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Working Paper

Plant and Animal Health Threats to the Resilience of Food Systems in Africa*

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1 Introduction

The global demand for food is increasing significantly and is projected to continue to increase in the coming decades, due to a growing human population and rising incomes in developing countries. Shifts in dietary patterns are also occurring in developing countries with greater consumption of ultra-processed foods, primarily driven by socio-economic factors, and urbanisation.[1] Food systems must therefore evolve by increasing production as well as dietary diversity to meet food and nutrition security goals. At the same time, food systems must be sustainable and resilient, with strategies that address biodiversity loss, climate change, and health impacts, along with other potential trade-offs.

Plant and animal diseases and insect pests are exacerbating food insecurity and poor diets, causing large chronic production losses, creating pressure on the environment, and causing very substantial economic costs. Outbreaks of both plant and animal diseases are a major disruptor and a source of shocks to food systems, causing sudden drops in production, and disrupting local, national and international supply chains.

Effective plant and animal health management is critical for improving the productivity, profitability, sustainability and resilience of food systems. Yet farming communities, especially in low- and middle-income countries (LMICs) in Africa, continue to struggle against an array of pest and disease incursions and outbreaks. The negative impacts of these pests and diseases are not limited to yield losses; in reality, all components of food systems, including food production and availability, access, utilisation including food safety and stability, as well as agency and sustainability are severely affected.

While livestock produce important nutrient-dense foods, they can be a source of a wide range of zoonotic diseases that can cause devastating impacts on public health. The type of zoonotic agents transmitted and the impacts they cause vary by livestock production system, because each system is supported by unique environmental features and has management practices that influence the emergence and transmission of infectious agents. Animal source foods can also transmit zoonotic diseases and can be an important source of bacterial food-borne disease. Mycotoxin contamination above permissible limits in crop produce significantly affects food safety, nutrition and public health, as well as trade. Chronic exposure to mycotoxins is associated with significant health burdens, especially impairment of child growth and increased mortality rates, primarily for individuals aged over five years.[2]

The integration of One Health approaches into food systems can help support enhanced food security by promoting the health of the environment, crops, animals, and humans. It can potentially address various challenges while improving the environment's role in food production, fostering multidisciplinary and multi-institutional synergies, and bringing together diverse expertise to create resilient and holistic solutions.

2 Economic impacts of some major crop and animal pests and diseases in Africa

Some existing and emerging pests and diseases that are substantially affecting the key crops and cropping systems in Africa include fall armyworm, maize lethal necrosis (MLN), and mycotoxins in maize; Bunchy top, Panama disease, and Xanthomonas wilt disease of banana; Ug99 stem rust of wheat; yellow mottle virus, bacterial leaf streak, and bacterial leaf blight of rice; vascular wilt of potato; cassava mosaic disease; pod borers, and parasitic weeds of grain legumes; Asian soybean rust; and citrus greening. Sileshi and Gebeyehu (2021) identified 14 emerging infectious plant diseases (including most of the diseases listed above) which can potentially inflict combined production losses worth over US$ 1.4 billion annually on food crops across Africa, with implications for the stability of food systems locally and food prices globally.[3]

Some of the important diseases of livestock that significantly impact productivity and food systems in Africa include (with zoonotic diseases in bold) African swine fever, trypanosomosis, **brucellosis**, *Chlamydia abortus*, contagious bovine pleuropneumonia, contagious caprine pleuropneumonia, East Coast fever, foot and mouth disease, fowlpox, **highly pathogenic avian influenza (Bird Flu)**, Gumboro, lumpy skin disease, Newcastle disease, peste des petits ruminants, **porcine cysticercosis**, Q fever, **Rift Valley fever** and sheep and goat pox.

The economic costs of plant and animal diseases include the cost of treatment, lost production (an estimated 25-50% of African crop harvests are lost due to post-harvest pests and diseases), decreased income to all value chain actors (not just farmers), and lower availability of food leading to undernutrition and malnutrition.[4–6] Malnutrition, especially in children can cause stunting and poorer learning ability and cognitive development, resulting in lifelong effects of lower incomes and economic development.[7] 43% of all children under 5 affected by stunting lived in Africa in 2022.[8] Zoonotic diseases and unsafe food also have devasting effects on human health, incomes and health care costs.

Plant and animal diseases not only cause enormous economic losses, but also severely harm biodiversity, the environment, and human health, mainly due to zoonotic diseases, and the application of toxic pesticides or mycotoxin contamination. A few examples of the most significant economic impacts of some of the major existing and emerging plant and animal pests and diseases are highlighted below:

2.1 Crops

- In 2011, the maize lethal necrosis (MLN), a devastating viral disease, was first reported in south-western Kenya. MLN-affected plots recorded yield losses worth US$ 53.2 million in 2012, US$ 180 million in 2013 and US$ 198 million in 2014.[9,10] The disease was then confirmed in six other Eastern African countries within three subsequent years. While significant progress has been made on curbing the spread and impact of MLN in Africa, the disease is still prevalent in eastern Africa.[11]
- The fall armyworm (FAW) which first appeared in Africa in 2016 has spread rapidly to over 40 African countries, affecting major crops, particularly maize. FAW was estimated to cause crop losses worth US$ 13 billion across sun-Saharan Africa (SSA), posing severe threat to the food security and livelihoods of millions of smallholders.[12]

- Banana bunchy top disease (BBTD), caused by the bunchy top virus, was first reported in SAA in the 1960s in the Democratic Republic of Congo and has since spread to 16 countries in the region. The disease has had a devastating impact on banana production, with crop losses of 70-90%. Many farmers have been forced to abandon banana production, further exacerbating food insecurity and economic hardship.[13]
- Fusarium wilt disease severely impacted banana crops in the Great Lakes region of Kenya, Uganda, Tanzania, Rwanda, Burundi, and the eastern region of the Democratic Republic of Congo (DRC), which is the major banana production and consumption region. Modelling results suggested that if the disease is left uncontrolled, within 10 years, banana production in SSA could decrease by as much as 55%, resulting in economic losses of around US$ 25 billion.[14]
- Cassava mosaic disease (CMD) is present in all the 39 cassava-growing African countries, where it is caused by a different set of begomovirus species, new variants of which have driven successive outbreaks over the last century. CMD was estimated to cause over US$ 1 billion in losses in East Africa alone, with yields reduced by 13 million tons annually.[15]
- Mycotoxin contamination reduces the competitiveness of agricultural commodities from SSA for international trade, besides severely affecting domestic marketability of crop produce, animal and human health. Thus, mycotoxins negatively impact household security, livelihood, productivity, and income and lead to significant costs and economic losses.[16] Unsafe foods impose an economic cost of more than US$ 24 billion of which more than US$ 20 billion are due to productivity losses. In addition, Africa's staple food grains including maize, sorghum and millet, which according to FAOSTAT account for more than 60% of the daily calorie intake, are severely impacted by mycotoxin contamination. In addition, Africa accounts for 40% of the estimated 160,000 global liver cancer cases from exposure to aflatoxin.[17]

2.2 Livestock

- Foot and mouth disease (FMD) is a viral infection of cloven-hoofed ruminants including swine, cattle, sheep, and goats. It is endemic in most African countries and many other countries in Asia and in some areas of South America. FMD causes severe socio-economic losses from reduced livestock productivity and disruption of regional and international trade of animals and animal products. Its economic impacts have been estimated at US$ 2.3 billion per year.[18]
- Contagious bovine pleuropneumonia (CBPP) is an important respiratory disease of cattle. CBPP is caused by bacteria *Mycoplasma mycoides mycoides* and its morbidity and mortality vary between different pathogen strains. It can cause losses ranging from 20% to up to 80%. CBPP affects 27 countries in Africa at an estimated annual cost of US$ 2 billion.[19]
- Contagious caprine pleuropneumonia (CCPP) is one of the most severe diseases of goats caused by bacterium *Mycoplasma capricolum* subspecies *capripneumoniae*. It is found in many countries in Africa, Asia and the Middle East. In naive herds, the morbidity and mortality rates may reach 100% and 80%, respectively. CCPP causes major economic losses in endemic areas which translate to about US$ 507 million per year.[20]
- Peste des petits ruminants (PPR) is a highly contagious viral respiratory disease of goats and sheep. The virus is a member of the genus Morbillivirus in the family Paramyxoviridae. The disease is present in many parts of Africa, the Middle East and the Indian subcontinent. Heavy

losses can be seen, especially in naïve herds (up to 80%). The total yearly cost of the disease is estimated to be US$ 1.2 – 1.7 billion.[21] Currently FAO and the World Organisation for Animal Health (WHOA) are coordinating a global campaign to eradicate the disease.

- Newcastle disease (ND) is a viral infection of birds, with chickens being particularly susceptible. ND is endemic in areas of Mexico, Asia, the Middle East, Africa, Central and South America, and in wild birds of North America. Outbreaks of ND have a major impact on backyard chickens in developing countries. Morbidity and mortality rates can be up to 100% in unvaccinated chickens.[22]
- Animal African Trypanosomosis (AAT), is a protozoan parasitic disease of cattle, water buffalo, sheep, goats, horses, pigs, dogs and other vertebrates. The disease is caused by the protozoan parasites *Trypanosoma c*ongolense, *T. vivax* and, to a lesser extent, *T. brucei brucei* which are all mainly transmitted by tsetse flies. AAT is estimated to kill 3 million cattle annually. Losses from reduced productivity and the cost of treatment and vector control are estimated to be US$ 1.2 billion and losses in agricultural gross domestic product for all tsetse-infested lands was estimated to be US$ 4.75 billion per annum.[16]
- Rift Valley fever (RVF) is a zoonotic mosquito-borne viral disease that affects a variety of livestock species, including ruminants and camels.[23] The disease is endemic in Africa and the Middle East, and its outbreaks often cause substantial socio-economic and public health impacts. High abortion and mortality rates in young animals result in reduction in livelihoods and food security. The RVF outbreak that occurred in Kenya in 2006/2007 cost US$ 32 million.[24]
- Avian influenza (H5N1) emerged in 1996 in southern China. Since then, the disease has caused huge economic impacts globally. In Nigeria alone, HPAI outbreaks are estimated to cost US$ 2.2 billion per year.[25]

3 Existing and evolving drivers of plant and animal health threats in Africa

There are complex factors that drive the emergence and evolution of plant/animal pathogens. These include the emergence of new strains, climate change, intensification of cropping and livestock systems and trade. Some of these drivers, for instance changing climate and agricultural intensification, combine to amplify each other's impacts on the plant/animal pathogen and pest spectrum.

Increasing global trade and travel have also accelerated the global spread of invasive plant/animal health threats. This is exacerbated by weak sanitary and phytosanitary systems (SPS) in LMICs that lack capacity to monitor effectively soil-, seed- and, air-borne and insect-vectored plant diseases, and livestock diseases in live animals and animal source foods. The situation is being further exacerbated by the effects of a changing climate and agricultural intensification, driving the emergence and scale of new threats, as detailed below for both crops and livestock.

3.1 Crops

Changing climates, including increases in temperature and CO_2 level, and changes in precipitation patterns, have a significant influence on pathogen and insect-pest dynamics and their interactions with crops, including alterations in their life cycles, virulence, distribution and abundance.[19] For

example, elevated temperatures foster the proliferation and propagation of plant pathogens, notably fungi, and bacteria, while concurrently compromising host defence mechanisms. However, it is important to note that the optimal temperature range for pathogens can vary, with some pathogens exhibiting susceptibility to extremes of heat or cold.[20]

While agricultural intensification is necessary to meet the growing global demand for food it can also have negative environmental impacts.[21] Plant health threats can be exacerbated by agricultural intensification in multiple ways. These include the emergence of pathogens that can overcome resistant crops due to monoculture, high-density cropping that can be more favourable for some pathogens, and overreliance on synthetic pesticides leading to loss of the natural enemies of pests.

Many new plant diseases emerge when pathogen populations adapted to one or more other host plants overcome genetic barriers that once prevented infection of a former non-host. Rahnama et al. demonstrated this by studying the recent coevolution of two pandemic plant diseases – wheat blast and grey leaf spot of ryegrass – caused by the haploid fungus *Pyricularia oryzae* (synonymous with *Magnaporthe oryzae*).[26] As Makiola et al. (2022) and Laine et al. (2023) pointed out, our ability to understand, model and predict disease dynamics is becoming increasingly difficult as both plant and pathogen populations and communities are undergoing extensive changes.[27,28] These include changes in response to a changing climate, and habitat loss and fragmentation, as well as changes in evolutionary trajectories at both the pathogen and host plant levels (e.g., inter- and intra-specific, diversity, and community composition), and their interactions.

3.2 Livestock

The prevalence and impact of different livestock diseases depend not only on the livestock species but also on the type of production system, which can be linked to the prevailing climate, management system, animal population and density.

Intensive livestock production systems (also called industrial livestock farming systems or factory farms) are often linked with the emergence of new zoonotic viral infections, especially those caused by RNA viruses. Intensive farms provide a good environment for the proliferation of new viral strains. This is because thousands of animals are kept in proximity which facilitates effective contact and transmission of infectious agents. The very high animal densities, combined with poor ventilation and stressful living conditions, also weaken animals' immune systems, making them more susceptible to infection. Given the increase in these systems in Africa, especially in the poultry sector, we may expect to see an increase in such diseases in the coming decades.

Grassland livestock production systems (such as ranching and pastoralism) present other health challenges, including those associated with human-animal-environment interactions. Of the 11 diseases that the World Health Organization (WHO) has prioritised for research and development in emergency contexts, three (Crimean Congo haemorrhagic fever [CCHF], Middle East respiratory syndrome corona virus, and Rift Valley fever [RVF]) usually occur in pastoral areas. The causative agents of these diseases have also been listed by USDA on its Select Agents and Toxins list as being pathogens that can pose serious threat to human and animal health together, together with *Coxiella burnetii* and *Brucella* spp. and *Bacillus anthracis* (the causes of Q fever, Brucellosis, and anthrax, respectively) which are also prevalent in these ecologies.

Climate, land use and demographic changes are likely to influence the transmission of diseases including zoonoses. Rising temperatures in Africa will increase heat stress in livestock and directly affect livestock health by causing metabolic disruptions, oxidative stress, and immune suppression, causing increased disease susceptibility.[29] The changing climate will also alter the geographical distribution of many livestock diseases. This is especially the case for vector borne diseases. Analyses conducted by Olwoch et al. showed that East Coast fever, an important tick-borne disease of cattle transmitted by the brown ear tick, would become more prevalent in the northern and eastern Cape provinces in South Africa, Botswana, Zambia and eastern Democratic Republic of Congo but less so in Angola, Namibia and southern DRC.[30] The 6th assessment report of the Intergovernmental Panel on Climate Change also indicates that incidences of climate and extreme events including temperature, precipitation droughts and floods will increase over many land areas.[31] These conditions would provide ideal conditions for outbreaks of vector borne diseases such as Rift Valley fever. As human and livestock populations grow and forested areas are increasingly used for livestock grazing, the risk of zoonotic disease transmission is heightened.

Antimicrobial resistance (AMR) is an additional health challenge associated with livestock farming. Antibiotics are used to prevent diseases or as feed additives to prevent infections and maintain growth rates. However, the indiscriminate use of antibiotics often leads to the development of antibiotic-resistant bacteria, posing serious risks to both animal and human health. The use of antibiotics in livestock is estimated to contribute between 20% - 40% AMR infections in humans. AMR jeopardises not only individual health, but also the stability of entire healthcare systems, making it one of the most pressing public health challenges of our time. One estimate suggests that by 2050 if the AMR situation is not alleviated there could be as many as 20 million people dying every year worldwide of common microbial infections, and the global economic costs could be as high as US$ 100 trillion.[32]

Food safety challenges have also increased with time as markets transform to meet the rising demand for food and changing consumer preferences. WHO estimates that the burden of illness from food safety risks worldwide is comparable to that of malaria and tuberculosis. Increased populations often require larger quantities of food to be processed, preserved, and transported over greater distances to reach urban and rural markets. Pathogens that are associated with food contamination include *Listeria* sp., *Campylobacter* sp. *Salmonella* sp. and *Escherichia coli*.

4 Making African agrifood systems more resilient to plant and animal health threats

There are several potential approaches to make the food systems more resilient to plant and animal health threats. Priorities include:

4.1 Surveillance systems and networks for plant and animal diseases

The increasing rate at which both plant and animal disease threats are evolving and emerging, emphasises the urgent need for coordinated strategies for disease monitoring and surveillance. These need to link national, regional and global networks and systems, coupled with a unified and transparent international strategy to support the accurate and timely reporting of systems to develop proactive disease management strategies.

For emerging infectious diseases (EIDs) of livestock and zoonotic diseases, integrated risk-based surveillance systems should be deployed to support the identification of hotspots or production systems from where EIDs are likely to emerge. Integrated surveillance systems can detect signals for multiple infectious diseases. Several viral families such as Coronaviridae, Paramyxoviridae, Orthomyxoviridae and Filoviridae, for example, have been associated with zoonotic epidemics and pandemics and there is often uncertainty on the type of pathogen that would emerge at any one time. A comprehensive integrated surveillance system that combines data from human, animal and environmental indicators can facilitate early detection of an EID risk. Signals from animals can also give early warning of risks to the human population. Deforestation has in the past been linked with an outbreak of Ebola virus disease, while disruption of bat ecologies has been linked to outbreaks of Nipah virus. Most of the current surveillance systems are structured to track one disease at a time. The range of data that are often used for risk detection is also limited.

Many African counties need support from international agencies and high-income countries in building the physical and human capacity to strengthen surveillance systems. International agencies such as FAO, WOAH, and in the case of zoonotic diseases One Health, WHO and the UN Environment Programme (UNEP) have an important role to play in developing and supporting global networks and systems.

4.2 Diagnostics surveillance - early detection and response to infectious diseases in plants and animals

These depend on the availability of reliable diagnostic tests. Many countries in Africa, however, have limited laboratory infrastructure and it often takes a long time before pathogens responsible for outbreaks detected are identified. The development and deployment of rapid test kits is needed to complement the standard laboratory tests. These kits would allow for rapid identification of pathogens, even in remote or resource-limited settings, for appropriate actions to be taken in good time. Investment in research to develop rapid diagnostic kits, by both the public and private sector, coupled with investment in IT-based data capture and analysis, would have a major impact on disease surveillance.

4.3 Disease modelling and disease risk maps

Modelling based on an understanding of epidemiological factors, including seasonal variability, vector behaviour, seed and animal movements and pathogen spread needs to be stepped up globally. Predictive data such as transportation and trade networks, geography, weather and climate parameters, and early pathogen detection data from DNA sequences, incidence records, disease sensors, citizen science, data mining, and disease identification applications should be used as inputs into models to develop dynamic disease surveillance networks for both plants and animals. These data can then be used to model and predict future outbreak hotspots at the landscape level. In addition, data mining techniques using natural language processing and geoparsing, text mining, and crowd sourcing of social media data should be harnessed as a resource for monitoring past and predicting future plant pathogen outbreaks.[33] Disease risk maps at the national, regional and continental levels should be developed based on robust data, and dynamically communicated to relevant decision makers to design and implement appropriate risk management, and sanitary and phytosanitary policies.

4.4 Animal vaccines

Prevention of animal disease by vaccination can be an extremely effective disease control measure. For some diseases, vaccines exist, for others they exist but may be too expensive for smallholder farmers to buy or may not be available. For some diseases no vaccines exist. Where effective vaccines exist, harmonisation of registration across countries would considerably reduce the costs of delivery. GALVmed is an organisation working with governments and the private sector to help achieve this. For so-called 'orphan diseases', i.e. those for which there is little investment from the private sector because the market is deemed too small, but which cause large losses to smallholder farmers in Africa, continued public sector investment in research is required to develop effective vaccines. There is also a need to develop effective distribution channels to ensure vaccines can be delivered to those who need them. This may require investment in cold chain facilities or development of thermo-tolerant vaccines. Both the public and private sectors need to collaborate and invest.

4.5 Harmonised and science-based Sanitary and Phytosanitary (SPS) systems

With agri-food commodities accounting for more than 70% of intra-Africa trade, aligning and meeting SPS standards by African Union (AU) Member States will be critical for successful implementation of the Africa Continental Free Trade Area. The continent is increasingly prioritising SPS issues. In recent years AU policy organs have endorsed the SPS Policy Framework for Africa, Animal Health Strategy for Africa, Food Safety Strategy for Africa and Plant Health Strategy for Africa, providing continental policy guidance to address SPS issues holistically.[34–37] These policy frameworks/strategies now need to be implemented with rigour, consistency and adequate investment.

4.6 Diversification at farm, village, and landscape levels

McDonald and Stukenbrock argued for a re-design of agroecosystems that embrace the concept of dynamic diversity to improve their resilience to pathogens.[38] Moreover, while current research in both crops and animals mostly focuses on single pathogen-host interactions, the growing body of evidence shows complex interactions between hosts, co-infecting pathogens and vectors favouring emergence of hypervirulent pathotypes. Besides dynamic diversification of agroecosystems at farm, village and landscape levels, greater attention needs to be paid towards biosecurity measures, and integrated management of vectors and alternate hosts.[39]

4.7 Integrated management systems

There needs to be more effective integration, validation and deployment of an array of gender- and culturally- appropriate approaches, including clean seed systems, host plant resistance, biological control, good agronomic and animal husbandry practices, including biosecurity measures, reduced and more targeted antimicrobial use in livestock, and use of safer pesticides only when absolutely needed. Integrated pest and disease management packages must be based on five criteria: cost, efficacy, safety, accessibility, and scalability.[37] Understanding gender and cultural influences and heterogeneous socio-economic impacts of plant and animal health innovations, and intensively promoting farmers' collective action, can aid in bridging the gender gap and improve adoption of integrated plant and animal health packages by resource-constrained farmers.[40]

4.8 Governance and regulation of food systems

While the legal and regulatory frameworks governing plant and animal health are often in place, many African countries struggle to implement the regulations. The effectiveness of these measures is often limited by lack of capacity for enforcement of the measures by regulatory bodies, and lack of compliance by the farmers. For example, outbreaks of some animal diseases can, in theory, be controlled by risk communication, movement control, slaughter bans and market closures, but these measures may not be pursued. Some of the incentives that can be used to enhance compliance include provision of insurance schemes to livestock owners which compensate for losses incurred from quarantine measures, certification of products for local and export markets, provision of subsidies and offering more training that covers the benefits of observing the regulatory measures.

Governance of food systems should be further evolved, including a) equitable access to resources, especially land, water, improved inputs such as seeds and animal health products, information, and services, to produce food; b) science-based systems to gather, analyse, and disseminate information on the prevalence of high-risk diseases, pests, or food safety hazards; c) control over food choices; and d) gender and social inclusion in plant and animal health management.

5 Relevance of One Health

Given the complexity of plant and animal health and their drivers and interaction between animal, plant, human and environmental health, a One Health approach seeks to bring these interacting components together. FAO, WOAH, WHO and UNEP have come together to foster and promote the One Health concept which they have defined as:

One Health is an integrated, unifying approach that aims to sustainably balance and optimize the health of humans, animals, plants and ecosystems. It recognizes the health of humans, domestic and wild animals, plants and the wider environment (including ecosystems) are closely linked and interdependent.

The approach mobilises multiple sectors, disciplines and communities at varying levels of society to work together to foster well-being and tackle threats to health and ecosystems, while addressing the collective need for clean water, energy and air, safe and nutritious food, taking action on climate change, and contributing to sustainable development.[41]

These organisations have developed a joint plan of action to promote the concept. The One Health approach has a huge potential role to play in reducing the impact of plant and animal diseases and pests, but it will require considerable political buy-in, a 'whole of government approach' at national level, funding, and strengthening of human and institutional capacity.

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