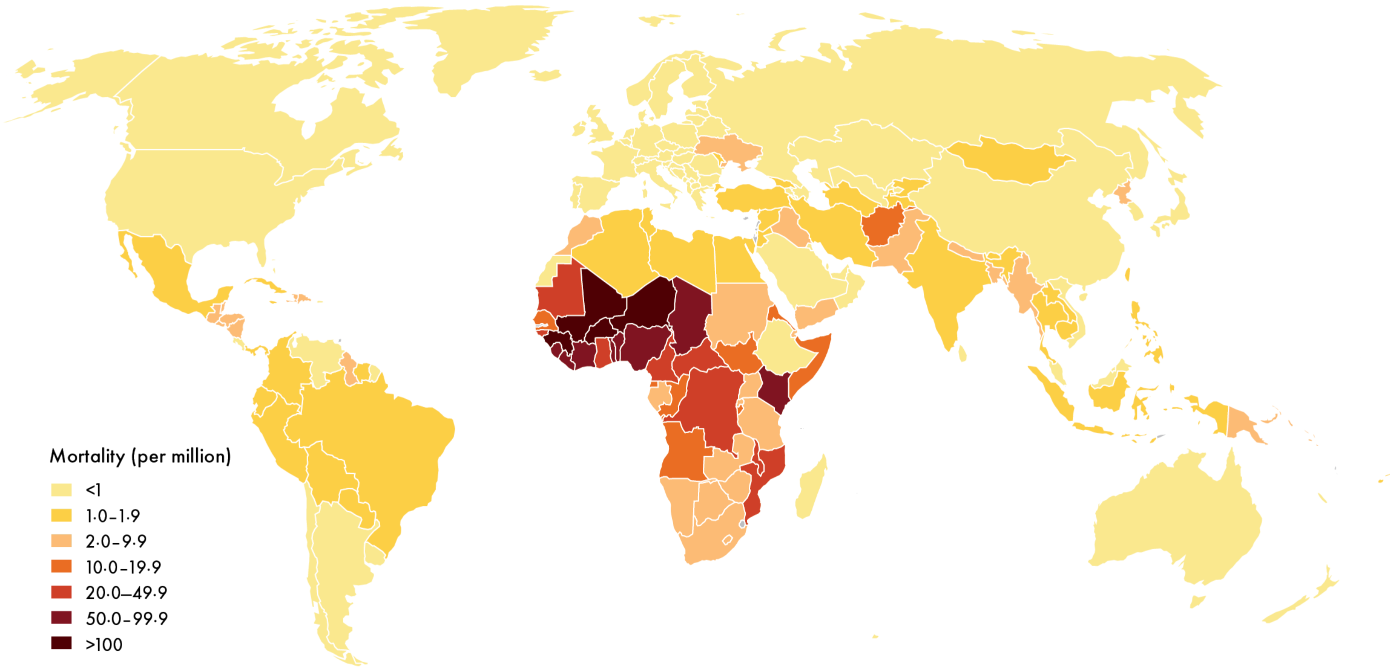


Figure 14 - Non typhoidal Salmonella invasive disease mortality rates (per million), by country, in 2017[136].

Listeriosis is one of the most important food-borne diseases of humans. Foodborne listeriosis can result in miscarriage or stillbirth or result in new-born babies having low birth weight, septicaemia, and meningitis. Listeriosis is caused by Listeria, a type of bacteria that is commonly found in water, soil, and faeces. High risk foods include deli meat and ready-to-eat meat products (such as cooked, cured and/or fermented meats and sausages) as well as ready-to-eat fish products[137]. Between 2017–2018 there was an outbreak in South Africa that resulted from contaminated processed meats, resulting in the deaths of 217 people[138].

Chemical hazards

Chemical hazards can result from factory farming activities and include veterinary medicines, mycotoxins, dioxins, and nitrites to name but a few. Chemicals can also end up in LDFs either intentionally (e.g., food additives), or through the pollution of air, water, and soils.

For example, dioxins are a group of chemically related compounds arising either naturally or as by-products of industrial livestock systems including the manufacture of some pesticides and herbicides, smelting, or burning of chlorine-containing organic chemicals such as plastics. Once produced they persist in the environment and concentrate in the livestock food chain. More than 90% of human exposure is through food, mainly meat and dairy products, fish, and shellfish[139]. Some animal feeds have also been found to contain dioxins because of concentrated surface contamination contributed by local incinerators or by persistent soil contamination from past herbicide applications.

Marine biotoxins are also becoming more prominent and are caused by certain types of toxic algae that accumulate in fish and shellfish. The increasing incidence and severity of algal blooms, predominantly caused by fertilizer and manure that runs off from intensive factory farms, contributes to the eutrophication of freshwater systems and coastal areas resulting in increased concentration and more widespread contamination of seafoods with these toxins. Factory farms cause excess nitrogen and phosphorus which runoff farms polluting water courses and contributing to the eutrophication of freshwater systems and coastal areas by encouraging growth of harmful algae blooms and the subsequent formation of over 400 dead zones (hypoxia) in many parts of the world. These dead zones can stretch for thousands of square miles – the Gulf of Mexico dead zone for example, stretches along the coast and covers over 7,800 square miles[140], with a significant impact on the fisher communities whose livelihoods depend on the sea. Climate change and associated warming oceans, are also extending the range and frequency of these biotoxins[141]. The health impacts of contaminated seafood vary, depending on the toxins, but the symptoms can be nausea, diarrhoea, vomiting, stomach cramps and in extreme circumstances death[142]. Every year, these dead zones inflict $3.4 billion in economic damage in Europe and the U.S. alone due to lost tourism and fishing, declining property values, water treatment and adverse health impacts[143].

Certain veterinary drugs pose a risk for food safety and can be present in animal feeds. Health hazards include multidrug resistance, carcinogenicity, and disruption of intestinal microflora[144]. Antimicrobial drugs, growth promoters, sedative drugs, anticoccidials, nonsteroidal anti-inflammatory drugs and anti-helminthics are the main veterinary drugs are also used in animal feeds that can potentially contaminate LDFs[145]. According to one USA study, 450 animal drugs, drug combinations, and other feed additives are administered to livestock[146], with the aim of increasing growth rates and to address diseases that result from poor husbandry and low animal welfare standards within factory farms.

Ractopamine is one example of a drug added to animal feeds used to promote leanness and increase food conversion efficiency in factory farmed animals. The use of ractopamine has been banned in 160 countries[147], including the European Union, China, and Russia, while other countries, such as Japan, the United States, South Korea, and Australia have deemed meat from livestock fed ractopamine safe for human consumption. Ractopamine causes animal suffering, and its use has resulted in more reports of sickened or dead pigs than any other livestock drug with increases lameness, broken limbs, and immobility. Whilst studies on the potential human health effects of ractopamine are extremely limited, data from the European Food Safety Authority indicates that ractopamine can cause elevated heart rates and heart-pounding sensations in humans[148].

Food adulteration

Adulteration and mislabelling of LDFs is a growing food safety concern worldwide, corresponding to the rapid growth in industrial livestock systems. Adulteration of LDFS not only has the potential to undermine the confidence of consumers but it poses a health risk, it occurs when, unbeknown to the consumer, substances are added to artificially augment the quality or quantity of a product, to lower production costs or increase sales prices[149]. Some of these chemical additives can be extremely toxic – In 2008, melamine-tainted milk from China killed six infants and hospitalized 54,000 others[150]. Another example of adulteration was the horse meat scandal that hit Europe in 2013 - foods advertised as containing beef were found to contain horse meat, containing 100% horse meat content in some cases. Long and complex industrial global livestock supply chains, combined with citizen demand for cheap meats, have made food adulteration a global concern[151] which has often highlighted the lack of transparency, traceability and accountability within these supply chains and the vulnerability posed by food fraud. Despite the prevalence of adulteration and food fraud and its devastating impacts on human health, there is no systematic economic analysis on the issue.

2.4 Environmental contamination and degradation

Environmental contamination causes health impacts via the exposure of people to contaminated environments because of livestock production and processing, through pollution of soil, air, and water resources. These contaminants include pesticides, hormone growth promoters, fertilizers, air pollution; and GHGs including methane, nitrous oxides, and carbon dioxide. These impacts are particularly felt by poorer and marginalised communities living in proximity to factory farming operations.

Pesticides

Industrial farming systems, whether growing crops or animals, rely heavily on the use of pesticides, that can pollute the air, soils, and water courses, contaminating the foods we eat. Industrial monoculture corn and soy plantations, three quarters of which ends up as animal feed for the meat industry, particularly for chickens and pigs, are dependent on vast quantities of pesticides and dominate many farming landscapes. More than 93% of corn and soybeans grown in the USA are genetically modified to be resistant to herbicides and pesticides[152]. The global pesticide market was valued USD 68.6 billion in 2019 and estimated to grow to USD 87.5 billion by 2024. Roughly 55% of the 4.5 million tons of pesticides applied globally each year are applied in agriculture, with corn and soy alone representing 49% of the highly hazardous pesticide sales[153]. More than one third of the pesticides sold by the top 5 companies (Syngenta; Bayer; BASF; Corteva (formerly Dow and Dupont); and FMC (Food Machinery and Chemical Corporation)) are substances that are classified as *'highly hazardous'* to human health, wildlife, or ecosystems. Herbicides such as paraquat, glyphosate, and atrazine, and insecticides such as chlorpyrifos and bifenthrin, are being manufactured by companies in Europe, China, and the US and sprayed in vast quantities throughout the US, Latin America, Asia, and Australia on soyabean and corn crops.

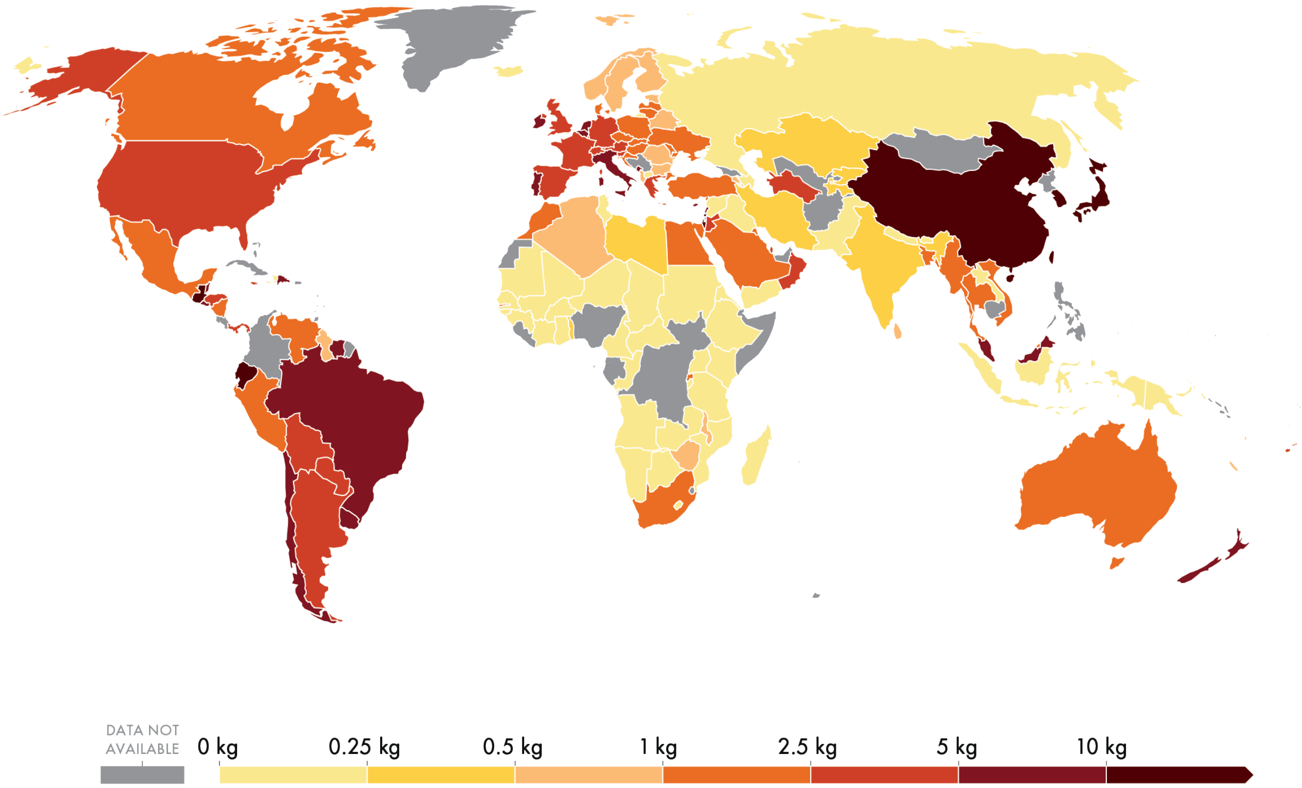


Figure 15 - Pesticide use per hectare of cropland. A significant proportion of these pesticides are used to grow crops to feed factory farmed animals with a significant correlation between countries with the highest use of pesticides (dark red) and countries with the greatest concentrations of factory farms 2017[154].

Pesticides are among the leading causes of death by self-poisoning in LMICs[155] and there are 385 million cases of Unintentional Acute Pesticide Poisoning annually world-wide including around 11,000 fatalities[156]. Based on a worldwide farming population of approximately 860 million this means that about 44% of farmers are poisoned by pesticides every year.

Many pesticides contain endocrine-disrupting chemicals (EDCs), that mimic or interfere with the body's hormones. They are ubiquitous across our food systems and are now recognised as serious and urgent threats to public health, emerging as one of the leading environmental risks globally[157]. As well as being found in pesticides, EDCs can be found in hormones used in meat, poultry, and dairy production and compounds used as food preservatives[158]. EDCs have been associated with altered reproductive function, increased incidence of breast cancer, abnormal growth patterns, and neurodevelopmental delays in children, as well as with changes in immune function[159]. EDCs have been estimated to cost the United States USD 340 billion annually (2·33% of GDP) and the European Union Euros 163 billion (1·28% of GDP) due to health-care costs and lost productivity[160].

Farmworkers are particularly susceptible to exposure, encountering pesticides when spraying fields, inhaling pesticide 'drift' and exposing their families and local communities via contamination of groundwater or on their clothing. Research by the International Agency for Research on Cancer found that 60% of soyabean farmers had glyphosate in their samples taken within 24 hours after they applied a formulation containing the chemical – with 4% of their spouses and 12% of their children found to have traces of glyphosate in their samples. The agency also concluded that the herbicide is a *'probable human carcinogen'*. Despite this, driven by the continued industrialisation of livestock systems, glyphosate use on soya continues to increase globally, with a 15-fold increase in use since 1996[161].

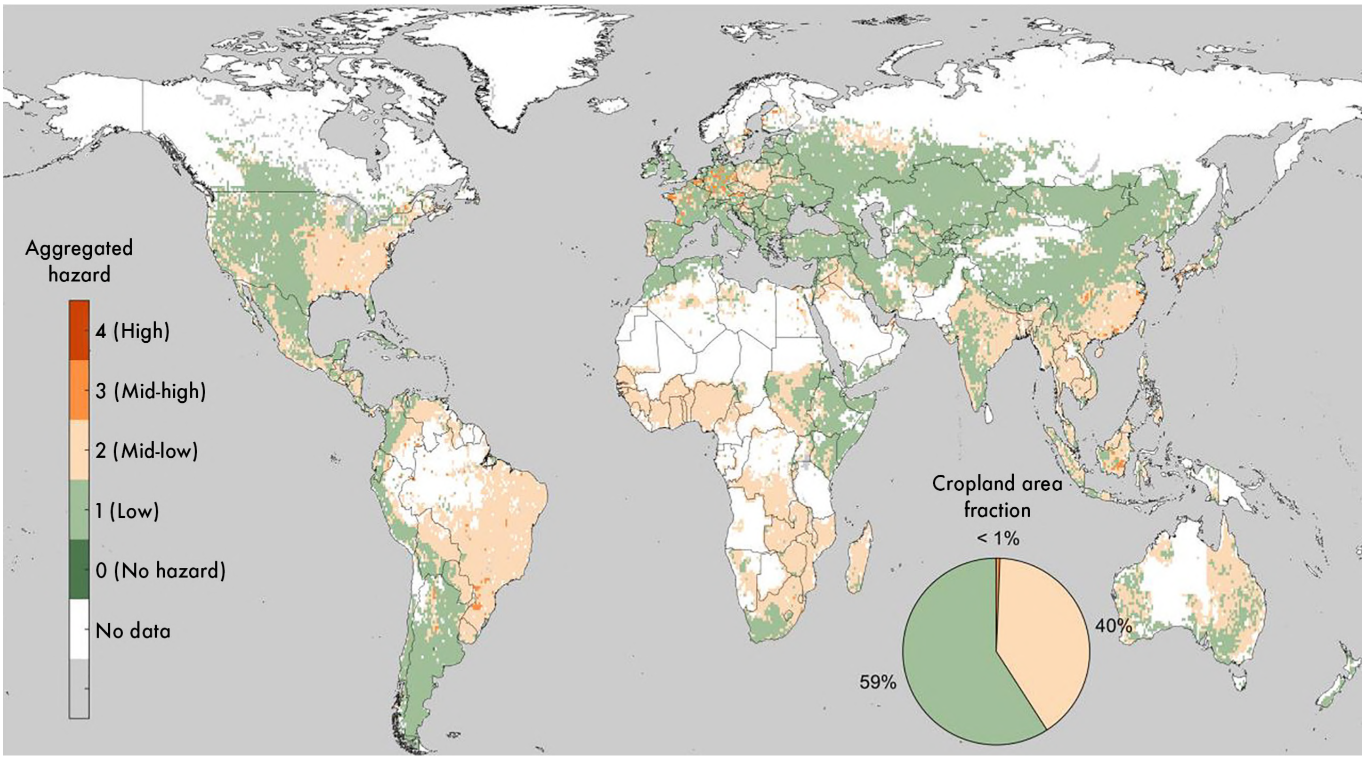


Figure 16 - Showing the global contamination hotspots of glyphosate with hotspots found in South America, Europe, and East and South Asia were mostly correlated to widespread use in pastures, soybean, and corn used for livestock feed[162].

Despite increases in the use of global pesticide use, there are still difficulties in obtaining an accurate and up-to-date picture of global pesticide poisoning, particularly within LMICs, due to a lack of available documentation and/or diagnostic skills amongst some health care workers[163].

THE IMPACT OF PESTICIDES ON THE HEALTH OF COMMUNITIES IN THE ARGENTINE GRAN CHACO

Argentina is the world's third largest exporter of soybeans[164], producing over 30 million tonnes each year. Glyphosate is used on more than 28 million hectares in Argentina[165], land sprayed with about 300 million litres of glyphosate per year, the key ingredient in the widely used herbicides Roundup and Endosulfan. Endosulfan is a highly toxic pesticide that has been banned in 80 countries because of its threats to human health and the environment. In May 2011, it was added to the UN list of persistent organic pollutants to be eliminated worldwide.

Civil society leaders and environmental groups in Argentina have called for an outright ban on the use of glyphosate, seeking to encourage a change in the way we grow our food. In Argentina, there are now more than 400 towns and cities with measures that restrict the use of glyphosate[166]. Many experts are also backing that approach. The rising global population could be fed by agroecology, they claim, by adjusting our approach to consider natural ecosystems, using local knowledge to plant a diverse range of crops. '*Industrial agriculture is leading us to economic, social and environmental bankruptcy*', said Franco Segesso, a member of the Land Workers' Union, which groups over 10,000 small-scale farmers. '*Instead, we should be encouraging agroecology, which seeks food sovereignty, economic and climate resilience, larger biodiversity and pest control*'.

Fertilizers and heavy metals

Direct human health impacts of fertilizers may occur through, for example, inhalation of ammonia, hydrogen sulphide and dusts from manure. On many factory farms, animals are crowded into relatively small areas and their manure and urine are funnelled into massive waste lagoons. These can often leak, overflow or are sprayed onto surrounding land in quantities far greater than the land can absorb, resulting in contamination of drinking water resources. Nitrate pollution is associated with adverse health impacts including colorectal cancer, bladder, and breast cancer and thyroid disease[167]. Consuming water containing high nitrate concentrations can also have almost immediate effect on a person and could cause the risk of methemoglobinemia, sometimes referred to as 'blue baby syndrome')[168]. Studies in the United States, Canada, Australia, and Europe have found elevated nitrate levels in groundwater that feed into the public water system of rural communities and shown a positive association of water consumption with adverse health effects[169].

Artificial and natural fertilizers can cause significant human and ecosystem health impacts. These sometimes result from the use of synthetic fertiliser or high volumes of animal manures and slurry, often found in intensive livestock units. About 190 million tons of inorganic fertilizers were used in agriculture in 2018, with demand expected to reach 200 million tons by 2022[170]. A variety of practices in the intensive livestock sector, particularly the liquification and spraying of untreated animal faeces onto soils, have been closely linked to water contamination and the resulting health impacts. Groundwater contamination, through rain and soil seepage, takes with it manures and fertilizers containing nitrogen, phosphorus, and metals (such as copper, zinc, and arsenic) added to animal feed.

Although data on the economic costs of nitrate pollution are limited, there are a few studies that have assessed these impacts at a local level. For example, a study in Wisconsin (US) found that 90% of nitrate contamination of drinking water can be traced back to intensive animal agriculture systems, which in turn led to an estimated 111-298 annual cases of colorectal, ovarian, thyroid, bladder, and kidney cancers, with direct medical costs ranging between USD 23 million and USD 80 million annually. Across the USA there are 2,300 to 12,594 nitrate-attributable cancer cases annually of which 54-82% are colorectal cancer cases[171].

The industrialisation of livestock agriculture has led to increased concentrations of arsenic, zinc, and copper, which can work as endocrine disruptors. Heavy metals from industrial livestock wastes (slurry's, manures etc) and added to animal feed (zinc and copper can be added to animal feed to promote growth) can contaminate drinking water, soil, fodder, and food. Toxic heavy metals such as cadmium, zinc, lead, arsenic, and mercury can have significant impacts on health. Mercury for example, can enter the livestock food chain through water contamination and can be harmful at extremely low concentrations because of its high toxicity and ability to bioaccumulate[172]. It initially accumulates in algae and bacteria and then it enters fish, shellfish, and finally the consumption of seafood contaminated with mercury leads to toxic effects in humans. There is some emerging evidence to suggest that these heavy metals may also lead to the co-selection of antibiotic resistance genes[173].

One million illnesses, over 56,000 deaths, and more than 9 million DALYs result from heavy metal contamination of food[174]. One estimate suggests that the costs associated with harmful chemical (pesticides, EDCs) and heavy metal exposures around the world likely tops 10% of global Gross Domestic Product (GDP)[175].

Image: Aerial drone view of the Xingu Indigenous Park territory border and large soybean farms in the Amazon rainforest, Brazil. Almost 80% of the world's soy bean crop is used to feed farmed animals not people. Credit: PARALAXIS / Shutterstock

Air pollution

Factory farming operations produce massive amounts of animal waste like urine and manure that emit around 400 different harmful gases into the atmosphere. Some of these gases include nitrous oxides, ammonia, particulate matter, endotoxins, and hydrogen sulphide. Because thousands of animals are kept together in factory farms, the concentration of the gases produced can be extremely dangerous to the local community. People living near industrial factory farming operations often have higher rates of illness, including respiratory problems and infections with antibiotic-resistant pathogens[176]. Agriculture is the single largest contributor of ammonia pollution as well as emitter of other nitrogen compounds (nitrous oxides). Higher ammonia concentrations in the air are associated with acute deficits in lung function in adults and asthmatic children living close to factory farming operations[177]. High exposure to ammonia is associated with acute lower respiratory illness, cerebrovascular disease, ischaemic heart disease, chronic obstructive pulmonary disease, and lung cancer. Nitrogen-based air pollution has been identified as the largest contributor to air pollution in many regions of the world, including Europe, Russia, Turkey, Korea, Japan, and the Eastern United States[178]. In the USA research estimates that 16,000 USA deaths are the result of air polluted by growing and raising food–and 80% of those result from producing animal products like meat, dairy, and eggs[179].

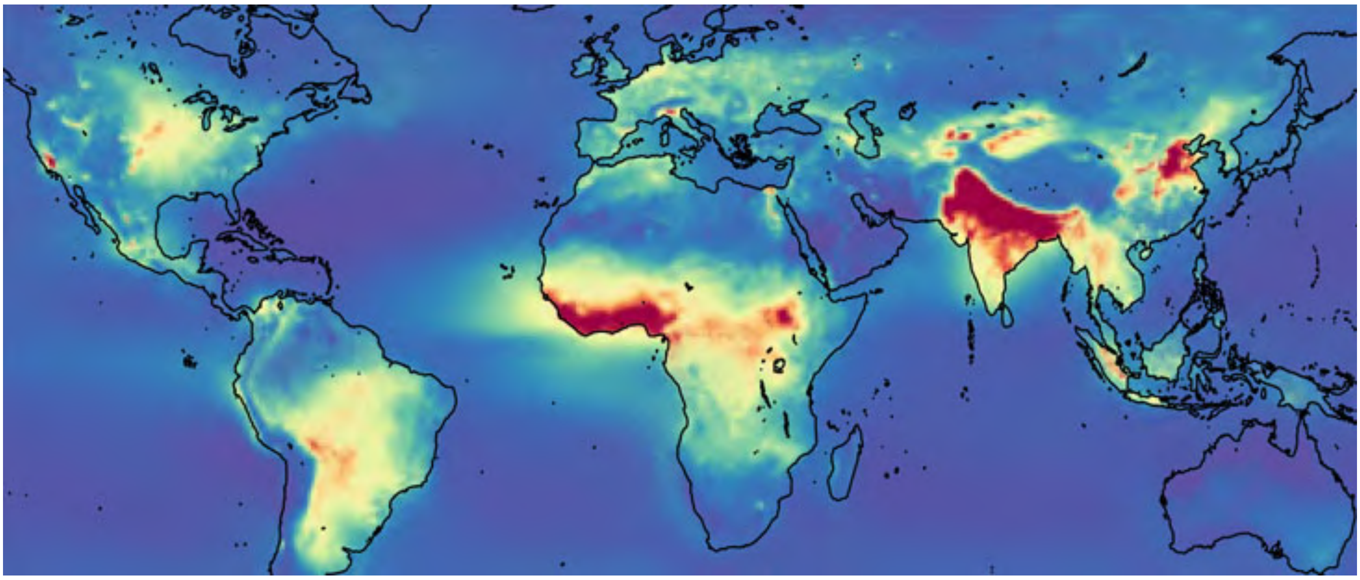


Figure 17 - A map showing 248 nitrogen emission hot spots across the globe. Eighty-three of those hot spots arose from agricultural activity that involved high numbers of cows, pigs, and chickens. Ammonia emissions from feedlots come largely from livestock waste. Another 158 sites were affected by industrial emissions – mostly from sites that produced ammonia-based fertilizer, which in turn is used to produce crops for industrial livestock systems[180].

2.5 Occupational hazards

An occupational hazard is a health hazard experienced within the workplace. Within industrial livestock systems these can be physical and mental health impacts suffered by actors within their place of work and include livestock factory farmers, agricultural workers supplying feedstocks, aquaculture workers, abattoir workers, those working within meat processing and packaging facilities, livestock/meat distributors and those selling meat within the marketplace (retail, formal and informal markets).

Poor working conditions within meat slaughtering, processing, and packaging facilities

Meat slaughtering, processing, and packaging plants are often labour-intensive. Although modern plants have made ergonomic improvements over the years, repetitive strain injuries are common, such as are cuts, slips and falls. Due to the intensification of work, a growing number of workers are now suffering from new occupational diseases, such as musculoskeletal disorders and from psychosocial factors at work (the most common being work-related stress). Job insecurity, poor wages and long working hours have become the norm for many meat workers. In the USA meat processors have some of the highest occupational injury and illness rates at 4.3 per 100 full-time workers in 2018. This is almost 40% higher than the national average across industries[181]. A recent investigation[182] uncovered that Europe's USD 258 billion meat companies across Europe have been hiring thousands of workers through subcontractors, agencies and bogus co-operatives on inferior pay and conditions and has become a global hotspot for outsourced labour, with a floating cohort of workers, many of whom are migrants, with some earning 40% to 50% less than directly employed staff in the same factories. In the Netherlands, one of Europe's largest meat exporters, the labour inspectorate said migrants, primarily on precarious contracts, make up to 90% of the workforce. In Australia, hundreds of migrant meat processing workers have been victims of unscrupulous practices with unkept promises made of a path to permanent residency involving visa fraud, through a network of middlemen working for meat processing plants[183].

COVID-19 has brought to the fore the poor working practices and conditions within livestock slaughtering and packaging plants in many countries including the United States, France, Germany, and Spain. Meat packing workers working for companies such as Tyson, JBS, Cargill, and Smithfield were placed at significant risk with nearly 59,000 testing positive for COVID-19[184]. In the United States, meat processing plants were associated with 236,000 to 310,000 COVID-19 cases (6 to 8% of total) by the end of July 2020[185]. Occupational health risk factors have contributed towards the spread the disease and included long work shifts in close proximity to co-workers, lack of access to personal protective equipment, environmental conditions in warehouses, and shared transportation and dormitories among workers[186]. Inequality issues also contributed to COVID-19 outbreaks – for example, most of the workforce in meat plants represent migrant and minority workers who are inherently more vulnerable to exploitation[187].

SUPPORTING MEAT PROCESSING WORKERS WITH MENTAL HEALTH ISSUES AND NEW EMPLOYMENT OPPORTUNITIES

The Brave New Life Project (BNLP)[188] is community-based initiative, working in Colorado, USA, that supports workers to transition out of the animal agriculture industry and into careers that are more humane, sustainable, and prosperous. They actively advocate for the transition of agricultural workers in the animal industry and their families by providing the services, resources, and tools they need to have a better quality of life. They offer one on one job coaching for resume help, interview preparation, and support workers looking for new job opportunities.

The core employment approach of BNLP has been adapted from the Individual Placement and Support (IPS) Model, a model of supported employment for people with serious mental illness (e.g., schizophrenia spectrum disorder, bipolar, depression). Many of the workers in the meat processing industry that BNLP supports are migrant workers with very few rights and who have little access to health care within the USA. They often endure long hours and constantly increasing quotas with the increase of line speeds. Most are poorly represented by their employers and their own unions and feel discontentment within the meat processing industry. BNLP supports these workers and connects them with other professional organisations to provide practical support to address mental health issues and with new employment opportunities.

Physical injury in factory farms and aquaculture

According to International Labour Organization (ILO), at least 170,000 agricultural workers are killed each year[189], although there is very little specific data available on the proportion of these working specifically within industrial livestock systems. Furthermore, widespread under-reporting of deaths, injuries, and occupational diseases in the agricultural sector, means that the real picture of the occupational health and safety of workers is likely to be worse than official statistics indicate. Many injuries within the meat processing industry for example, go unreported, often because they can be undocumented migrants or from poorer backgrounds, which gives employers a great deal of control over workers who are always fearful of deportation or dismissal should they cause problems in the workplace. Workers are afraid to report injuries out of fear of losing their job. Much work within factory farms and in aquaculture is, by its nature, physically demanding. The risk of accidents increases with fatigue, poorly designed tools, difficult terrain, exposure to extreme weather conditions, and poor general health. For example, workers in meat processing facilities face risks from operating machinery at high speeds with one report finding that US meat processing workers are subject to considerable health and safety risks and mistreatment at work[190].

The world's estimated 19 million aquaculture workers regularly contend with hazardous conditions including injury and death resulting from a variety of causes including drowning, electrocution, crushing-related injury, hydrogen sulphide poisoning, and fatal head injury[191], although these incidences are often under reported, particularly from LMICs[192]. These often include vulnerable populations in precarious work, including women, Indigenous People, children, seasonal, migrant, rural and remote workers.

Image: Seven day old broiler (meat) chickens in a commercial indoor system. Credit: World Animal Protection

Psychosocial and mental health issues

Many psychosocial and mental health issues result from illness and sickness described within this report. For example, slaughterhouse and meat packaging workers, working in cramped conditions, on low salaries and who are exposed to several diseases, such as Covid-19, suffer from a range of serious psychological and mental health impacts[193]. Food insecurity, driven by the industrialisation of livestock and their associated longer supply chains, can result in mental health issues by creating uncertainty, anxiety, and stress over the ability to maintain food supplies or to acquire sufficient food in the future[194]. Overweight, obesity and associated NCDS, caused by an excess in meat consumption, are also significantly associated with mental health problems[195]. There is also a strong link between pesticide poisoning associated with the animal feed industry and the incidence of suicide, which according to some accounts is responsible for 14-20% of global suicides[196]. Farmers, farm workers and their families experience one of the highest rates of suicide of any industry and there is growing evidence that they are at higher risk of developing mental health problems – confronting a range of stressors related to the physical environment and economic difficulties[197].

3. TRANSFORMING INDUSTRIAL LIVESTOCK SYSTEMS: OPPORTUNITIES FOR BETTER HUMAN, PLANETARY AND ANIMAL HEALTH AND WELL-BEING

This section highlights how we can transform our entrenched industrial livestock systems to livestock systems which nourish, restore and regenerate health. It focusses on nine systemic shifts which have the potential to deliver the biggest health gains, across the five impact pathways described in this report.

3.1 A shift in mindsets

Delivering the ambitions of the SDGs, limiting global heating, reducing environmental degradation, and addressing malnutrition will be impossible using industrial livestock systems. We need to address the root causes and not the symptoms of an industrial livestock system that makes humans, animals, and the planet sick. This means an end to cruel, unjust, and inhumane and unhealthy factory farming systems and a shift to livestock systems that are humane, healthy, and sustainable. Mindsets need to shift to recognise that planetary health and high animal welfare are integral to human health, well-being, and happiness.

The prevailing mindset can be referred to as a *'feed the world'* or 'productivist' mindset, which focuses on the quantity of LDFs, and calories produced. It is a mindset driven by a desire to make profits and based on assumptions that we need to increase factory farming to feed a growing global population with cheap meats. It is based on maximizing production, with little consideration given to animal welfare using export-oriented models, where production is concentrated within a few countries and within a few companies, predominantly situated within and driven by the global North. There is a need to ensure that policies support a shift in mindsets that support industrial livestock systems which drive ill health, animal suffering and environmental destruction, to livestock systems which are humane, fair, healthy, and sustainable.

3.2 A shift to true costs and pricing

Globally we spend an estimated USD 9 trillion on food and yet the real costs are double this (USD 19.8 trillion) because of the USD 7 trillion in environmental costs (climate change, biodiversity loss, soil degradation, water contamination), the USD 11 trillion in human health costs (across the five health impacts described in this report) and the USD 1 trillion in economic costs[198]. These costs are not factored into the industrial livestock business model. Whilst companies make massive profits from industrial livestock production, many of the health costs highlighted in this report, including cleaning up watercourses, the spread of AMR and zoonotic diseases, malnutrition or the associated food borne diseases, are borne by taxpayers.

There is a need to develop ways of internalising these negative impacts so that the costs and losses they engender are properly reflected in the price of food. If this was done, industrial LDFs, would be more expensive than LDFs produced using higher animal welfare and environmental standards. To achieve this there is a need for policy makers to shift agricultural subsidies so that public money is used for public goods – re-orientating subsidies away from industrial livestock systems to those that support regenerative and agroecological practices. According to the UN Food and Agriculture Organisation (FAO), 87% of global agricultural subsidies, equating to USD 540 billion annually is harmful to planetary, human, and animal health and wellbeing. In the USA for example, it is factory farms not farmers who have been benefitting from US government policies which have subsidized the production of soya and maize which go into animal feeds. Between 1997 and 2005, US factory farms saved an estimated USD 3.9 billion per year because they were able to purchase corn and soybeans at prices 5-15% below average operating costs. Industrial livestock companies have collectively saved almost USD 4 billion per year since 1997[199]. In effect, US taxpayers have been subsidizing factory farms and unwittingly supporting the demise of many family farmers who once reared livestock using more humane, sustainable and extensive grazing systems but who have found it more cost effective to grow corn and soya for the animal feed industry.

A range of fiscal tools, such as taxes and financial incentives can also be used to reflect the true cost of LDFs. For example, taxes can be placed on unhealthy, inhumanely produced LDFs with the revenue raised being used to subsidise the price of healthy food produced to high standards of animal welfare, ensuring equitable access to food. In countries which charge Value Added Tax (VAT) on LDFs, the VAT charged on LDFs produced using humane, sustainable, and healthy principles could be reduced with higher VAT rates applied for LDFs produced using industrial livestock systems.

Many negative health impacts of LDFs and their costs fall disproportionately on the poorest and most disadvantaged in society, reinforcing health inequalities. Governments must help facilitate the affordability and access to healthy and sustainable diets for poorer households through social protection programmes such as vouchers, cash, school feeding, or food supplement programmes with households supported by governments investing in a wide range of social infrastructure and safety nets, for the public interest. Creating a healthy food environment is also critical to support a dietary shift – so planning policy and urban design for example, plays a vital role in shaping these environments and ultimately access to healthy and nutritious foods, such as fresh fruit and vegetables, for the most vulnerable.

3.3 A shift to a just transition

To shift away from industrial livestock approaches towards livestock systems based on high welfare agroecology, regenerative and pastoral systems, a just transition approach is needed to enable this transformation. The transition must be supported in a way that works for farmers, farmworkers, abattoir workers, processors, and disadvantaged citizens; and must provide them with the fiscal incentives, support, safety nets and social protection required to make these shifts. There is strong potential for those negatively impacted by the industrial livestock system to become advocates for change if equity considerations are prioritised. Many farmers and workers often feel trapped and that their livelihoods are precarious, squeezed by more powerful players, including large agrochemical suppliers and livestock buyers. A just transition approach would involve enhancing equity in livestock value chain relationships and ultimately improving the negotiating power of the smaller most vulnerable producers[200].

Transition support should be provided for farmers no longer wishing to engage in industrial livestock systems – for example those who wish to diversify to regenerative or agroecological livestock systems, move to horticulture or to silvopastoral systems. With an aging farmer population in some parts of the world, it may also provide an opportunity to support the younger generation enter the humane and sustainable farming sectors. Whilst a just transition is important in every region and country, the approaches must be tailored after thorough consideration of local realities, relevant to specific cultures and geographies, and must respect community rights and decision-making. A recent assessment by the ILO and Inter-American Development Bank highlights how shifting to healthier and more humane and sustainable diets in Latin American and the Caribbean, which reduce meat and dairy consumption while increasing plant-based foods, would create 19 million full-time equivalent jobs despite 4.3 million fewer jobs in livestock, poultry, and dairy sectors[201].

3.4 A shift in power and influence

The governance of industrial livestock systems has changed dramatically over the last 70 years with the liberalization of agricultural markets, the commodification of food and the corporate consolidation of power and influence. At the same time, those actors whose livelihoods, health and wellbeing are most impacted by policy and practice decisions, such as small holder farmers, pastoralists, citizens, processors and packers, seasonal and migrant workers, are often the ones excluded from decision making.

JBS, Tyson Foods, Cargill and Smithfield are the world's largest meat-producing corporations. In the US, these corporations process 85% of the beef, 71% of the pork and over half of the chicken between them[202]. They create an illusion of choice for the consumer, offering over 60 meat-focused brands between them[203]. The phenomenal rise of these corporations, often funded by subsidies from public funds, continues to drive significant hidden external health and sustainability costs, which are picked up by the public purse (Section 3.2). Corporate power and influence pervade the industrial livestock systems with a few companies (who often own many parts of the livestock value chain, including factory farms, animal feed operations, distribution to the final brand), having a significant influence over government policy making, research, investment, and finance. The industry has been able to block, undercut and shape laws and regulations that should protect the public from the environmental, public health and economic consequences of industrial livestock systems[204].

These corporations receive huge amounts of private sector investment. Between 2015 and 2020, global meat and dairy companies received over USD 478 billion in backing from 2,500 investment firms, banks, and pension funds around the globe, in the form of loans, underwriting, investment or revolving credit, most of them based in Europe and North America[205]. Recent research found that 3,000 investors provided USD 228 billion to the 35 largest meat and dairy corporations. In addition to investment, between 2015 and 2020, loans totalling USD 167 billion flowed from over 200 banks to these companies, with banks based in the USA, France and the UK providing 51% of the total credit. These financial flows continue to prop up industrial livestock systems that make us sick as a result.

There is an urgent need to shift corporate power and influence which gives the largest livestock corporations unbridled power and influence over the rules that govern our food system and significant influence in the marketplace.

3.5 A shift in trade

International trade in LDFs has risen from USD 64 billion in 2000 to USD 173 billion, accounting for 16% of world agri-food trade with the top five exporting countries being the European Union (with 21% of the total in 2018), the United States (15%), New Zealand (10%), Brazil (9%) and Australia (8%) with China and Japan as the two largest importers (17% and 10% respectively)[206]. World trade in animal products is dominated by a few large private multinational companies or very large cooperatives. These companies include JBS, Tyson Foods, Cargill, Dairy Farmers of America, Smithfield, Fonterra, Nestlé, Lactalis, Arla, Campina-Friesland, Yili, Danish Crown, Vion, Saputo, BRF and Marfrig.

Today, most international trade and investment agreements support global food systems that preference industrially produced LDFs, ultra-processed foods and concentrate power among a few corporate actors[207]. Many trade policies are invariably driven by goals that have little to do with sustainability or health, instead focusing on issues such as economic growth, incomes, jobs, and export earnings, which in turn tend to reinforce the dominant industrial livestock systems model rather than transform it. Industrialisation, both in high income countries and LMICs has helped to put small- and medium-sized farms out of business, since they have been unable to compete with large corporations.

There is a need to shift trade policy to reflect the true health, social and environmental costs associated with industrial livestock systems – without this, trade will continue to undermine animal welfare standards and planetary and human health. One recent report[208] highlighted the need for policymakers to consider the impacts of trade tariffs on the promotion and importing of ultra-processed foods and reduce the price of nutrient-rich foods, as this can particularly benefit the poorest. The dumping of foods from European markets (e.g., powdered milk or other animal feeds such as wheat, maize etc.) often undermine prices in local markets[209], reinforcing the dominance of global markets in driving health and nutritional standards. The World Trade Organisation (WTO) rules currently make no reference to animal welfare which is a significant gap that needs to be addressed. Within bi-lateral trade agreements there is also a need to ensure the highest animal welfare standards, with for example, minimum agreed standards for the use of antibiotics in farming.

3.6 A shift to higher animal welfare standards

Many of the health impacts that result from industrial livestock systems could be significantly reduced by adopting high welfare farming systems, where animals are under less stress, develop improved immunity and become resilient to disease. There is a need to ensure that all livestock producers follow minimum standards with respect to how farm animals are raised, transported, and slaughtered. For example, schemes such as the Farm Animal Responsible Minimum Standards (FARMS)[210] outlines minimum welfare standards for existing industrial farms, covering beef cattle, chickens raised for meat (broilers), dairy cattle, laying hens and pigs. The scheme is designed to eliminate conditions resulting in the worst forms of suffering on factory farms including cages, confinement, barren environments, painful procedures, extreme genetics, long distance transport and inhumane slaughter. These standards can be applied to factory farmed animals, resulting in improved welfare and a life worth living, but don't necessary mean farm animals will have a good life.

Figure 18 - The Five Domains Model for assessing animal welfare with domains 1-4 contributing to an animal's mental state in domain 5. Examples of positive and negative mental states originating from domains 1-4 are given. An animal cannot have an overall positive mental state within a factory famed system

3.7 A shift to regenerative and agroecological systems

High welfare agroecological, regenerative, pastoral, and organic livestock farming systems focus on farming practices and principles that can build soil health, improve biodiversity, reduce global GHGs, improve farmer livelihoods, improve the nutrition of the poorest and build health back into the system. They are characterised by ownership models focussed on the farmer and focus on traditional and culturally appropriate breeds of animals which are more resilient to local environmental conditions. In many parts of the world these traditional systems are increasingly being squeezed by more industrial livestock production systems.

Extensive grassland, pastoral grazing systems, and silvopastoral (livestock grazing with trees) systems, when properly managed and high welfare, are examples of approaches to livestock management that work in harmony with nature. Millions of people's livelihoods depend on these systems as an important source of nutrient rich foods within variable environments where alternatives do not exist. Well-managed silvopastoral systems for example, can increase forage quantity and quality, promote animal welfare, diversify farm income, and reduce pressure on the surrounding forests[211].

The redirection of subsidies from industrialised farming systems to agroecology and regenerative practices will bring significant health co-benefits. New incentives to support and reward farmers to transition to higher animal welfare agroecological, diversified practices, and support alternative land use practices and ecosystems integrity, should be a priority for governments.

PEASANT FARMERS BUILD AGROECOLOGICAL ALTERNATIVES TO INDUSTRIAL FARMS, BRAZIL[212]

Roseli Nunes is a pioneering settlement located within the Mato Grosso region of Brazil that has resisted the dominant industrial approach to farming that has swept across much of the rest of Brazil over the last 20 years. It is surrounded by large, intensive farms in a state that has been heavily deforested; Mato Grosso has the largest cattle herd in the country (about 31 million) and produces more soybeans, corn, and cotton than any other Brazilian state. Roseli Nunes is seen as a symbol of peasant resistance and the struggle for control of the land. Once a cattle ranch where rural workers were held in slave-like conditions, it was expropriated by the Brazilian state in 2000 following a battle led by the Landless Rural Workers Movement MST). The ranch's 11,000 hectares were then divided equally between 331 families, with each receiving a 25-hectare plot.

Agroecology at Roseli Nunes became the antithesis of the surrounding industrial farms. It now includes productive smallholdings, agroforestry systems, pasture management, creole seed production, women's empowerment, the production of a diverse range of fruits and vegetables and raising a range of drug-free and heritage breeds of livestock and farm animals. The Regional Association of Agroecological Producers provides training and support for many families at Roseli Nunes with the aim of achieving food sovereignty through socially just methods of production and economic management. Despite more recent setbacks, including government support for industrial systems over agroecological approaches, for those still involved, agroecology remains the most politically, economically, and healthy option.

3.8 A shift to sustainable and healthy diets

Shifting to healthy and sustainable diets is the single biggest intervention that would help to reduce the GHG, biodiversity and the health impacts of our food systems. Sustainable healthy diets are dietary patterns that promote all dimensions of individuals' health and wellbeing; they have low environmental pressure and impact; improve the welfare of farmed animals; are accessible, affordable, safe, and equitable; and are culturally acceptable[213].

Several recent studies have demonstrated the significant impact that increasing consumption of plant-based foods relative to animal-source foods can have on human health. The EAT-Lancet Commission found that premature mortality could be reduced for up to 11 million people by doubling the consumption of nuts, fruits, vegetables, and legumes and halving red meat and sugars within diets[214]. Another study found that 11 million deaths and 255 million disability-adjusted life years (DALYs) were attributable to dietary risk factors that include high intake of sodium, low intake of wholegrains and low intake of fruits in many countries[215]. It is estimated that 80% of all chronic NCDs are preventable through a combination of physical activity and changes to our diet[216].

Overall, a global reduction in the consumption of LDFs is necessary, recognising that countries with high per capita consumption would need to make larger cuts than those with low average per capita consumption. Globally this would entail a reduction in the global production and consumption of LDFs of 50% of LDF by 2040, to deliver on the global ambitions as set out under the SDGs, the Decade for Action on Nutrition, and the Paris Agreement on climate change. This would enable some increased consumption of LDFs in some countries and regions and substantial reductions amongst high-consuming populations[217 218]. As meat consumption and production declines, protein needs should be met by increasing the proportion of plant-based proteins within the diet.

Where LDFs are consumed, these should be sourced from high welfare agroecological and regenerative livestock systems, given the heath and sustainability co-benefits these provide as compared to industrial livestock farming systems. In addition, there is a need to ensure that farmed animals, even under more regenerative and agroecological systems, do not consume food suitable for humans. Farmed animals should only convert food that people cannot consume (grass, by-products, food waste, crop residues etc.), given the inherent inefficiencies and sustainability impacts of converting plant proteins into animal proteins for human consumption.

Image: Meat in the supermarket, likely linked to soy production in Brazil. Credit: World Animal Protection / Julia Bakker

Animals in a future humane and sustainable food system must have a good life and align with ecological farming principles. These principles should act as a guiding star for the future of livestock systems:

Sustainable	Humane				
	1. Nutrition (food & water availability + variety)	2. Physical environment (space, flooring, atmosphere, odours, temperature, noise, and light)	3. Health (injury, disease, physical fitness – genetics & painful procedures)	4. Behavioural interactions (with the environment, other animals, humans)	5. Mental States (as a result of domains 1-4, e.g. comfort, pleasure, interest and confidence)
1. Ecological food and feed (for humans and animals, i.e., no food-feed competition, wildlife harm)	• Animals are not fed human-edible crops or housed on land suitable for the production of human-edible crops, meaning fewer animals produced so fewer animals suffer. • The use of local, seasonal animal feed means more variety with greater interest and pleasure for animals.				
2. Biodiversity of plants & animals (locally adapted, climate resilient breeds with genetic diversity, production systems align with the natural environment maximising carbon sequestration)	• Genetic selection prioritises welfare over production traits making animals better adapted to cope with the local conditions, so they experience better welfare. • Animals better able to cope with the environmental conditions are more likely to cope with extreme environmental conditions and diseases meaning fewer suffer. • Animals are raised in biodiverse environments that allow expression of their full behavioural repertoire; positive animal impact on the land results in healthier soils and greater biodiversity.				
3. Responsible resource use (habitats, land, water, soil, energy, antibiotics, waste reduction, pesticides, fertilisers + technology, minimise GHG emissions, avoid harm to wildlife)	• Animals produced and consumed locally benefit from short transport distances. • Responsible antibiotic use means animals are raised in healthy environments. • Genetic modification or technology that enables factory farming to continue is avoided. • Animals are raised in environments better suited to their genetics and natural behaviour. • The use of dual-purpose breeds (meat and milk cows or meat and eggs chickens) means less suffering and no waste for male layer hen chicks and dairy calves.				
4. Food resilience and sovereignty (all society rather than vertically integrated corporations take control, adaptable to 'shocks')	• Smaller scale, more localised food systems mean people are more connected to their food and conscious of animal welfare. • Farm decision makers are those responsible for taking care of the animals directly so prioritise the needs of the animals as well as financial sustainability. • Smaller scale, local ownership, and community empowerment improve ability to respond to challenges (natural disasters, food shortages, disease outbreaks) resulting in increased resilience for animals and people alike.				
5. Benefitting society (food security, nutrition, rural development, livelihoods, one health, one welfare)	• A good life for animals benefits wider society through better health and well-being (eg reduced zoonotic disease risk). • High welfare conditions for animals creates better healthier working conditions for farmers and animal carers. • Animals in high welfare conditions, adapted to the local conditions are more productive, higher quality, making them healthier for consumers and provide a good living for the farmers.				

Figure 19 - World Animal Protection humane (1) and sustainable (5) protein criteria with ✓ examples of what this means for animals in farming.

There is an opportunity for governments to develop national and regional dietary guidelines which should include emphasising the important role plant-based proteins play in meeting the nutritional and cultural needs of local and national populations. In addition, National climate action plans (known as Nationally Determined contributions) and National Adaptation Plans should be updated to include national meat production and consumption targets and policies that facilitate the consumption of LDFs for humane, healthy, and sustainable diets. Policies need to address the health impacts that arise from livestock farming in tandem with the health impacts of what people eat.

3.9 A shift to One Health, One Welfare

'One Health' is defined as '*an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems. It recognizes the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and inter-dependent*'[219]. One Welfare extends and overlaps with the One Health approach and is defined as '*the interrelationships between animal welfare, human wellbeing and the physical and social environment*'[220] A One Welfare approach promotes the direct and indirect links of animal welfare to human welfare and sustainable, humane livestock systems[221].

Figure 20 - A One Health, One Welfare Approach would enable policy, investment, and research to address multiple health impacts[222].

These concepts have gained significant traction in national and international settings and offer an opportunity to mobilize multiple sectors, disciplines, and communities at varying levels of society to collaborate to improve the health and wellbeing of people, planet, and animals. They demand a shift in policies which focus on treating the disease (a curative approach) to policies that take a systems-based approach (preventative approach) focussing on the underlying drivers of ill health across the multiple impact pathways highlighted in this report.

It has been estimated that one dollar invested in One Health approaches can generate five dollars' worth of benefits at the country level through increased GDP and the individual level[223]. For example, the cost of treating and controlling bird flu (avian influenza) in people is vastly outweighed by the cost of vaccinating poultry against the disease. Savings can be used to build resilience to absorb health shocks. Strengthening human, environment and animal health capacity by the One-Health approach could result in 10%–30% cost saving in surveillance and communication costs[224].

4. RECOMMENDATIONS FOR POLICY MAKERS

Throughout this report we have highlighted the importance of government policy and action (at international, regional, national, and local levels) as a way of recognizing the true costs of industrial livestock systems, and to level up the playing field so healthy, humane, and sustainable livestock systems are not placed at an unfair disadvantage. This section lays out ten policy recommendations for government action to address the health impacts of industrial livestock systems and address the nine shifts highlighted in this report:

1. **Governments must recognise the inter-connected public health and planetary impacts of industrialised farming systems and commit to stopping the support for factory farms.** Delivering the SDGs, addressing malnutrition, limiting GHG emissions below 1.5 degrees centigrade and stopping biodiversity loss will be impossible using industrial livestock systems. This means governments must put a stop to supporting factory farming systems and the continued industrialisation of livestock systems which undermine small family farmers and pastoralists that use high animal welfare agroecological or regenerative farming systems.

2. **Ensure fiscal policies, including taxation and social policy and programs, research, and infrastructure investments, align to reflect the true health, sustainability, and animal welfare costs of livestock production systems.** Applying True Cost Accounting (TCA) approaches will provide transparent, consistent guidance for governments, investors, farmers, corporations, and other stakeholders. Taxation measures could be considered on agricultural inputs that cause significant health and environmental harm, for example, taxes on chemical fertilisers and pesticides or on those LDFs originating from industrial livestock systems. A range of other financial incentives could also be used to support those groups most impacted by taxation, for example, through social protection programmes that support the poorest, improving the affordability and access to fruits, vegetables, and plant-based proteins.

3. **Establish national plans to support a just transition away from industrialised livestock production towards agroecological systems that produce sustainable plant-based foods and fewer farmed animals in high welfare environments.** Countries should establish an inclusive Just Transition policy process which engages trade unions, farmers associations, pastoralists, indigenous groups, abattoir workers, meat processing and packaging workers, retailers, farmers' associations, citizens, and civil society organisations to determine what kind of transition is required and how to ensure a Just Transition. Less powerful groups should be given support to engage on an equal footing and resulting policies and plans should support the priorities of the most vulnerable groups.

4. **Ensure integrated, participatory, transparent, and rights-based approaches to governance and policymaking at all levels across the livestock system.** There is an urgent need to address corporate power and influence which gives the largest livestock corporations unbridled power and influence over the rules that govern our food system and significant influence in the marketplace. There is a need to build processes and policy platforms on democratic principles, transparent deliberations, shared power, and inclusive participation to ensure that policies are driven not only by profits but by the need to address the health, animal welfare and planetary impacts of industrial livestock systems.

5. **Introduce trade policy incentives that facilitate shorter LDF value chains and that support agroecological, regenerative and pastoral LDFs.** Improving animal welfare standards and sustainability must be a priority. Trade tariffs should be applied on industrially produced LDFs to ensure that where they exist, the high animal welfare and sustainability standards of importing countries, are not undermined. Governments should advocate for a new protocol for minimum health, animal welfare and sustainability standards as part of the World Trade Organisation.

6. **Meet FARMS animal welfare requirements for production or procurement as a minimum.** This includes developing an overarching animal welfare policy informed by the Five Domains model[225] that leads to a Good Life[226] for farmed animals. Governments should introduce and phase in production or procurement standards in line with FARMS animal welfare standards, as a minimum.

7. **End subsidies and policy support for inhumane, unhealthy and unjust industrial livestock systems and redirect these to support to regenerative, agroecological and pastoralist systems that deliver better human, animal, and planetary health outcomes.** Agricultural subsidies must incentivise the production of humane, sustainable, healthy, and nutritious LDFs. No public money should be used to prop up damaging industrial livestock production systems or subsidies for health damaging activities such as chemical fertilisers, pesticides, antibiotics, or growth promoters.

8. **Commit to a moratorium on factory farming within National Climate actions plans (known as Nationally Determined Contributions (NDCs) in recognition of factory farming's climate impacts.** These NDCs should include specific targets for reducing livestock emissions from land-use change, reducing food waste, supporting agroecology/regenerative agriculture and livestock systems, and supporting the move towards humane, sustainable, and healthy diets (in line with an average global reduction in meat consumption and production of 50% by 2040).

9. **Promote humane, sustainable, and healthy diets, including those that support an average global reduction in meat and dairy consumption and production of 50% by 2040, through the provision of healthy eating advice and other financial incentives.** Governments should reflect human, animal, and planetary health within their food-based sustainable dietary guidelines (FBSDGs) and public procurement policies with specific recommendations focusing on the adequate consumption of fresh fruits, vegetables, wholegrains, legumes, nuts, etc. Greater reductions in the production and consumption of LDFs should occur in countries with high per capita rates of current consumption. Increased consumption of LDFs may be needed to support nutrition security in some countries and contexts.

10. **Develop national One Health, One Welfare action plans and national AMR plans that recognise the health impacts of industrialised livestock and restrict its growth.** Governments should develop One Health, One Welfare National Action plans, including AMR National Action Plans, with sufficient budgets to support these, that include the prudent and responsible use of antimicrobials. Within these action plans antimicrobials used in group disease prevention or to promote growth should be phased out with a focus placed on improving animal welfare standards and protecting and restoring ecosystems thereby addressing the underlying causes of animal disease and suffering and human health impacts.

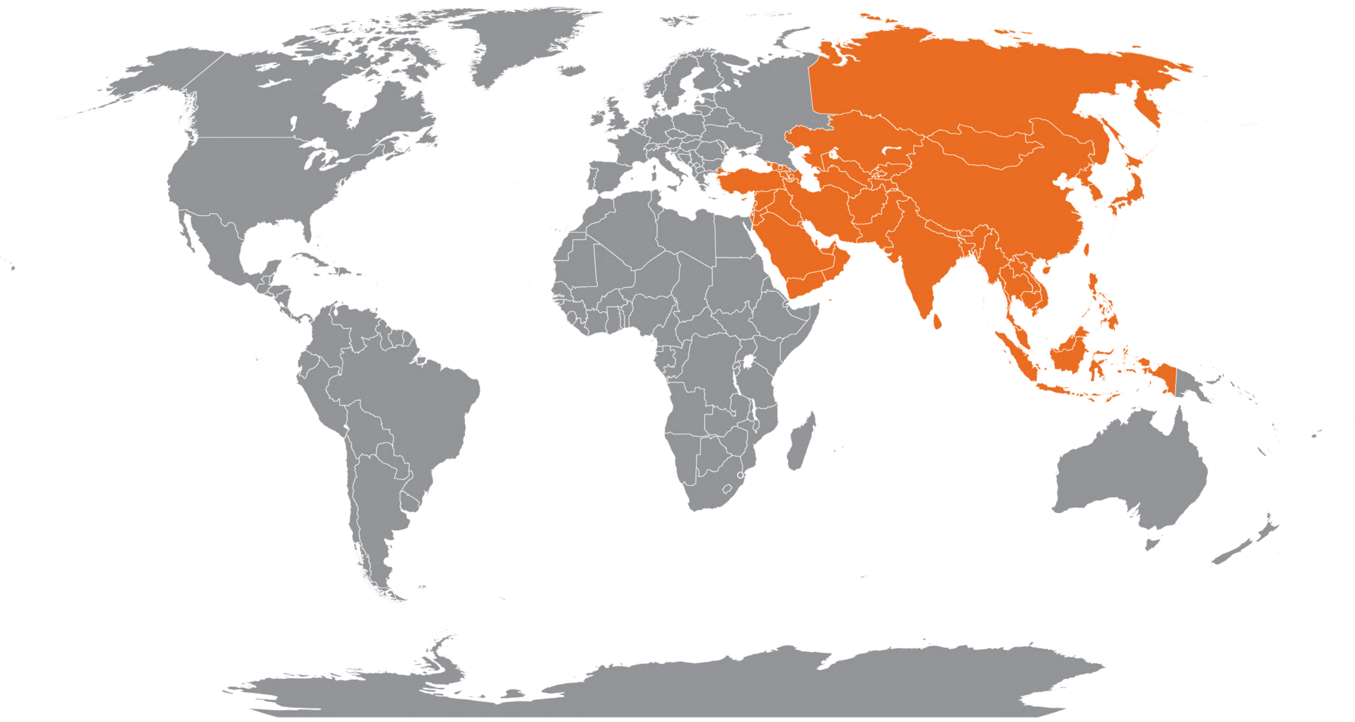
5. CONCLUSIONS

The true health impacts and costs of industrial livestock systems remain hidden and yet they damage our health through multiple and interrelated pathways of impact. They make us ill, damage our planet and cause suffering to billions of farmed animals each year. Whilst industrial livestock foods may appear cheap, they cost trillions of dollars in poor health and ecological damage annually. Many of these 'external costs' are being picked up by taxpayers, citizens, rural communities, smallholder farmers, pastoralists, and future generations. Governments need to act now - to stop support for factory farms, reorientating agricultural subsidies in support of agroecological, regenerative and pastoral livestock systems, committing to global reductions in average meat production and consumption, and tackle the unbridled power and dominance of the few multinational corporations. Within the decade for action, now is the time for governments to deliver better health and wellbeing outcomes for people, planet, and animals.

APPENDIX 1 - A SYNTHESIS OF REGIONAL INSIGHTS ACROSS THE FIVE IMPACT PATHWAYS

This appendix provides an overview of key regional trends and more detailed regional health impacts of industrial livestock systems, under each of the five impact pathways described within this report.

ASIA REGION



Key trends

- Significant growth, driven by population increase, urbanisation, and a growing middle class, is forecast to continue to drive the industrialisation of livestock production in Asia and China in particular, posing a significant threat to public health in the years to come.
- Meat consumption, particularly of poultry meats, is expected to rise in the region by 18% by 2030, continuing to drive the demand for LDFs for both the home markets and export markets. Vietnam, Korea, Malaysia, and China have seen the highest growth in meat consumption per capita since 2000, at 161%, 81%, 56% and 24% respectively. In contrast, meat consumption in Thailand has stabilised over the same period[227].

- Asia is the largest meat producing region, accounting for around 45% of total meat production[228] with significant growth in the production of pork and poultry forecast over the next 10 years. The region will account for 53% of global trade by 2029 with greatest increases originating from the Philippines and Vietnam[229].

- The phenomenal growth witnessed in Aquaculture over the last twenty years will continue with growth forecast to double over the next 10-20 years.

- There is also growing momentum behind higher welfare farming in Asia and animal welfare concerns are becoming increasingly important for Citizens. This awareness is likely to drive the demand for plant-based protein options with early signs that numerous Asian companies are already diversifying into plant-based proteins.

- Pressure will continue for governments to put strong policy measures in place to deal with the health impacts of industrial livestock systems with increasing support for 'One Health' approaches.

Unhealthy diets and food Insecurity

- The region is home to the largest number of overweight and obese people – about 1 billion or two of every five adults. Unhealthy diets are the main risk factors associated with the rapid rise in NCDs, including cancers and diabetes. In 2018 the direct cost of obesity and being overweight accounts for 12.36% of health care expenditure, or 0.78% of GDP in the Asia region[230].

- More than 350 million people in the Asia and the Pacific were undernourished in 2019, or roughly half of the global total[231].

- Industrial livestock systems continue to replace small-holder, pastoralist, and traditional livestock systems, lengthening supply chains with significant negative impacts on food security and animal welfare.

Zoonotic pathogens and AMR

- China and Southeast Asia have become zoonotic hotspots, due to dense populations in these countries and rich biodiversity.

- The particularly steep global demand in poultry will accelerate the establishment of factory farmed poultry units across Asia, increasing the threat of Zoonosis such as bird flu spreading within and beyond the region, with the potential of more deadly strains taking hold[232].

- African Swine Fever has been spreading globally for several years and since the first reports of the virus into China in August 2018, there has been increasing concern over this disease in Asia and the Pacific. With over 60% of the world's domestic pig population, predominantly within crowded factory farms, the impact of this disease in the region is significant. The total economic loss attributed to African Swine Fever was 0.78% of China's GDP in 2019. Further outbreaks continue in Thailand, Indonesia, South Korea, and Malaysia.

- AMR has become a critical political, social, and economic problem across Asia with WHO deeming it to be one of the highest risk regions globally[233].

- The use of antibiotics in factory farms is set to more than double in just over a decade. The use of antibiotics in poultry and pig farms will increase by more than 120% by 2030, based on current trends. Half of all antibiotics globally are now consumed in China alone. Some of the highest levels of AMR in animals are found in China and India[234].

- Elevated levels of multi-drug resistance are present in farmed aquatic animals intended for human consumption within Asia (33%) and this resistance is expected to rise significantly with the forecast growth of aquaculture in the region. China will remain the world's largest fish consuming country, projected to account for 37% of the global total in 2030[235].

- In China, nearly 80% of children in the Yangtze River Delta region have been detected with veterinary antibiotics in their urine, a consequence of the overuse of veterinary antibiotics.

Unsafe and adulterated foods

- There are 255,000 deaths per year from foodborne illnesses, the highest number of any global region with deaths forecast to increase in line with the increase in the number of factory farms[236]. The top four foodborne bacteria are Campylobacter, Shigella, enterotoxigenic E. coli, and Salmonella enteritidis.

- Poor food safety is a very high and immediate risk in Asia. Animal feeds can often be contaminated with chemicals such as dioxins[237].

Environmental contamination and degradation

- GHG emissions from meat and seafood consumption in Asia will grow almost 90% from 2.9 billion tonnes carbon dioxide equivalent (CO2 e) to 5.4 billion tonnes CO2e from 2017 to 2050[238].

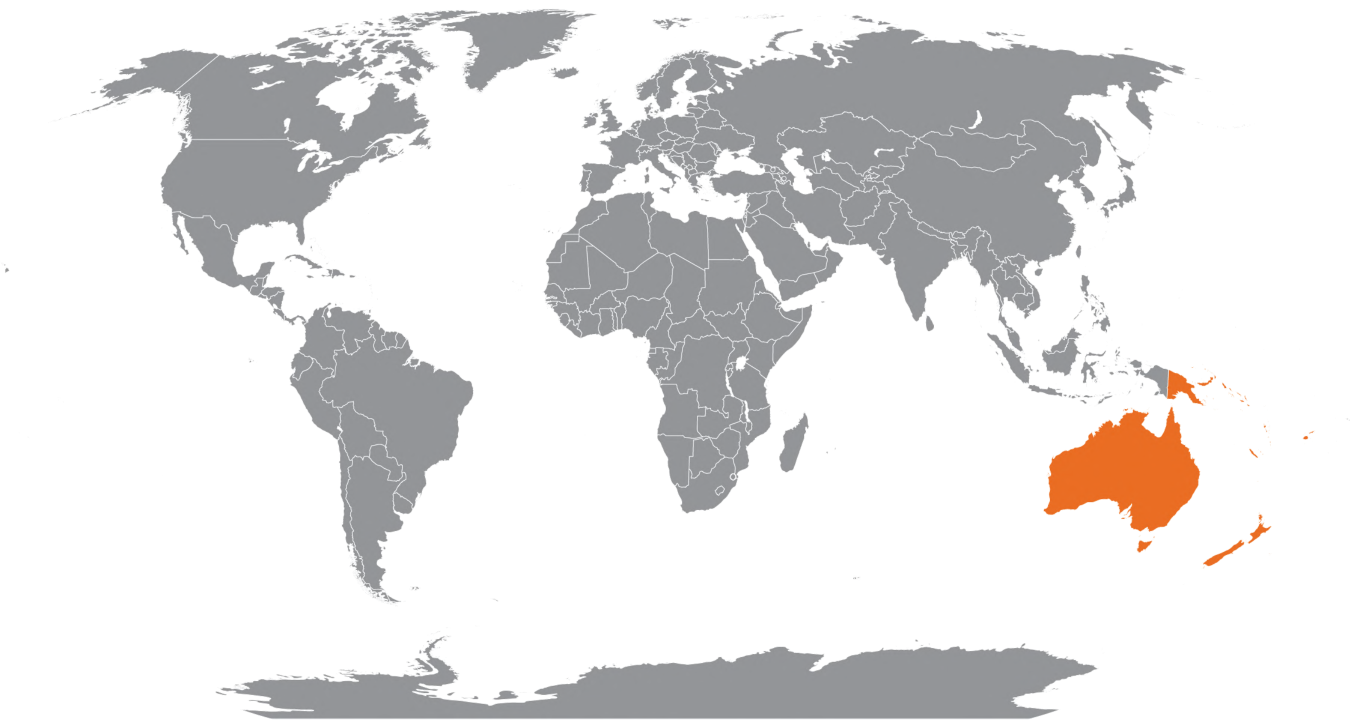
- The demand for animal feeds such as soya continues to accelerate deforestation. SE Asia is forecast to become the fastest growing importer of soya for animal feed by 2022[239].The use of pesticides to grow animal feed will also increase as a result.

- Nitrate pollution of water courses is a growing health concern. Nitrogen and phosphate from livestock in Asia are some of the highest globally with levels of nitrogen at 20kg/ha and phosphate 99.9kg/ha[240]. In India, analysis of the groundwater collected at various sites around caged poultry factory farms, found considerably high levels of nitrate, sulphate and total dissolved solids all indicators of contaminated water[241].

Occupational hazards

- Asia's factory farms have been associated with increased risk of forced labour of migrants, children, and trafficked workers. One report found clear breaches of human rights standards within the Thai poultry sector[242].

AUSTRALASIA REGION



Key trends

- Although Australia and New Zealand are nations of meat eaters and have one of the highest per capita meat consumptions in the world, total meat consumption in Australia rose by 1.2% from 2000-2019, although has fallen in the last year[243]. In New Zealand, per capita meat consumption has fallen by 13% between 2000 – 2019.

- High levels of meat consumption, combined with growing market demand for LDFs in LMICs (driven partly by an increase in outbreaks of African Swine Fever in these countries) has supported the growth of industrial farms (those with receipts above AUS $1 million per year in real terms) from around 3% to 14% of the farm population over the past 4 decades[244].

- Australasia is one of the world top exporting countries for LDFs such as beef, with New Zealand contributing 10% and Australia 8% in global trade.

Unhealthy diets and food Insecurity

- Two-thirds of Australians and New Zealanders adults are now overweight (35.6% and 34% respectively) or obese (31.3% 30.9% respectively)[245 246], some of the highest rates globally.

- Estimates suggest that between 4% and 13% of the Australian population are food insecure. The rate is higher for Indigenous people, unemployed people, single parent households and low-income earners[247].

Zoonotic pathogens and AMR

- Over fifty zoonotic pathogens have been reported in Australia. Q fever is the most common zoonosis in Australia today, found in goats, sheep, and cattle. The LDF pathogens Salmonella and Campylobacter, also have significant health and productivity impacts[248]. Climate Change, combined with further expansion of industrial livestock systems and associated biodiversity loss, is likely to exacerbate the emergence of existing or new Zoonotic diseases in the future.

- The last publicly available data on antibiotic sales is now more than 10 years out of date. But those figures that are available indicate that significant volumes of antibiotics are used within industrial livestock systems across Australasia including the prophylactic use of antibiotics and their use as growth promoters. A high prevalence multi-drug resistance has been detected in bacteria isolated from retail beef, pork, and poultry[249].

Unsafe and adulterated foods

- There are at least 4.1 million cases of gastro each year. On average, there are more than 230,000 cases of Campylobacter and 55,000 cases of Salmonella each year. The total annual cost of foodborne illness in Australia is estimated at is $1.2 billion[250].

Environmental contamination and degradation

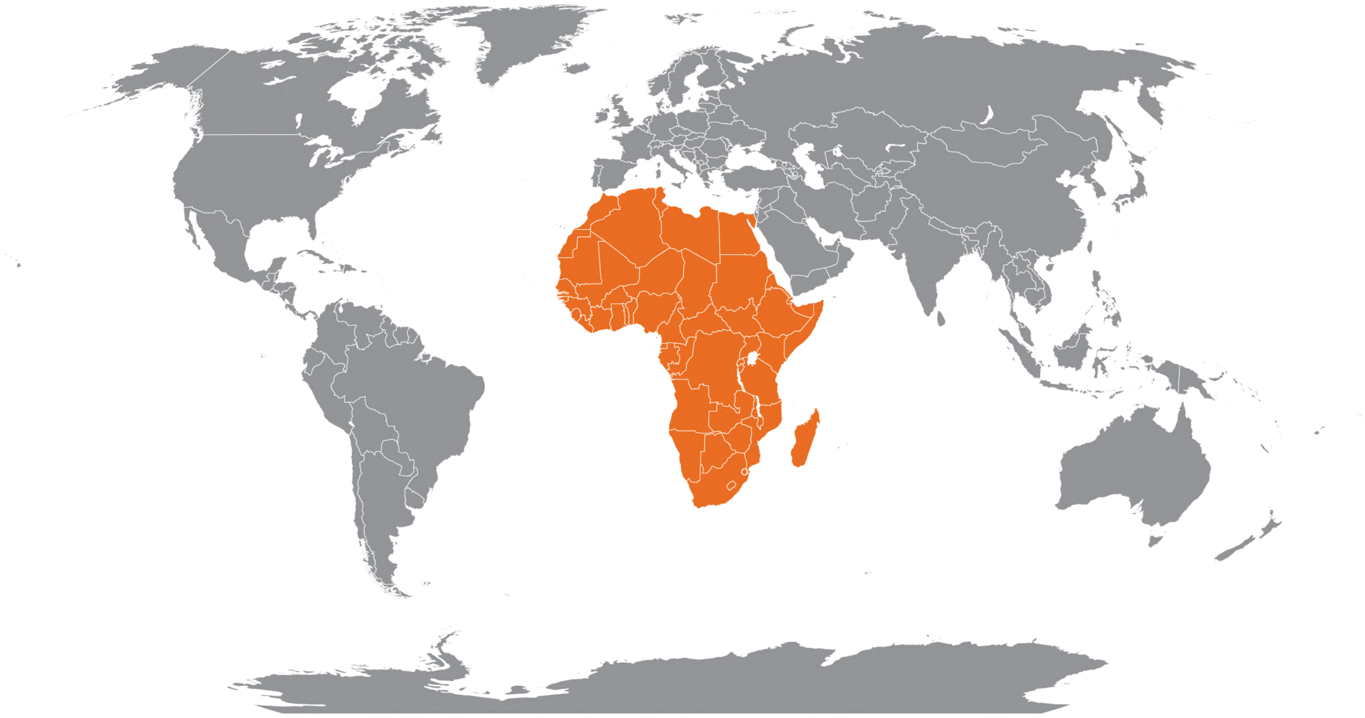
- Declining water quality, with rising nitrates and animal-based effluents has coincided with a boom in factory farming across Australasia and the growth on industrial dairy operations. Cow effluent and fertiliser run-off are significant polluters of inland waterways, as are beef, sheep, and deer farming. Mass deforestation and the extensive clearing of native wetlands has also played a significant role.

- The New Zealand government found nearly 60% of the country's rivers carry pollution above acceptable levels, with over 95% of rivers in pastoral, urban and non-native forested areas contaminated[251].

Occupational hazards

- COVID-19 outbreaks among meat processing plant workers, led to plant closures across Australia and New Zealand. In Australia, hundreds of migrant meat processing workers have been victims of unscrupulous practices and poor working conditions.

AFRICA REGION



Key trends

- Over the next 30-40 years the demand for LDFs will grow rapidly in the African continent (meat consumption is forecast to grow by 30% by 2030) due to growth in human population (from 1.2 billion today to over 2.5 billion in 2050), increasing consumer purchasing power and urbanization[252].

- Meat consumption trends across Africa are varied; Both Ethiopia and Nigeria for example, have seen a drop in per capita meat consumption over the last 20 years standing at 3kg and 5kg respectively. In South Africa meat consumption levels increased by over 61% in the last 20 years, to 62kg per capita[253]. Across Africa the current per capita annual consumption of meat and milk of about 14 kg and 30 litres, are projected to more than double to 26 kg and 64 L, respectively, by 2050[254].

- The future growth and transformation of the African livestock sector towards industrial livestock systems is happening at an unprecedented pace and scale and if uncontrolled, could also have negative effects on public health, the environment, and livelihoods. This will lead to increasing outbreaks of zoonotic diseases, such as avian influenzas and other animal food borne diseases; increasing pollution of water, air and soils by nitrates and antibiotics; and is likely to force pastoralists and small farmers to exit the livestock sector, with negative impacts on their livelihoods and food security.

Unhealthy diets and food Insecurity

- Across Africa over 100 million people in Africa are facing catastrophic levels of food insecurity whilst many countries in Africa are experiencing alarming increases in overweight and obesity, such as South Africa where rates for adult females are among the highest in the world. The latest statistics (2020) show that 18.4% of women and 7.8% of men on the continent live with obesity – up from 12% and 4.1%, respectively and 282 million people are undernourished[255].

- The continued growth in factory farming and the westernisation of human diets will have dramatic consequences on land use in Africa (for example more land will be used for animal feeds) which will make food security more challenging in areas which are already food insecure.

- Pastoral systems are in decline within Africa as land resources are increasingly used for more industrial forms of agricultural production practices.

Zoonotic pathogens and AMR

- Africa is now catching up with Asia as a zoonosis disease hotspot with the densities of humans and factory farmed animals also increasing–particularly in coastal West Africa, North Africa and parts of East Africa. Africa is home to a large portion of the world's remaining intact rainforests, however pressure from industrial systems mean encounters between people, livestock, and wildlife could provide the catalyst for new and emerging zoonotic diseases.

- AMR has already been documented to be a problem for HIV and the pathogens that cause malaria, tuberculosis, typhoid, cholera, meningitis, gonorrhoea, and dysentery. Without action 4.1 million people across Africa could die from AMR by 2050[256].

Unsafe and adulterated foods

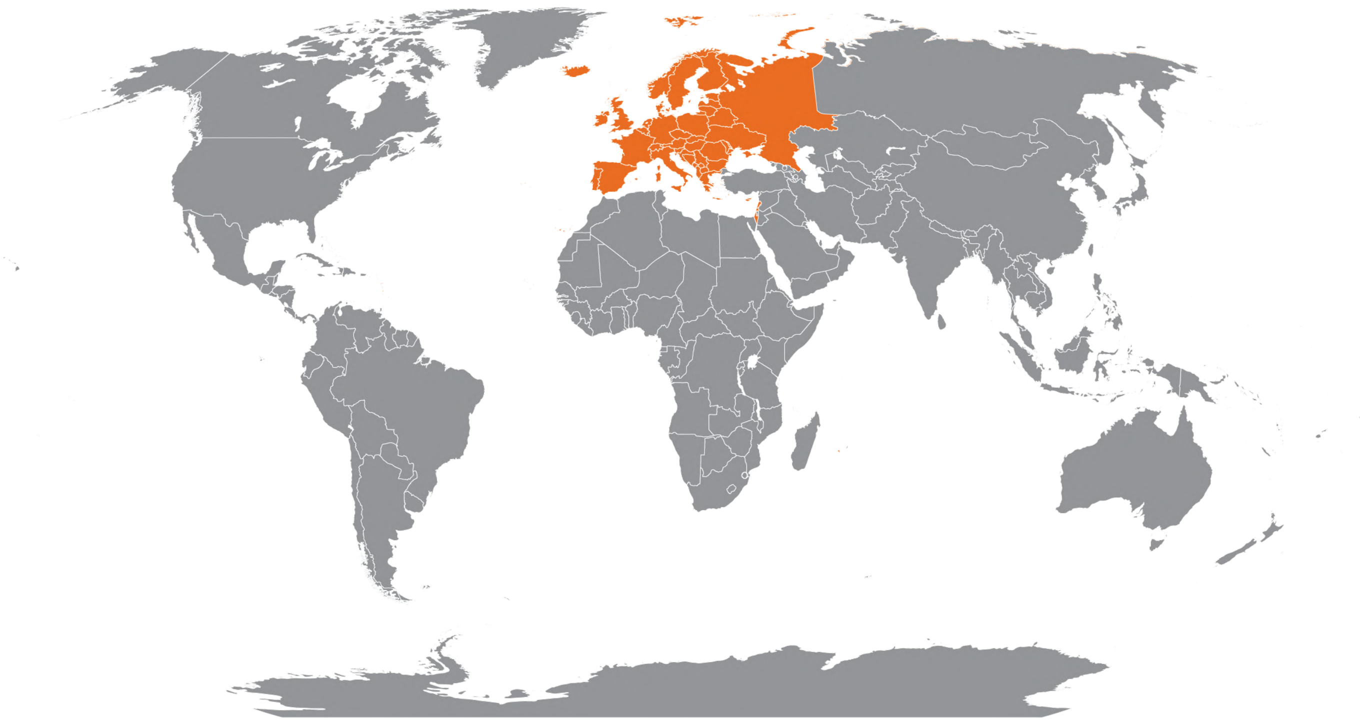
- Africa has the highest burden of foodborne diseases, relative to its population. More than 91 million people are estimated to fall ill and 137,000 die each year. Non-typhoidal Salmonella, which can be caused by contaminated eggs and poultry, causes the most deaths, killing 32,000 a year followed by deaths caused by the pork tapeworm, cyanide in cassava and aflatoxin, a chemical produced by moulds that grow on grains or corn that have been stored incorrectly[257].

- The productivity losses associated with unsafe foods in Africa were USD 20 billion in 2016, and the cost of treating these illnesses are an additional USD 3.5 billion[258]. These costs are heaviest in larger, middle-income countries such as South Africa, Nigeria, and Egypt, yet are also significant and rising elsewhere.

Environmental contamination and degradation

- Groundwater nitrate exceeds drinking water specifications in many parts of the southern African region and is associated with concentrated feedlot operations[259]. The anticipated expansion of industrial livestock production is forecast to contribute towards increasing incidences of manure, methane and nitrate contamination of water, soils, and air, particularly across sub-Sharan Africa[260].

EUROPEAN REGION



Key trends

- The number of factory farms has risen rapidly within the EU over the last few decades with some of the highest concentrations of factory farms found anywhere in the world the (Netherlands and Germany for example). At the same time the total number of agricultural holdings within the EU (mainly smaller family farms) has declined very rapidly (Between 2005 and 2013 the total number of farms in the EU fell by almost one quarter, (a decrease of 3.7% per year).
- The number of animals on very large farms has increased by almost 10 million animals between 2005 and 2013 to reach 94 million. Very large farms now account for 72.2% of all the animals being reared in the EU. In the Benelux countries and Denmark, more than 90% of animals are reared on very large farms[261].
- EU beef and pork and production is expected to fall by 8% and 4.6% respectively from 2020 to 2030, partly driven by expected reductions in the consumption of these meats. EU poultry production is expected to grow by 4.6% in the same period, driven by a consumer switch from beef/pork to poultry and an increasing demand in Asia/Africa for poultry driving exports[262].
- Meat consumption in EU countries is on average 77.1 kilograms per capita, with the highest per capita consumption found in Austria, Spain, Denmark, Luxembourg, and Portugal.

Unhealthy diets and food Insecurity

- Obesity has quadrupled in Europe over the last four decades. Weight problems and obesity are increasing at a rapid rate in most of the EU Member States, with estimates of 52.7 % of the adult (aged 18 and over) EU's population overweight in 2019[263].

- It is estimated that high red and processed meat consumption may contribute to 2.7% of all DALYs and 3.8% of all premature deaths within the EU[264].

- AMR is one of Europe's main health challenges of the 21st century and is responsible for 33,000 deaths annually with predicted ten million deaths a year globally by 2050 if not mitigated[265]. It is also estimated that AMR costs the EU EUROS 1.5 billion per year in healthcare costs and productivity losses[266].

Zoonotic pathogens and AMR

- AMR is responsible for an estimated 33,000 deaths per year in the EU. It is also estimated that AMR costs the EU €1.5 billion per year in healthcare costs and productivity losses[267].

- Progress is being made in the EU and the UK towards reducing farm antibiotic use with sales of veterinary antibiotics decreasing by more than 34% between 2011 and 2018[268].

Unsafe and adulterated foods

- Campylobacteriosis is the most common gastrointestinal disease in the EU affecting over 220,000 people in 2019 (70% of reported cases). This was followed by Salmonellosis affecting around 88,000 people and Escherichia coli, yersiniosis and listeriosis (most deadly among the diseases with a 90% hospitalisation and 17% fatality rate)[269].

Environmental contamination and degradation

- Air pollution is a significant health issue around factory farms in Europe. Ammonia emissions for example, strongly contribute to fine particulate matter pollution and premature human mortality. Manure from livestock farming is responsible for more than 70% of the emissions of ammonia in Europe[270].

- Nitrates are the main pollutant of European groundwater, affecting over 18% of the area of groundwater bodies. In 2015, 61% of the EU's agricultural area was designated "Nitrate vulnerable zones", areas at risk from agricultural nitrate pollution under the EU Nitrates Directive[271].

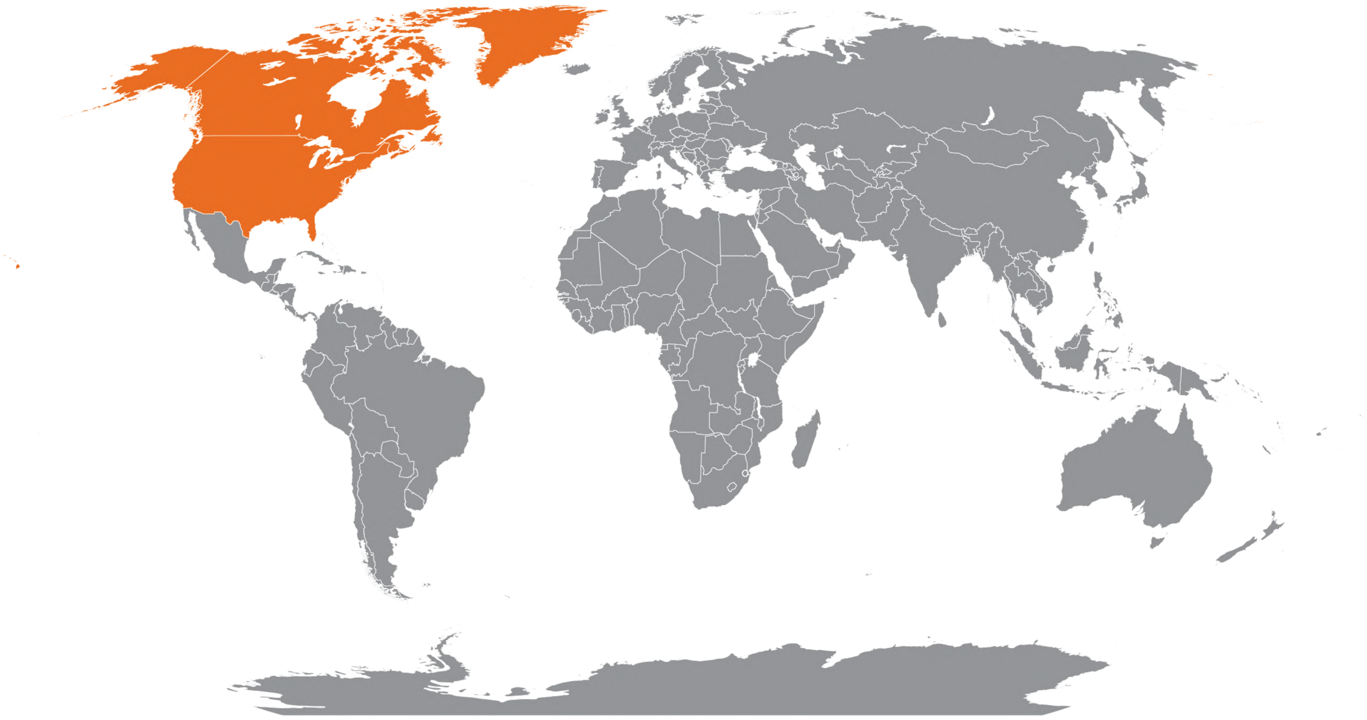
- The EU is highly dependent on imports of soy for factory farmed animals and imports 13 million tonnes of soy protein annually. Approximately 95% of soy imports are destined to feed animals for meat, eggs, and dairy products[272]. Growing crops to feed cattle is highly inefficient, resulting in significantly fewer calories than producing crops for direct human consumption and drives biodiversity loss, GHG emissions and pesticide poisoning within soya producing countries.

- In the EU, animal production was found to contribute 78% to agriculture's role in terrestrial biodiversity loss[273].

Occupational hazards

- Approximately 1 million people were employed in the meat processing industry in 2011. Although there is very little publicly available information on wages within the sector, the use of low-paid and (undocumented) migrant labour is also widespread. Working conditions in Europe's slaughterhouses have been reported as "modern slavery" in several European countries[274].

NORTH AMERICA REGION



Key trends

- The USA and Canada have some of the highest per capita meat consumption in the world at 101kg and 70kg per annum respectively. In the USA annual meat production increased by 184% between 1961 and 2018. Meat consumption is predicted to be stable from 2020 – 2030 with predicted declines in the consumption of beef and increases in the consumption of chicken[275].

- There are 1.6 billion animals living in 25,000 CAFOs in the USA representing an estimated 99% of all USA farmed animals. By species, 70.4% of cows, 98.3% of pigs, 99.8% of turkeys, 98.2% of chickens raised for eggs, and over 99.9% of chickens raised for meat are living in factory farms in the USA[276]. The USA ranked first among the largest exporters of meat and edible offal in the world during 2019, followed by Brazil and the EU[277].

- The explosive growth in CAFOs has been associated with a corresponding decline in the number of small- and medium-sized family farms, a trend which is likely to continue. For example, in Michigan (USA) the number of factory dairy operations in the state more than quadrupled between 1997 and 2017. Yet today, Michigan has fewer than half as many small- and medium-sized dairies (those under 500 head) than it did 20 years ago[278].

- Projections see the plant-based meat market growing significantly over the next 6 years from US$ 1.06 Billion in 2020, to and estimated US$ 2.63 billion by 2027[279].

Unhealthy diets and food Insecurity

- In the US and Canada, the proportion of obese adults are 36% and 29% respectively[280] and these rates continue to rise resulting in significant increases in non-communicable diseases such as type 2 diabetes and heart disease[281]. Meat consumption has been strongly associated with obesity amongst US adults[282].

- In the US 10.5% of households (13. 8 million) experienced food insecurity in 2020[283]. In Canada 9.3% of Canadians were living in food-insecure households[284]. Food insecurity has been associated with poorer diet quality (lack of access to fruit and vegetables etc) and a variety of physical and mental health problems.

Zoonotic pathogens and AMR

- In 2017, US factory farms fed their cattle, pigs, and poultry over 12.3 million pounds of antibiotics[285]. CAFOs routinely feed low doses of antibiotics to animals prophylactically, the result of poor animal welfare practices.

- More than 2.8 million antibiotic-resistant infections occur in the U.S. each year, and more than 35,000 people die as a result[286]. Over 14,000 deaths in Canada in 2018 were associated with antibiotic resistant infection[287].

- The estimated cost to treat infections caused by six multidrug-resistant germs in the US is $4.6 billion annually[288]. In Canada these costs were estimated at $1.4 billion in 2018 with an estimation of the cumulative costs of AMR to the Canadian healthcare system approaching $120 billion by 2050.

Unsafe and adulterated foods

- There are 1.35 million infections, 26,500 hospitalizations, and 420 deaths in the US every year, the result of consuming unsafe foods. LDFs are the main source for most of these illnesses[289].

- More than 1 million USA consumer illnesses due to Salmonella occur annually, and it is estimated that over 23% of those illnesses are due to consumption of chicken and turkey predominantly sourced from factory farms[290].

Environmental contamination and degradation

- The enormous accumulation of manure and other untreated waste created by CAFOs is often stored and disposed of in a manner that pollutes the air, surface, and groundwater, posing risks to the environment and human health, particularly for CAFO workers and nearby residents.

- CAFO manure contains a variety of contaminants which damage the local environment and cause significant health impacts (one US report highlighted there are 168 chemicals in and around manure)[291]. These include pathogens such as E. coli, growth hormones, antibiotics, chemicals used as additives to the manure or to clean equipment, animal blood, silage leachate from corn feed, or copper sulphates used in footbaths for cows.

- 16,000 USA deaths are the result of air polluted by growing and raising food–and 80% of those result from producing animal products like meat, dairy, and eggs[292].

- More than 5.6 million Americans are potentially exposed to nitrate in drinking water at levels that could cause health problems with elevated risks of cancer and birth defects[293]. In the USA there are 2,300 to 12,594 nitrate-attributable cancer cases annually of which 54-82% are colorectal cancer (CRC) cases. Up to USD 1.5 and USD 6.5 billion in medical and indirect costs may be associated with annual nitrate-attributable cancer cases[294].

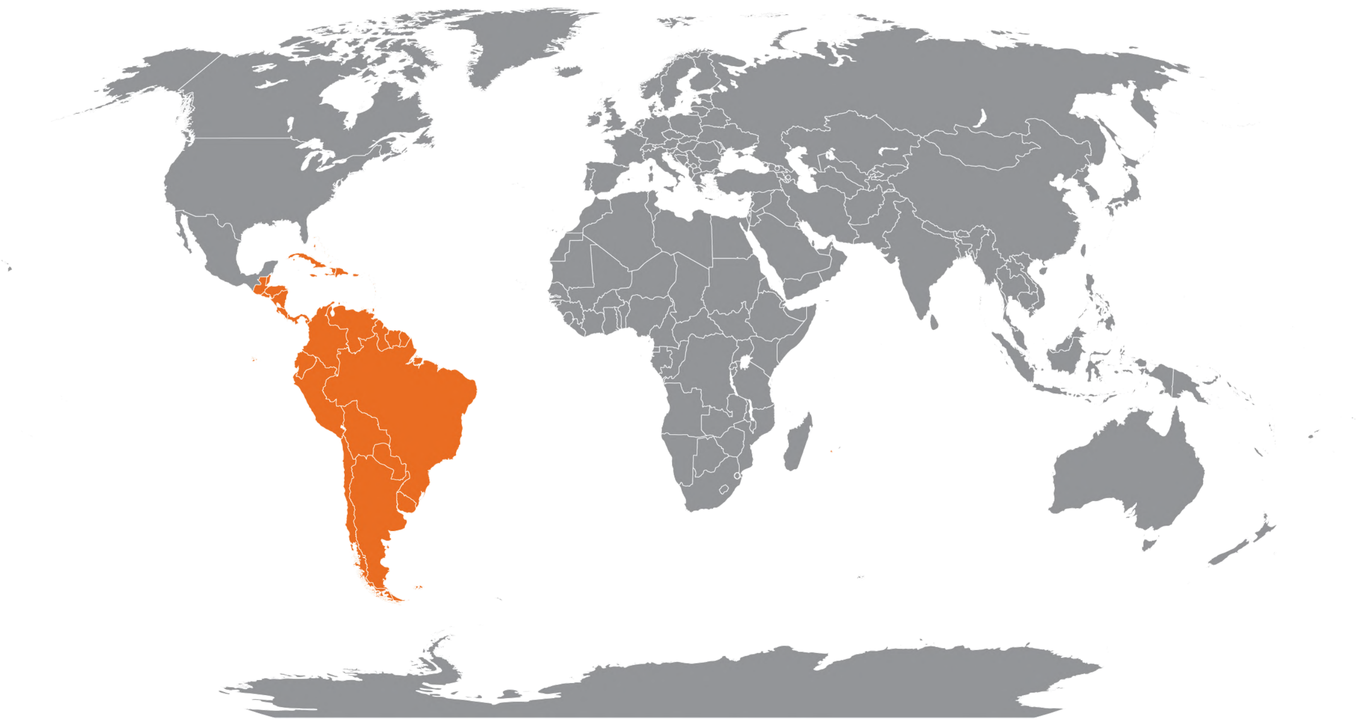
Occupational hazards

- In 2018, the Bureau of Labor Statistics reported that the median annual wage for farmworkers working with animals was $26,560, well below the all-occupation median wage of $38,640[295]. Generally, employees tend to be lower-income, minority populations. These operations present a multitude of psychologically and physically stressful jobs for the entire community[296].Psychological and physical stresses related to low socioeconomic status and demanding jobs can subsequently create vulnerabilities to infections and disease. These workers tend to be among the least unionized in the country.

- In the USA meat processors have some of the highest occupational injury and illness rates at 4.3 per 100 full-time workers in 2018. This is almost 40% higher than the national average across industries[297]. There are alarmingly high rates of serious injury and chronic illness among workers at chicken, hog, and cattle slaughtering and processing plants and between 2013 and 2017, 8 workers died, on average, each year because of an incident in their plant[298].

- Livestock farmworkers are exposed to animal waste in waste manure generated on CAFOs the risk of exposure increases with the increasing size of the CAFOs[299]. People who work in animal agriculture have two times the odds of being exposed to harmful substances, usually through animal waste, compared to those who work in crop production[300].

SOUTH AMERICA REGION



Key trends

- Argentina and Brazil have some of the highest per capita meat consumption in the world at 88kg and 79kg per annum respectively.
- Brazil is the world's largest beef exporter, accounting for 15.4% of global production, exporting one-fifth of its total production (with China the biggest customer). In 2019, Brazil was the 4th largest pork producer in the world, with almost 4 million tons, after China, the EU, and the USA. Brazil is the world's largest exporter of chicken meat: 3.77 million tons in 2019[301]. The trade of Brazilian meat, offal, and live cattle exports is worth more than USD 5.4 billion/year[302].
- Between 2021 and 2031 the production of meat (beef, pork, and poultry) is expected to increase by 6.6 million tons, which represents an increase of 24.1%. Chicken and pork show the greatest growth in the coming years: chicken meat (27.7%) and pork (25.8%) with beef production expected to grow by 17%[303].
- The livestock sector is notorious for its significant environmental impact, not least as a major driver of deforestation. Two-thirds of cleared land in the Amazon and Cerrado biomes have been converted to cattle pasture[304]. These pressures will continue to grow with expansion in beef production forecast up to 2029 and beyond[305].

Unhealthy diets and food Insecurity

- The percentage of obese adults in Brazil more than doubled in 17 years, with a change from 12.2%, between 2002 and 2003, to 26.8%, in 2019. In the same period, the proportion of overweight adults changed from 43.3% to 61.7% and represented almost two-thirds of the Brazilian population[306].

- According to latest statistics 43.4 million (20.5% of the Brazilian population) do not have enough food (moderate or severe food insecurity) and 19.1 million (9% of the population) are hungry, exacerbated by the COVID-19 crisis[307].

Zoonotic pathogens and AMR

- Across South America a lack of surveillance and monitoring means there is still a lack of data of AMR across the continent.

- Central and South America are considered world hotspots for the emergence of new mammalian viral zoonoses[308].

- As deforestation and fires in the Amazon continue and factory farming spreads, expect new zoonotic diseases to emerge. They could include a range of different encephalitis varieties as well as West Nile fever and Rocio, a Brazilian virus from the same family that produces yellow fever.

Unsafe and adulterated foods

- According to official data, which is likely to under report outbreaks, 13,163 Food borne disease outbreaks were reported in Brazil from 200 -2018 involving 247,570 cases and 195 deaths with Salmonella as the most frequently reported disease among those identified (14.4%) followed by Staphylococcus aureus (7.7%), Escherichia coli (6.5%), and Bacillus cereus (3.1%)[309].

- Complex supply chains for LDFs, such as milk and dairy products, are the main targets of food fraud and adulterations in Brazil. The most prevalent types of adulteration in Brazil were intentionally dilution and substitution, to obtain economic advantages[310].

Environmental contamination and degradation

- In Brazil, it is estimated cattle ranching is responsible for half the country's GHG emissions. Some 80% of deforestation was associated with demand for animal pasture between 1990-2005[311].

- Industrial livestock systems are directly connected to the expulsion of rural populations and indigenous groups driven by deforestation, land grabbing and the transformation of land into a financial asset[312].

- Brazil's vast plantations of soya beans and corn has turned it into the world's most important market for highly hazardous pesticides. Almost two-thirds of this Brazilian highly hazardous pesticide (HHP) spending went on the country's soya plantations, grown to service a global demand for animal feed for chickens, pigs, cows and fish[313]. Pesticide imports to Brazil also broke a record, with almost 335,000 tons of pesticides purchased in 2019, an increase of 16% compared to 2018. Pesticide use in Brazil increased 1.6-fold between the years 2000 and 2012. During the same period, pesticide use for soybean increased 3-fold[314]. HHP use will continue rising in Brazil with the Brazilian government approving 474 new pesticides for use.

Occupational hazards

- The livestock sector has been associated with the abuse of workers, who face a wide range of occupational health issues, such as musculoskeletal diseases, depression, and anxiety[315].

- Meat processing and slaughtering facilities were the source of several COVID-19 outbreaks, as a consequence of the reportedly abusive and unsanitary practices of the companies involved, such as JBS[316].

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The views within this report do not necessarily reflect the views of the people who were interviewed or who commented on early drafts of this report.

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