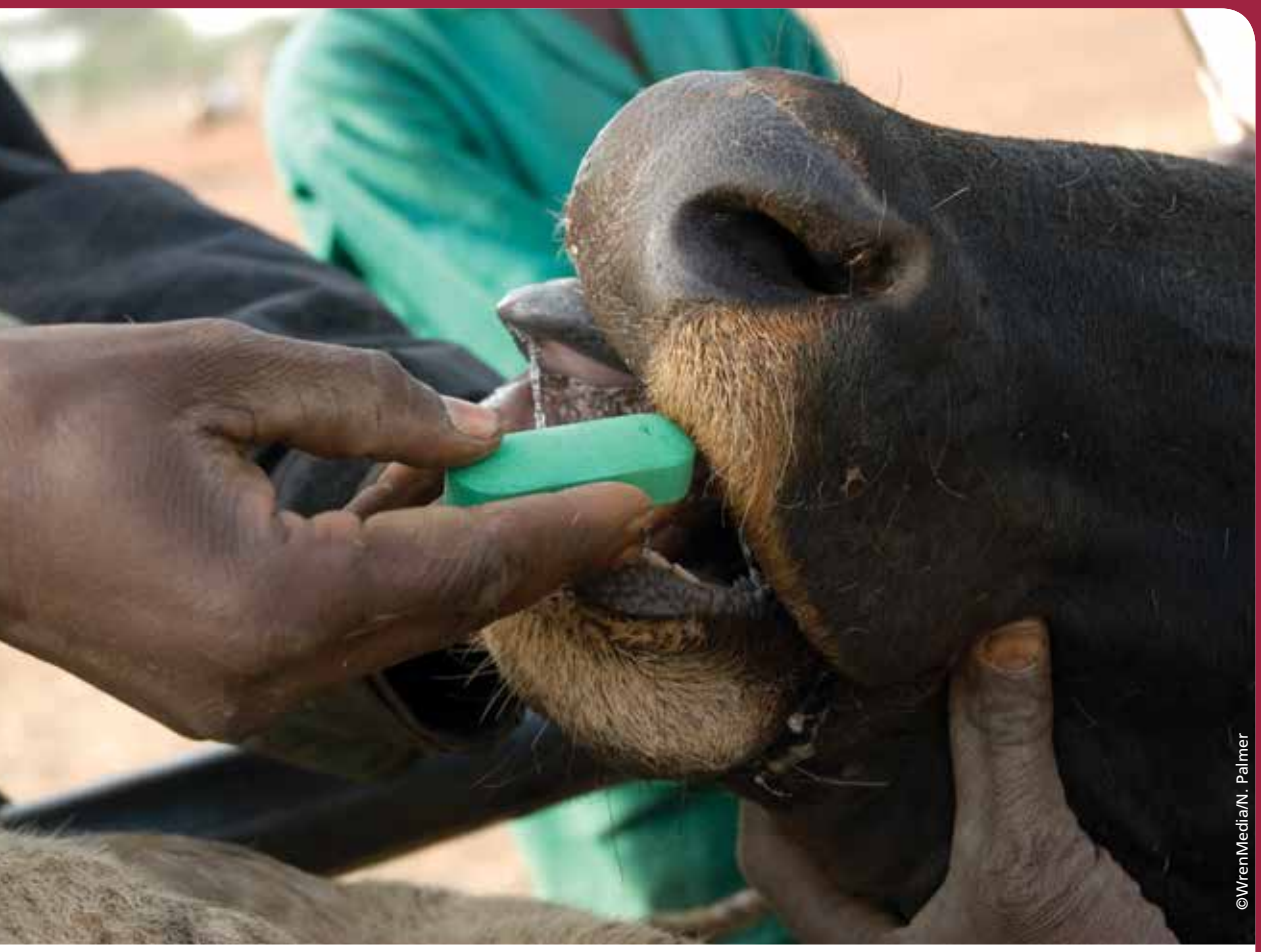

Response

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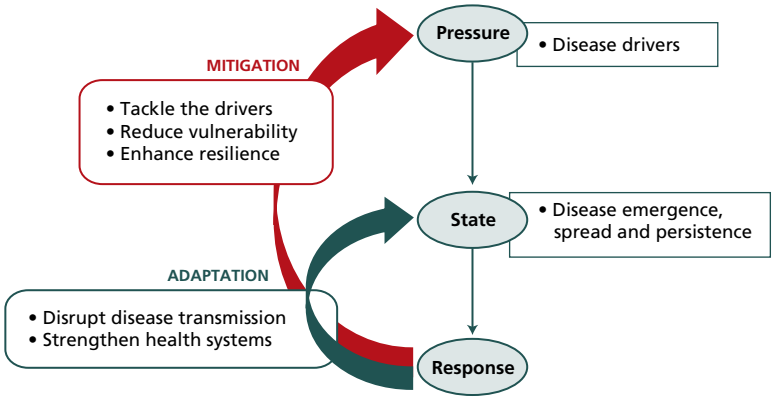
Addressing the drivers of disease emergence

The main conclusion of the analysis presented in the previous chapters is that there is need to act on the root causes of the ongoing emergence of diseases at the human–animal–ecosystem interface. The disease *Pressure-State-Response* framework (Figure 33) provides a convenient basis for defining the actions required and establishing the necessary collaboration. Analysis of the various drivers that act as a *pressure* to create a *state*, the disease dynamics and the multiple impacts helps to identify the elements of a *response*, which will be twofold, comprising both adaptation and mitigation. Mitigation efforts are increasingly necessary in providing structural solutions that will address the root causes of increasing global health threats. All the different disease challenges discussed in this publication require greater attention to prevention, to enhance social and agro-ecological resilience. This shift towards preventive measures entails society-wide action to move beyond the approaches currently adopted by health systems, which aim to protect humans, domestic animals *or* ecosystems; prevention requires addressing disease issues in all three dimensions. This new One Health[8] perspective is rapidly gaining in importance, but to succeed, major institutional and policy support will be necessary.

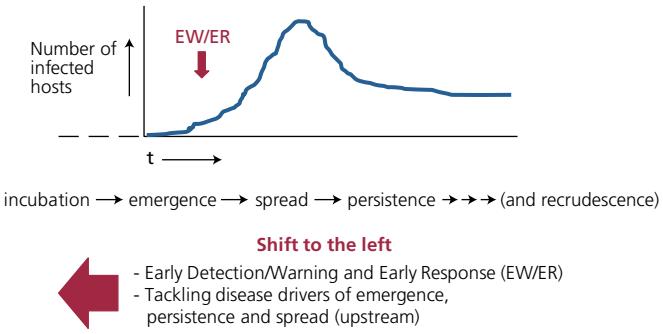
A business-as-usual approach to risk management no longer suffices. Human action (and inaction) are driving the increase in pathogen dynamics at the human–animal–ecosystem interface, and this causality has to be acknowledged and addressed (Jones *et al.*, 2013; Karesh *et al.*, 2012). A more driver-conscious risk assessment entails consideration of the full chain of causation, from incubation to emergence, spread, persistence and/or recrudescence. Such assessment will enable the required shift to the left on the disease outbreak timeline (Figure 34) and mitigate the disease impacts.

[8] One Health is a new, twenty-first-century global initiative involving health professionals, ecologists, socio-economists, development agents and many others which builds on the centuries-old notion that healthy people, healthy animals and healthy ecosystems go together. The One Health approach requires the integration of health issues into the full set of Sustainable Development Goals.

33 A DISEASE PRESSURE–STATE–RESPONSE ANALYSIS FRAMEWORK

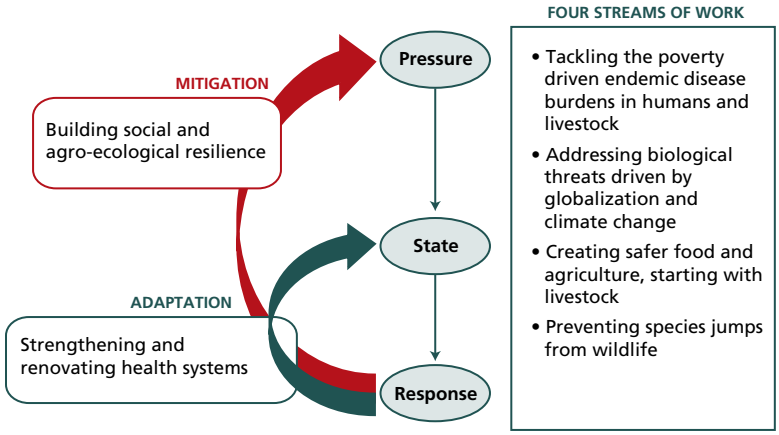


34 SPEEDING UP RESPONSE AND TACKLING THE DRIVERS OF DISEASE EMERGENCE, SPREAD AND PERSISTENCE



During the initial stage of a disease outbreak, the number of infected hosts increases at an exponential scale. Eventually, a peak is reached and a decline sets in, with the outbreak fizzling out, or the disease either stabilizing at a lower level or reappearing periodically. Health professionals typically seek to disrupt disease transmission at the earliest possible stage, to prevent the worst from happening. Early warning, early detection and early response are the precepts of the FAO Emergency Prevention System (EMPRES) created in 1994 in response to the rising threats posed by transboundary plant and animal pests and diseases. Early detection and early response were critically important during the final stage of global rinderpest eradication in the late 1990s and early 2000s. Given the global emergence of novel disease complexes, there is need to go a step further by taking action at the driver level. The shift to the left in Figure 34,

35 PRIORITIES FOR INTERVENTION



therefore implies both early detection and response, and tackling the drivers of disease emergence, spread and persistence, which will lower and shorten the epicurves of an outbreak and assist in preventing a recrudescence.

At the global level, factors commonly associated with the recent disease dynamics at the human–animal–ecosystem interface are lack of basic sanitary infrastructure; persistence of poverty; globalization; climate change; rapid development of the livestock sector and unsustainable practices in livestock production and related food supply; poor physical and land-use planning; and degradation of the natural resource base and wildlife habitats. Each of these drivers has impacts on disease emergence, spread and/or persistence, alone or – mainly – in interaction. The prominent global drivers and driver–disease complexes that require international attention and urgent responses are shown in Figure 35 and are discussed separately in the following sections.

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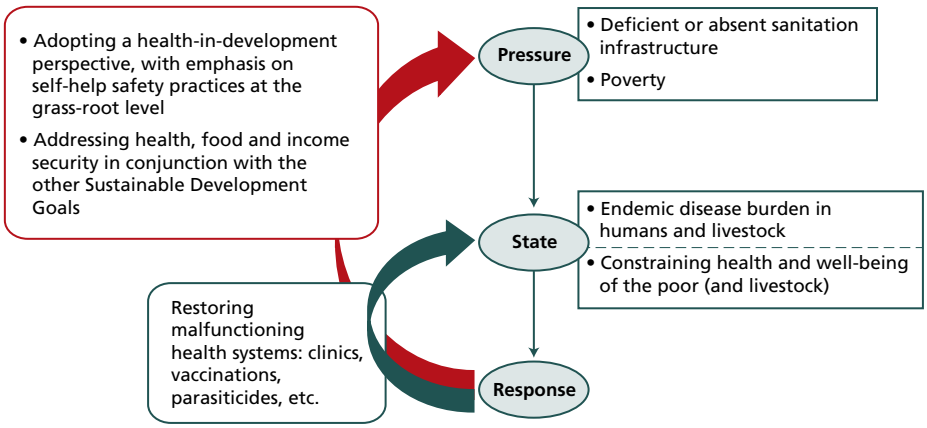
Reducing poverty-driven endemic disease burdens in humans and livestock

Poverty, deficient or absent sanitation infrastructure and malfunctioning health systems are typically associated with disease persistence. As shown in Figure 36, endemic disease burdens in humans and livestock severely constrain the health and well-being of the poorest strata of society (and of their livestock). Poor people generally lack access to health services, education, safe water, etc., and are often also deprived of food and income security. There may not be any major technical hurdles to improving the health status of the poor: recent successes in the fight against diseases in humans and animals include the reduction of child and maternal death, the control of several tropical zoonotic diseases, and the final elimination of rinderpest from remote drylands and harsh environments of Africa and Asia.

In this scenario, the response to disease persistence moves beyond the establishment of clinics, vaccination campaigns and medication supplies. Social resilience is enhanced through adopting a health-in-development perspective, emphasizing self-help health protection practices as an integral part of collective efforts to achieve health, food and income security. Where poor people and livestock are aggregated on the fringes of major cities, as in most developing countries, health and other benefits accrue from the introduction of sanitation infrastructure, clean water and precautionary food safety measures, which improve the conditions under which fresh, perishable food commodities are supplied every day to urban markets. The efforts required concern society at large and may reduce the incidence of human disease and food safety hazards caused by animal-origin pathogens, as well as supporting the livelihoods of marginalized people.

Efforts to improve the conditions of pastoral communities, forced ever-further into harsh

36 ADDRESSING THE DRIVERS OF DISEASE PERSISTENCE



environments, also require a broad set of measures, including the provision of access to forage and water resources, medical and veterinary services, and livestock markets. In these situations, health protection is an effective entry point for, and an integral part of, wider sustainable development efforts. As made evident during GREP, good animal health in remote pastoral communities has direct and positive impacts on food and income security. Addressing ruminant disease alongside efforts to tackle other sustainable development challenges contributes to reversing the marginalization of pastoral communities. These efforts need to be carried by a broad group of stakeholders including governments, the international development community, the private sector and, last but not least, the concerned rural communities.

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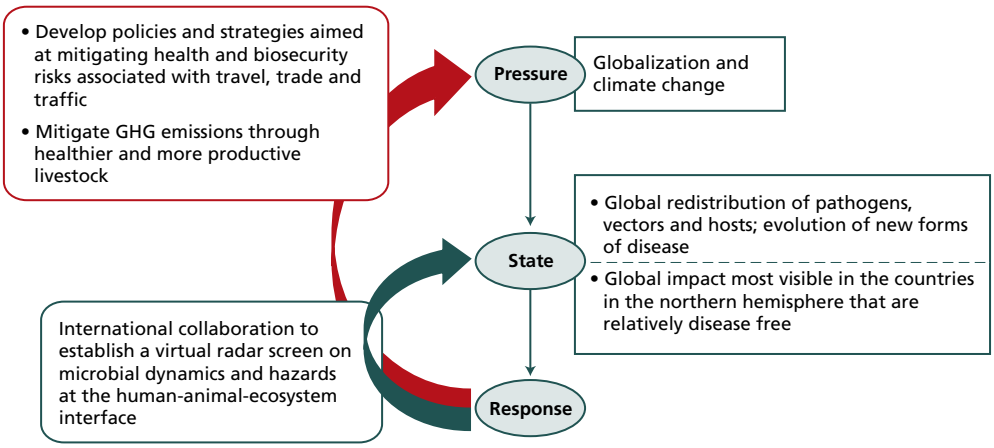
Addressing the biological threats driven by globalization and climate change

Many changes in disease landscapes are driven by a combination of globalization and climate change (Figure 37); both are drivers of the global redistribution of pathogens, arthropod vectors and hosts that is setting off the evolution of new forms of disease. This process is particularly visible in countries of the Northern Hemisphere that are relatively free from major infectious diseases; novel introductions often originate from the endemic settings prevailing in transition and developing countries. These biological threats are not restricted to human and animal diseases or food safety hazards, but extend to disease and pest agents and invasive species in plant production, fisheries and forestry, which also affect natural ecosystems and wildlife.

The traffic related to international travel and trade is expected to continue to increase, largely in line with projected economic growth. This growth in traffic is likely to be accompanied by a global redistribution of disease agents, vectors and hosts, with the evolution of novel disease complexes. Climate change will compound these developments. The collective impact will be considerable, and may challenge the sustainability of current, highly globalized agricultural and food supply systems, and threaten the integrity of the earth's natural resource base and biodiversity. Growing ecological instability calls for interventions at the driver level led by senior government decision-makers and international actors. International collaboration – involving health professionals and other disciplines, academia, research institutions, the private sector, civil society and UN agencies – is required to create a "virtual radar screen" for real-time monitoring of the more important pathogens, vectors and hosts. Collaboration in microbiological risk assessment, using the latest biotechnology and informatics will facilitate the defini-

37 ADDRESSING THE DRIVERS OF DISEASE EMERGENCE AND SPREAD 1



tion of safer practices for international travel, trade and traffic. Information on pests and diseases can be sensitive, with potentially major economic and/or biosecurity consequences, so there is need for advanced international agreements on policy and regulations for handling the expected increase in the flow of disease information. Preventing disease emergence and spread requires open and transparent reporting by proficient health services, which, in turn, rely on adequate resourcing, supportive health education systems and sustained human resource development efforts. The ongoing exponential growth in disease-related information calls for a concerted global disease intelligence platform. The pioneering work of the International Society for Infectious Diseases in creating ProMED, a global information and communication network on new emerging disease events, may assist in attaining this objective. The FAO/OIE/WHO tripartite platform already operates a joint global early warning system at the headquarters of the three organizations. Development agencies, regional organizations, academia, research institutions, the private sector and civil society are encouraged to join such efforts.

Climate change mitigation, such as reductions in GHG emissions, relies, in part, on having healthier, more productive livestock, particularly among the large ruminant populations in the Indian subcontinent and sub-Saharan Africa; improvements in animal health may lead to major increases in productivity, and hence food security and market opportunities. The livestock sector needs to adapt to resource scarcity and climate change at the global level; this topic is addressed by the Global Agenda of Action in Support of Sustainable Livestock Sector Development.[9] With more than 750 million people depending on livestock for survival and income, the Global Agenda of Action seeks to reduce GHG emissions and pollution while enhancing the livestock sector's contribution to food security and poverty reduction.

[9] www.livestockdialogue.org (accessed 26 October 2013).

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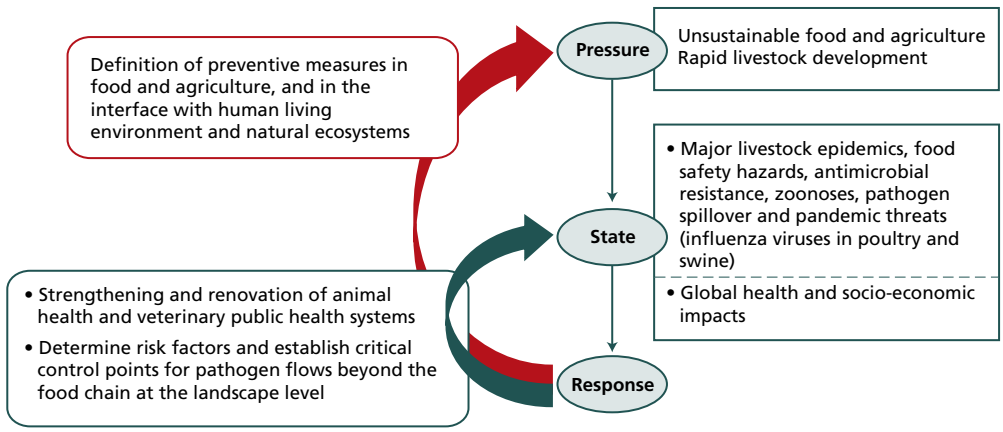
Providing safer animal-source food from healthy livestock agriculture

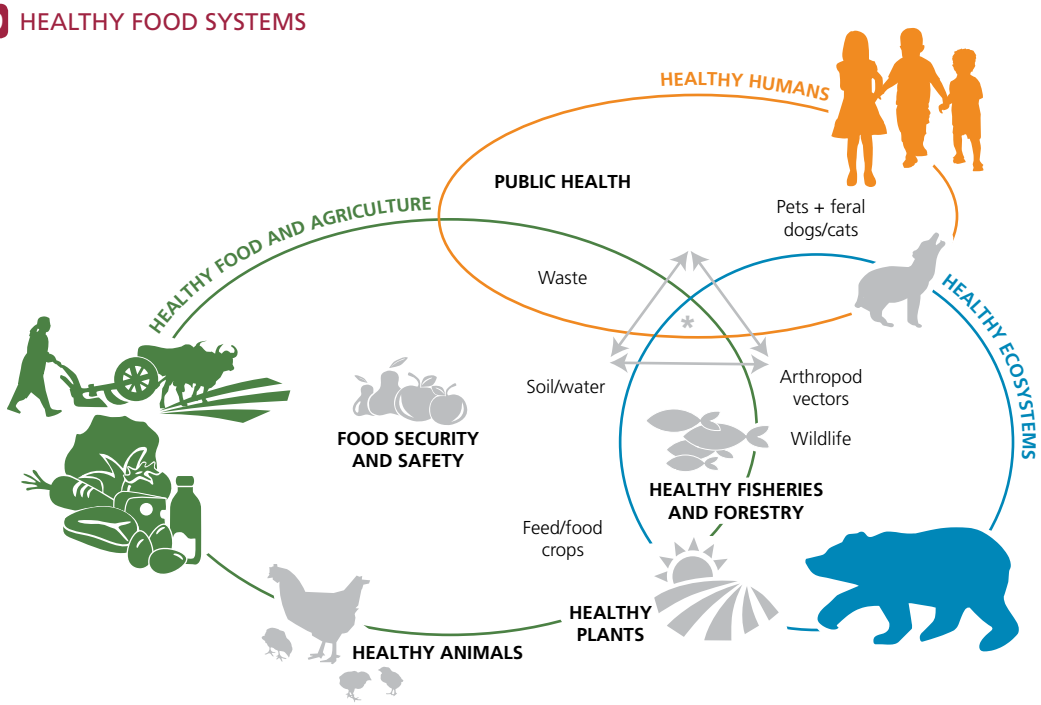
The changing disease landscape driven by the global food and agriculture system, particularly rapid development of the livestock sector, provides a distinct disease Pressure–State–Response scenario (Figure 38). The livestock-related *pressure* forces are rapid intensification coupled with poor biocontainment; a mix of intensive and extensive production systems; and food chain dynamics, including those related to processing, distribution and marketing practices. The resulting *state* comprises major livestock epidemics; food safety hazards; development of antimicrobial resistance; and new, possibly severe, pandemics involving influenza A viruses circulating in swine and poultry.

The food chain provides a potential route for a range of animal-origin pathogens that cause disease in humans. To secure food safety and protect consumers, food industries routinely carry out microbiological exposure assessments along the food chain, often termed "farm-to-fork" or "stable-to-table" risk analysis protocols. However, so far, relatively little attention has been given to pathogen flows in the environment beyond the food chain. For example, waste disposal may lead to microbiological (or chemical, etc.) contamination of surface water, soil and biological systems, with pathogens recycling in farming and natural landscapes. Environmental pathogens are present even in microbiologically safe food chains. Food safety hazards involving vegetables contaminated with faecal material are increasing. There is also growing interest in more comprehensive risk assessment that goes beyond food safety to clarify the relevant risks to public health, animal health and ecohealth. Such assessment requires analysis of the microbiological exchanges between natural and farming landscapes, farming landscapes and human environments, and human environments and natural landscapes. As better information

38 ADDRESSING THE DRIVERS OF DISEASE EMERGENCE AND SPREAD 2



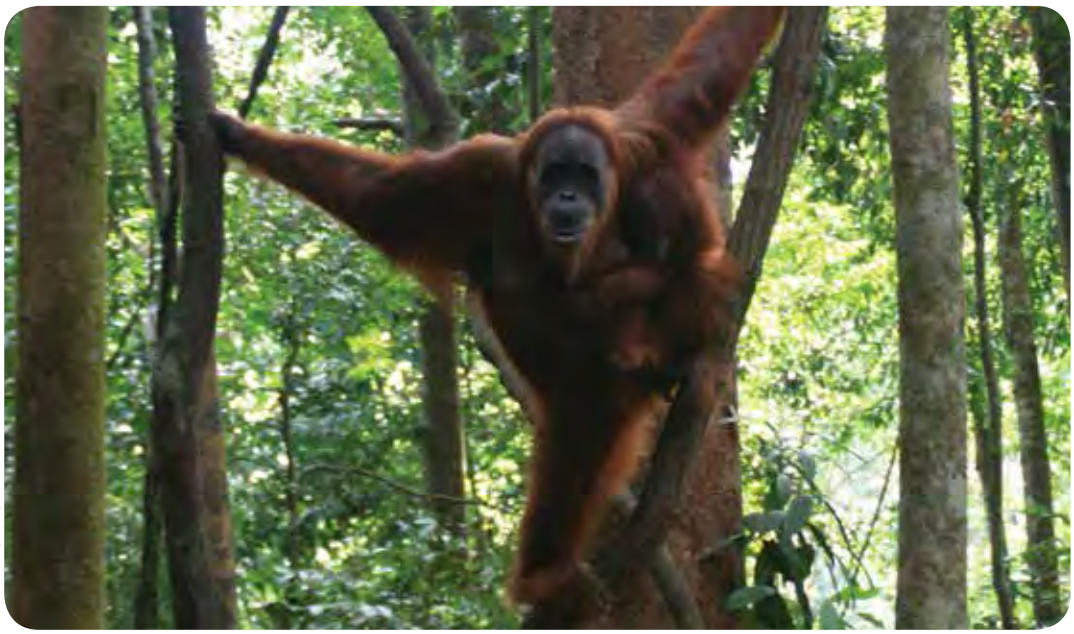
39 HEALTHY FOOD SYSTEMS



becomes available, these efforts will broaden health protection approaches and lead to the definition of new safety practices for food and agriculture, community health and ecohealth (Figure 39).

The options for safer livestock production and food chains have to be considered in conjunction with poverty reduction and environmental concerns. Balancing health, social and environmental goals is critical to achieving sus-

tainable intensification. These efforts involve difficult choices, as there are few win–win–win scenarios. Smallholder dairy development in South Asia may present an exception; for decades, national governments and international development agencies have focused on raising standards in small-scale dairy networks in the Indian subcontinent. This process has paved the way for incremental investments in animal husbandry, animal health, dairy processing, distribution and marketing, and related development; benefits have accrued to producers, consumers and society, at large. As well as health gains and enhanced food and income security, there are also major environmental and emission-related benefits. The significance of the smallholder dairy subsector and the large size of ruminant livestock populations in South Asia, particularly the Indian subcontinent, justify the prioritization of sustainable livestock intensification.



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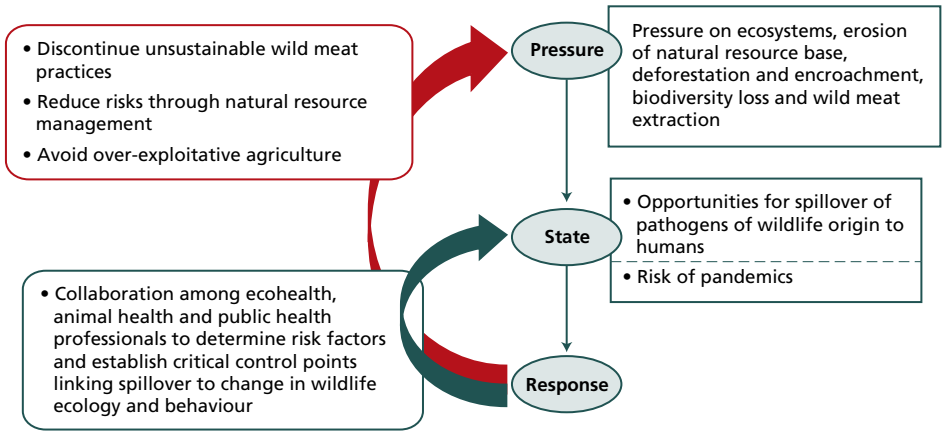
Preventing disease agents from jumping from wildlife to domestic animals and humans

A fourth category of drivers are the *pressures* on ecosystems (Figure 40). Deforestation, human and agricultural encroachment into forest and game reserves, habitat destruction, biodiversity loss, and bushmeat- or wild meat-related practices all enhance the risk of animal-to-human species jumps by disease agents. Once a novel, wildlife-origin pathogen starts to be transmitted among humans, the risk of a pandemic is real (Daszak, 2012). Livestock production plays a role in deforestation through expansion of the feed crop area or ruminant livestock's encroachment into grassy woodlands. World agriculture is currently the main driver of biodiversity loss.

Habitat destruction forces wildlife to invade farming landscapes or human living environments. The extent of agriculture-driven deforestation in South America (Brazil) has declined since the 1990s, while in Asia it is currently at or just past its peak. In sub-Saharan Africa, major expansion of crop and (ruminant) livestock production, combined with timber logging, is expected to be the main cause of deforestation in the future. With this increased production, it is likely that microbial reservoirs circulating in bats, rodents, monkeys and large game in savannah areas will contribute to increased spillover of wildlife-origin pathogens to livestock and humans, and pandemic risk. The evolution of new diseases resulting from changes in the pathogen-host range or host specificity may take various forms, depending on ecoregional characteristics.

For example, the acute form of sleeping sickness in humans, caused by the protozoan blood parasite *Trypanosoma brucei rhodesiense,* used to be transmitted by bloodsucking tsetse flies that had previously fed on game animals. Today, ruminant livestock has become a main reservoir of what used to be a mainly wildlife-related blood

40 ADDRESSING THE DRIVERS OF DISEASE EMERGENCE: ANIMAL-TO-HUMAN SPECIES JUMPS OF DISEASE AGENTS



parasite. As a result, humans increasingly contract the *Trypanosoma brucei rhodesiense* form of sleeping sickness at a distance from game reserves and main tsetse infestation areas, such as in livestock–crop agriculture systems (Figure 41). A similar pathogen shift from wildlife to ruminant livestock has altered the disease ecology of ECF and AAT in the savannah areas of East and Southern Africa. This wildlife-to-livestock pathogen shift results from the increased mixing of large game animals and ruminant livestock, along with the growing prominence of ruminants and the declining populations of certain large game species. This suggests that agro-ecological (and social) resilience varies among different geographic regions and may best be tackled under an ecoregional approach.

The anthropogenic drivers of disease emergence often receive little attention. An exception is a study on tick-borne encephalitis in Europe, which reported that increases in incidence coincided with the achievement of political independence following the fall of the Soviet Union. The patterns of relevant human activities, typically those related to the use of forest resources, were also found to be driven and/or constrained

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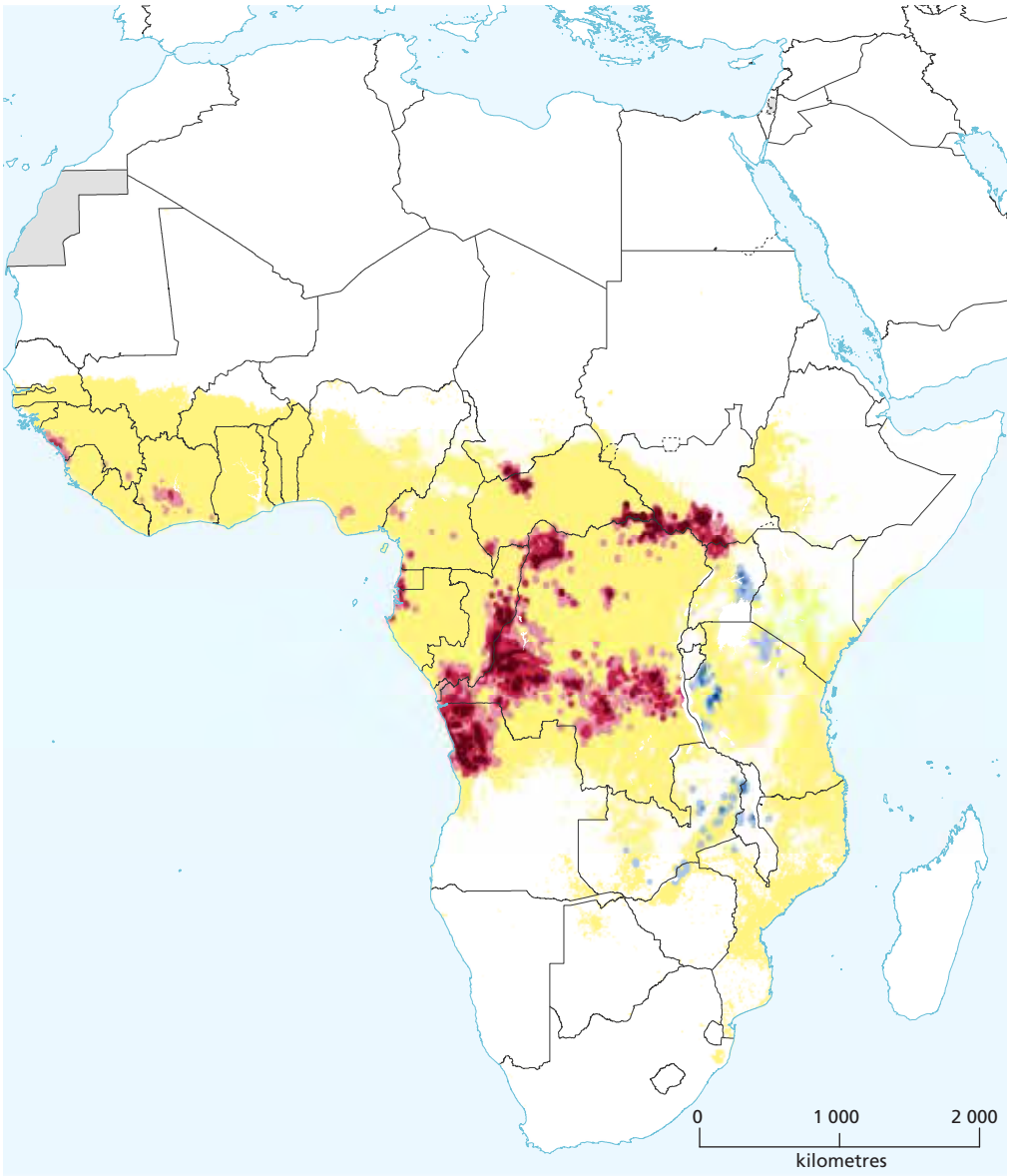
by the specific cultural and socio-economic circumstances in each country, resulting in contrasting national epidemiological outcomes (Randolph, 2010).

Again, there is need for collaboration among ecohealth, animal health and public health professionals, along with other disciplines, to link the changes in landscape and wildlife ecology and behaviour to the increases in pathogen spillover, and to check for changes in the molecu-

41 RISK OF SLEEPING SICKNESS (2000–2009) AND DISTRIBUTION OF THE TSETSE FLY



Risk of *Trypanosoma brucei gambiense* infection
(No. cases/inhabitants/year)

- High and very high (≥ $1/10^3$)
- Moderate (<$1/10^3$ to ≥ $1/10^4$)
- Low and very low (<$1/10^4$ to ≥ $1/10^6$)

Risk of *Trypanosoma brucei rhodesiense* infection
(No. cases/inhabitants/year)

- High and very high (≥ $1/10^3$)
- Moderate (<$1/10^3$ to ≥ $1/10^4$)
- Low and very low (<$1/10^4$ to ≥ $1/10^6$)

Predicted distribution of tsetse flies (Genus: *Glossina*)

Source: Simarro *et al.*, 2012.

lar determinants of pathogen-host specificity. The wildlife–livestock interface may serve as a model for disease agents' host species jumps involving humans. Action at the driver level may involve discontinuing unsustainable practices related to wild meat, enhancing natural resource management and selecting less exploitive forms of agriculture.

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Rationale for concerted action

Disease landscapes change as a result of human actions. Humans alter the host environment, leading pathogens to behave differently. Where host populations expand, the presence of large numbers of susceptible individuals may select for a pathogen that spreads more swiftly and – at least initially – aggressively. In situations where habitat destruction and biodiversity loss modify the host community and contact structure, pathogens may jump to a novel host species. Human living environments, farming landscapes and natural ecosystems become increasingly intermingled, as do their respective pathogen pools. The emergence, spread and persistence of diseases at the human–animal–ecosystem interface are increasing. Developing countries face a staggering burden of human, zoonotic and endemic livestock diseases; both old and new diseases create a major impediment to sustainable development at the global level. Globalization and climate change redistribute pathogens, vectors and hosts. Recurrent epidemics in livestock affect rural livelihoods and national economies in both poor and rich countries. Food safety hazards and antimicrobial resistance are on the increase worldwide. Pandemic risks caused by pathogens of animal origin remain a major concern.

With human behaviour providing the basis for today's disease dynamics, it follows that human action may also lead to a reversal of this increased disease activity. Major technical improvements in risk analysis and management are within reach. As well as introducing new technologies, efforts to strengthen health systems may also include enhancing the role of institutions, leading to new partnerships, processes and practices. Rapid growth in milk, meat and egg production encourages increased investments in animal and veterinary public health. Addressing the emergence, spread and persistence of animal-origin pathogens is an international public good of growing importance. Disease dynamics should be considered along with food security, poverty alleviation and protection of the environment. Deciding to reduce disease implies enhancing social and ecological resilience, and there is need for society at large to engage in

these endeavours: basic sanitation brings major benefits to the poor; healthy animals, healthy people, higher yields and safe food of high quality and affordable price tend to go together; and the control and prevention of animal diseases are beneficial for the environment, assist in mitigating climate change, and contribute to sustainable agricultural and rural development.

Priority consideration should, therefore, be directed to the four main streams of work identified by the current analysis:

- reducing poverty-driven endemic disease burdens in humans and livestock;
- addressing the biological threats driven by globalization and climate change;
- providing safer animal-source food from healthy livestock agriculture;
- preventing disease agents from jumping from wildlife to domestic animals and humans.

Most of these concerns already receive some attention: for example, international NGOs, UN and other development agencies are focusing on some neglected zoonotic diseases; the nexus of hunger, disease and poverty is increasingly addressed as a joint sustainable development domain; and pandemic risk assessment is the subject of productive collaboration among the world's leading public and animal health research bodies. The experience acquired from the fight against animal and pandemic influenza has translated into novel forms of public–private partnerships; the "Towards a Safer World" initiative grew out of the influenza pandemic preparedness work; and novel One Health projects are emerging around the globe, with Bangladesh, Kenya, Uganda and other countries encouraging collaboration among health professionals and other disciplines, and working across sectors and institutional divides. ProMED and the FAO/OIE/WHO tripartite platform facilitate worldwide disease information and intelligence functions that cover human, animal and plant health.

The main focus of *international agencies* is on facilitating and supporting global-level risk assessment, highlighting and communicating major international concerns, and enhancing international and regional cooperation and coordination, to integrate immediate and long-term perspectives for all countries, regardless of their economic development stage (Bogich *et al.*, 2012; De Cock *et al.*, 2013). The *national level* is where actions take place and field programmes are customized to specific national conditions. At this level, professionals in public health, food safety, animal health, plant protection, ecohealth and other disciplines work together with development actors to formulate locally applicable risk analysis protocols, guidelines and best practices (Chua and Gubler, 2013; Preston, Daszak and Colwell, 2013; Zinsstag *et al.*, 2012). The development of these tools requires the drawing up of disease impact profiles that reflect the full range of impacts of a disease and its control on the health and well-being of people, the economy and the environment. Health professionals and other development actors may aim to re-educate themselves, gaining experience through working together and directly involving the full range of stakeholders. *One Health*-inspired initiatives – such as that being undertaken in Bangladesh, where the Ministers of Agriculture, Health and Environment have signed a joint agreement – are very encouraging. A growing number of countries are introducing cross-sectoral health education in primary and secondary schools, and children are being encouraged to assume environmental stewardship responsibilities.

At the *global level,* the primary concern is the emergence of animal-origin disease agents that infect humans as hosts and show evidence of human-to-human transmission. There is need to continue the work of the Senior United Nations System Coordinator for Avian and Human Influenza, created in 2005 to ensure cooperation and coordination within the UN system in support of initiatives to address the AI epidemic and the threat of a human pandemic. It is essential to update and broaden the agenda, build consensus on new priorities, and revise global risk assessment to deal with pandemic threats at

the human–animal–ecosystem interface (Morse *et al.*, 2012). The FAO/OIE/WHO tripartite platform, along with laboratory networks, research institutions, academia, the private sector, civil society and development agencies, may facilitate this development. The coalition created for animal and pandemic influenza has demonstrated that novel partnerships, such as those involving producers and civil society organizations, play an important role in risk communication and preparedness building at all levels. Global concerns of both medical and veterinary interest relate to the rises in food safety hazards, antimicrobial resistance, wild meat-related practices, and the emergence, spread and persistence of animal, zoonotic and wildlife-origin diseases.

In countries of the *developing world* there is urgent need to strengthen the animal health and veterinary public health systems as an integral part of sustainable intensification of the rapidly growing milk, meat and egg production subsectors and associated supply chains. Innovation of health systems is necessary to increase attention to the human–animal–ecosystem interface, clarify pathogen flows in food systems and among the different host environments and landscape types (urban, farming and natural), and restore safety, based on the risk factors and critical control points identified. This approach relies on the proactive engagement of all concerned entities and individuals and on adequate efforts to identify the needs and motivations of local communities.

Countries in temperate climate zones of the *developed world* are particularly vulnerable to incursions of pathogens and vectors, driven by globalization, climate change and land-use dynamics. These incursions may involve infected human and animal hosts (tourism), contaminated food items, fomites and arthropods, and include the re-emergence of diseases that were successfully eliminated in the past, or, occasionally, the evolution of a novel disease complex. Improved risk assessment in these aspects requires the integration of methods for molecular surveillance, electronic reporting and Internet-based risk analysis platforms, which, in turn, rely on innovative partnerships and collaboration between the public and private sectors. Surveillance approaches will have to be broadened to encompass all the health-related risk factors in food systems and landscapes, including across political boundaries, requiring transparency and stronger agreement on elaborate international regulation mechanisms.

The high burden of human, zoonotic and animal diseases in *sub-Saharan Africa* is related to a combination of developmental, climatic and ecological factors. Wild meat-related practices concern mainly the forested areas of West and Central Africa. In the savannah areas of East, Southeastern and Southern Africa, the large game–livestock–human interface is growing, increasing the probability of pathogen spillover. Health professionals and other stakeholders should define a risk management and communication approach that will help people to protect themselves, safeguard and increase the revenues from tourism, and support the building of ecological resilience in both natural ecosystems and farming landscapes. In general, there is need for greater clarity regarding how the myriad of diseases affect the health status of humans and animals, livelihoods, economies and environments.

In *East* and *Southeast Asia* the main priorities are to explore the options for enhancing safety in food and agriculture and establish the prerequisites for sustainable intensification of livestock production, processing and marketing (Coker *et al.*, 2011). Given the nature of recent pathogen dynamics at the animal–human interface, these efforts should involve health professionals, food industries, farmers, traders and others in the food supply chain, including the general public. The presence of wet markets, the selling of wild meat and the slaughtering of poultry in live bird markets are notable risk factors (but see Box 3). Influenza viruses in poultry, pigs and humans are increasing in diversity, while rapid growth of the poultry and pig industries and the dairy subsector is leading to recurrent food safety hazards and antimicrobial resistance challenges.

BOX 3

JOINING FORCES TO SUPPLY HEALTHY POULTRY TO CLEAN LIVE BIRD MARKETS

In consultation with veterinary public health authorities, a city council may work with poultry workers, vendors and other intermediaries in the food supply chain to contain pathogen loads in live bird markets. Local veterinarians may assist poultry producers in improving on-farm sanitation and hygiene at source. Poultry transport vehicles require cleaning and disinfection before and after supplying live birds to collection points and markets, while markets themselves should be cleaned and disinfected at the end of each market day. Other helpful measures include introducing one or two rest days a week, ensuring that no poultry is kept in the market overnight, and separating aquatic from terrestrial birds and industrial from village poultry. Along with improved sanitation infrastructure, waste disposal systems and supportive health communication efforts these measures are all proven means of reducing the circulation of influenza virus in live bird markets and keeping human exposure to a minimum. Together, they facilitate safer animal-source food supply from healthy livestock agriculture.

In *South Asia,* the congregation of poor people and animals near urban agglomerations presents major health-in-development challenges. The need to step up the fight against rabies requires attention, while the development of small-scale dairy production in the Indian subcontinent justifies both public and private investment in dairy production and supply, animal health, food safety and quality control, and veterinary public health in general. A more productive dairy subsector will safeguard food and income security, protect the environment and reduce GHG emissions. Deforestation in parts of the eastern Indo-Gangetic plain and in Indonesia requires attention in view of the associated risks of wildlife-origin disease outbreaks in humans and livestock.

For countries in the *Greater Horn of Africa* and *Central Asia,* the marginalization of pastoral communities is a major challenge. One option is to exploit the growing demand for ruminant meat and dairy products in the *Near East* and *North Africa*, which would require an area-wide approach to address high-impact ruminant and zoonotic diseases and the scarcity of forage and water.

Countries in *Latin America and the Caribbean* experience recurrent vector-borne and other zoonotic disease outbreaks, involving bats, rodents and livestock. The priority is to establish the root causes, the risk factors and practices for preventive action. Rapid intensification of the poultry and pig industries has created a dichotomy between small-scale and industrial production, creating a mix of social, disease and environmental challenges.

It will be necessary to fine-tune the different work streams to ensure cohesion and efficiency, build ecoregional perspectives, support the formation of (sub)regional networks, and collaborate in human resource development, research, strategic planning and joint implementation across political boundaries and through public–private partnerships.

It is important to include all of these efforts in a common, sustainable development approach that puts collective global health protection endeavours into perspective and captures the best conditions for collaboration. An international policy and institutional framework may be necessary to facilitate the required paradigm shift in global health management. IPCC serves as an example; the World Meteorological Organization and the United Nations Environment Programme jointly established IPCC in 1988

to assess available information on the science, impacts and economics of, and the options for, mitigating and/or adapting to climate change. The root causes of and successful response to both climate change and disease dynamics relate to human action and choices.

Questions arise for each new work stream: Why take the extra step? What difference will it make compared with the current approach? In risk management, tackling the roots of a problem entails a shift towards greater stability and resilience, reducing the overall level of risk. This will, in turn, rely on establishing internationally agreed objectives; targets will have to be set for phased, prioritized actions to reduce the overall numbers of infected human and animal hosts, curtail pandemic risk and food safety hazards, and contain pathogen loads in the environment and circulating across landscapes and international boundaries. Creating a safer world requires that health protection becomes an integral part of overall sustainable development efforts, whether in food and agriculture, natural resource management or socio-economic development. Such a health-in-development perspective will guide the necessary adjustments to the policy and institutional realms, paving the way for integrated action in capacity development through human resource development, enhancement of physical infrastructure, and building of novel partnerships that operate across disciplines, sectors, and geographic and political boundaries.

Health and well-being concern all. Revitalization of the collective health systems that protect humans, animals and ecosystems is due; inaction is not an option.