

# ILRI One Health Strategy: Stopping the global rise of high-impact zoonotic disease, foodborne disease and antimicrobial resistance



# **ILRI One Health Strategy: Stopping the global rise of high-impact zoonotic disease, foodborne disease and antimicrobial resistance**

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# Contents

|                                                                          |           |
|--------------------------------------------------------------------------|-----------|
| Acknowledgements                                                         | 4         |
| Acronyms and abbreviations                                               | 6         |
| Executive summary                                                        | 7         |
| <b>Chapter 1: Introduction</b>                                           | <b>10</b> |
| Drivers of zoonotic disease and AMR emergence, spread and persistence    | 11        |
| Health and socio-economic impacts of zoonoses, foodborne disease and AMR | 11        |
| Endemic and foodborne diseases                                           | 11        |
| Antimicrobial resistance                                                 | 12        |
| Outbreaks, epidemics and pandemics                                       | 12        |
| Lessons learned from COVID-19                                            | 13        |
| <b>Chapter 2: One Health</b>                                             | <b>14</b> |
| Role of ILRI in One Health research                                      | 15        |
| ILRI's One Health strategy                                               | 16        |
| Vision                                                                   | 16        |
| Mission                                                                  | 17        |
| <b>Chapter 3: The three pillars</b>                                      | <b>18</b> |
| Pillar 1: Technical                                                      | 19        |
| Thematic area 1: Outbreaks, epidemics and pandemics                      | 22        |
| Thematic area 2: Endemic zoonoses                                        | 26        |
| Thematic area 3: Foodborne diseases                                      | 29        |
| Thematic area 4: Antimicrobial Resistance                                | 33        |
| Pillar 2: Policy                                                         | 36        |
| Pillar 3: Institutional                                                  | 40        |
| <b>Chapter 4: Implementation and partnerships</b>                        | <b>44</b> |
| <b>Chapter 5: Theory of change</b>                                       | <b>47</b> |
| References                                                               | 50        |

# Acronyms and abbreviations

|            |                                                                  |
|------------|------------------------------------------------------------------|
| ACCAHZ     | ASEAN Coordinating Center for Animal Health and Zoonoses         |
| AFROHUN    | Africa One Health University Network                             |
| AMR        | Antimicrobial resistance                                         |
| ASEAN      | Association of Southeast Asian Nations                           |
| AU         | African Union                                                    |
| IBAR       | Inter-African Bureau for Animal Resources                        |
| AVEG       | ASEAN Veterinary Epidemiology Group                              |
| BSE        | Bovine spongiform encephalopathy                                 |
| Africa CDC | Africa Centres for Disease Control and Prevention                |
| CIFOR      | Center for International Forestry Research                       |
| COVID-19   | Coronavirus disease 2019                                         |
| DNA        | Deoxyribonucleic acid                                            |
| ECOWAS     | Economic Community of West African States                        |
| FAO        | Food and Agriculture Organization of the United Nations          |
| GDP        | Gross domestic product                                           |
| FETP       | Field Epidemiology Training Program                              |
| FETPV      | Field Epidemiology Training Program for Veterinarians            |
| GHSA       | Global Health Security Agenda                                    |
| HIV/AIDS   | Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome |
| HPAI       | Highly pathogenic avian influenza                                |
| IHR        | International Health Regulations                                 |
| ICRAF      | World Agroforestry Centre                                        |
| IFPRI      | International Food Policy Research Institute                     |
| ILRI       | International Livestock Research Institute                       |
| IMF        | International Monetary Fund                                      |
| KAP        | knowledge, attitude and practices                                |
| IWMI       | International Water Management Institute                         |
| LMICs      | Low- and middle-income countries                                 |
| MERS       | Middle East Respiratory Syndrome                                 |
| MERS-CoV   | Middle East Respiratory Syndrome Coronavirus                     |
| NGO        | Non-governmental organization                                    |
| PVS        | Proficiency of Veterinary Services                               |
| REDISSE    | Regional Disease Surveillance Systems Enhancement                |
| REOs       | Regional economic organizations                                  |
| RNA        | Ribonucleic acid                                                 |
| RVF        | Rift Valley fever                                                |
| SAARC      | South Asian Association of Regional Cooperation                  |
| SARS       | Severe acute respiratory syndrome                                |
| SARS-CoV   | Severe acute respiratory syndrome coronavirus                    |
| SARS-CoV-2 | Severe acute respiratory syndrome coronavirus 2                  |
| SDGs       | Sustainable Development Goals                                    |
| UN         | United Nations                                                   |
| UNEP       | United Nations Environment Programme                             |
| UNESCO     | United Nations Educational, Scientific and Cultural Organization |
| WCS        | Wildlife Conservation Society                                    |
| WHO        | World Health Organization                                        |
| WOAH       | World Organisation for Animal Health                             |
| WorldFish  | WorldFish Center                                                 |
| WWF        | World Wildlife Fund                                              |

# Executive summary

This document describes a strategy to establish and lead a One Health Research platform at the International Livestock Research Institute (ILRI). This will build on ILRI's track record of interdisciplinary expertise and experience in developing sustainable livestock production systems in Africa and Asia, and further strengthen its mission to improve food and nutritional security and reduce poverty in developing countries through the safe and sustainable use of livestock. The strategic objectives led by ILRI will be to:

- Conduct multi-sectoral and multi-disciplinary research for development
- Generate evidence to promote and catalyse One Health application and practice
- Develop, test and promote science-based products and policies
- Strengthen interdisciplinary research collaboration at ILRI and build One Health research capacity at national and regional levels
- Establish strategic One Health research partnerships

The vision of the One Health platform led by ILRI is to improve the lives, livelihoods and well-being of people in the Global South by building healthy, sustainable and resilient livestock/animal production systems at the intersection of humans, animals and the environment.

The mission of ILRI's One Health platform is to develop integrated, science-based, risk mitigating measures for preventing and controlling high-impact emerging and re-emerging zoonoses; endemic zoonoses; foodborne diseases; and antimicrobial resistance (AMR) at the human, animal and ecosystem interfaces through national and regional capacity strengthening, outreach and advocacy.

The long-term mission of ILRI's One Health strategy will be to grow into a centre of excellence for a collective, interdisciplinary partnership and ownership, promoting One Health collaboration among CGIAR centres and other international and national partners to generate scientific knowledge and products to address a range of development issues that are central to the Sustainable Development Goals (SDGs) such as poverty, food and nutrition security, diseases, climate change and environmental degradation.

Over the short to medium term (5–10 years), ILRI's One Health platform will aim to develop integrated science, technology and policy-based, scalable solutions for mitigating health risks due to high impact animal-derived infectious disease threats at the human, animal and ecosystem interfaces. The focus of research will be on multi-sectoral and interdisciplinary approaches that support early detection of pathogens through risk-based surveillance, early response through improved health capacities and cost-effective prevention and control measures targeted at source, at the farm level and along the 'farm-to-fork' food chain. National and regional capacity strengthening, outreach and advocacy will be integrated into the work undertaken in this strategy.

The research will be conducted under the three main interconnected pillars: technical, policy and institutional.

1. **The technical pillar** will address high impact pathogen threats (viruses, bacteria, fungi and parasites) of animal origin under four specific overlapping technical themes, namely:
  - Epidemics and pandemics that are mostly caused by emerging and re-emerging viruses originating from wild animals and jumping into humans either directly or indirectly via other intermediate hosts, including livestock. They can emerge anywhere and at any time, and can become a major global problem (e.g. the ongoing Coronavirus Disease 2019 [COVID-19] pandemic).
  - Endemic zoonoses that are mostly caused by bacteria, viruses and parasites. They are well established in human and animal systems and are mostly a major burden on poor people in the Global South.
  - Foodborne diseases that are mostly caused by contamination of animal products and fresh vegetables often fertilized with animal faeces by bacteria, viruses, fungi and parasites. These diseases remain a significant problem in the Global South and are an impediment to the international food trade.
  - AMR that is due to acquired resistance in various disease-causing pathogens (mostly bacteria) to various antimicrobial agents used

for the treatment of humans and animals. This is a worldwide problem.

**2. The policy pillar** will utilize evidence generated from technical research and analysis of social, cultural, gender and economic factors to drive One Health policy for early warning and response and improved prevention and control for mitigating pathogen threats.

**3. The institutional pillar** will promote the strengthening of health capacities, particularly the animal and ecosystem health sectors that are considered the weakest link in the One Health triangle. This pillar will generate an economic case for a One Health approach and promote the strengthening of government and regional institutions and their governance to support One Health action in mitigating disease threats from animals.

The research will build on a number of ILRI's existing, multi-disciplinary animal and human health research programs under the One Health umbrella and broaden the geographical and technical scope of its activities in both Africa and Asia. In conducting this research, ILRI will strengthen its existing collaborations and build new alliances with national, regional and international One Health partners, including those from the public health sectors to support One Health solutions that address infectious disease threats arising at the intersection of people, livestock and environment. ILRI will capitalize on its in-house expertise and research infrastructures in animal health, zoonoses, the environment and livestock development sector. The key areas where ILRI has relevant experience include:

- Its status as the only institute among the 15 CGIAR centres dedicated entirely to animal agriculture research for the developing world and as a leading research centre for addressing livestock disease in sub-Saharan Africa and Asia.
- The presence of experienced scientists at the institute that have been working on addressing zoonotic disease and foodborne illnesses for several decades, supported by advanced research laboratories.
- The recently established CGIAR Antimicrobial Resistance Research Hub, one of two CGIAR platforms that has a state-of-the-art antimicrobial susceptibility testing facility.

- The Mazingira Centre, that is tackling problems at the interface of livestock, the environment and climate change.
- The Biosciences for Africa facilities at ILRI, a shared agricultural research and biosciences platform with the highest biosafety and biosecurity measures that increases access to affordable, world-class research facilities for capacity building, training and development.
- The recently inaugurated One Health Research, Education and Outreach Centre in Africa, which aims to enhance the health of people, animals and their shared environment in sub-Saharan Africa.

The major outputs from ILRI's One Health platform will be knowledge, tools, policies, guidelines, methodologies, strategies and communication material for prevention and control strategies for addressing infectious disease threats to people, their livestock and the overall food systems.

The benefits of investing in integrated One Health prevention and control, principally using horizontal approaches that address many diseases that are amenable to similar risk mitigation measures across different systems, are wide-ranging. These include cost effectiveness, as well as enhancing capacities of health sectors more broadly to address not just pandemic, epidemic, endemic and foodborne diseases and AMR, but other infectious diseases of humans and livestock, enabling the development community to fulfil its agenda of protecting the poor and the most vulnerable, improving their lives, livelihoods and well-being, and building a healthy and resilient society safe from disease in a globalized world.

ILRI One Health Research aims to principally serve the needs of the livestock communities, consumers and public at large in the low- and middle-income countries (LMICs) of east, west, central and southern Africa, and south, southeast and east Asia, and provide research outputs that will have a wider global application. The key outcomes will contribute to the overall goals and impact of the CGIAR research agenda related to ensuring food and nutrition security, enhancing livelihoods, empowering women and protecting the environment.







Chapter 1:

# Introduction



Infectious diseases kill over 14 million people a year and are a leading cause of human fatality worldwide. According to the World Health Organization (WHO 2007), one or more new infectious diseases have emerged every year since 1979. Over 60% of these diseases are zoonotic, meaning they originate in animals (Heeney 2006; Karesh et al. 2012). In addition, 75% of all emerging and re-emerging zoonotic infections are caused by pathogens that emerge from wild animals (Woolhouse and Gowtage-Sequeira 2005; Taylor et al. 2001; Cleveland et al. 2001). In addition, a number of new and old pathogens resistant to available antimicrobials, known as AMR, are emerging in humans, animals and other agricultural sectors.

Bacteria, viruses, fungi and parasites are the predominant zoonotic pathogens that cause diseases in animals and humans. The types of disease syndromes and the impacts of zoonotic diseases vary and greatly depend on the specific pathogens and the hosts they infect. Broadly, zoonoses can be classified into three subcategories:

1. Emerging and re-emerging zoonotic pathogens that often cause outbreaks, epidemics and pandemics, mainly emerging following a spillover event from wild animals into humans and/or livestock. They can cause deaths and illnesses in thousands to millions of people worldwide.
2. Endemic zoonoses that cause chronic debilitating conditions and are common among poor communities that are closely associated with livestock. Some endemic diseases can emerge under certain conditions to create outbreaks and epidemics.
3. Foodborne diseases that cause acute to chronic diarrhoeal diseases and other chronic morbidities, usually through the contamination of livestock products along the food-chain. Like endemic zoonoses, foodborne diseases are also linked with poor food hygiene standards in LMICs.

It is now believed by the scientific community, that the incidence of all categories of zoonotic diseases and AMR will continue to rise, as the anthropogenic drivers that contribute to their emergence and spread are expanding at an unprecedented rate.

## **Drivers of zoonotic disease and AMR emergence, spread and persistence**

Population growth, economic developments and the unprecedented exploitation of the world's finite natural resources are the predominant forces driving the dynamics of these threats. These global trends exert enormous pressure on the earth's environment. Mining and deforestation, the encroachment on forests, land use changes, climate change, wildlife farming and an increasing consumption of wild meat create more opportunities for new pathogens to jump from wild animals to people and their livestock. Similarly, climate change is changing vector habitats, creating opportunities for vector-borne zoonotic diseases to spread in new areas and regions of the world.

A surging demand for food, particularly from animal-derived meat, milk and eggs, is driving intensification of livestock farming systems and creating complex value chains. Poor sanitary standards along these food chains present food safety challenges and necessitate the increasing use of antimicrobials, contributing to the emergence and spread of antimicrobial resistance. Complex and rapidly evolving interactions among humans, domestic animals, wild animals and the environment are the root causes of pandemics and endemic zoonotic diseases.

## **Health and socio-economic impacts of zoonoses, foodborne disease and AMR**

### **Endemic and foodborne diseases**

All types of zoonoses are now considered to cause significant health and socio-economic impacts. It is estimated that the 13 top ranked zoonoses are responsible for 2.2 million human deaths and 2.4 billion cases of illnesses every year (Grace et al. 2012).

Endemic and foodborne diseases are mainly a problem of the Global South, affecting poor farmers and their livestock. Endemic zoonoses affect an estimated one billion resource-poor smallholder livestock farmers and pastoralists in Africa and Asia (Grace et al. 2012), where these communities suffer the dual burden of zoonotic diseases affecting their health as well as that of their animals, resulting in loss of livelihoods. Of the foodborne illnesses that affect over 600 million people and kill some 480,000 people each year, infections derived from livestock products are a significant cause of all foodborne illnesses (Painter et al. 2013; Sudershan et al. 2014; Tam et al. 2014; Sang et al. 2014; Li et al. 2019). Nearly 98% of the global burden of foodborne diseases is carried by developing countries (Havelaar et al. 2015).

Recent World Bank estimates show that foodborne illnesses cost LMICs USD 110 billion in lost productivity and medical expenses every year (Jaffee et al. 2018). The economic cost of endemic zoonoses and foodborne diseases from animal sources are estimated to be higher than the combined impacts of HIV/AIDs, malaria and tuberculosis (Havelaar et al. 2015).

## Antimicrobial resistance

AMR is high impact threat that the world faces today. The progressive rise in AMR against pathogens over several decades has now become a major global health crisis (O'Neill 2016). Now considered a 'silent pandemic', if the AMR situation is not alleviated it is estimated that by 2050 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 USD 100 trillion (O'Neill 2016). The agriculture sector (livestock, fisheries and crops) will become vulnerable to disease and could force 24 million people into extreme poverty (IACG 2019).

## Outbreaks, epidemics and pandemics

The most visible impacts and challenges of zoonotic infections are due to epidemics and pandemics caused by predominantly new zoonotic pathogens emerging from wild animals. In the first two decades of this century, the world has seen four major pandemics—severe acute respiratory syndrome (SARs), H1N1 influenza A, Zika and the ongoing COVID-19—and several epidemics such as highly

pathogenic avian influenza (HPAI) virus A (H5N1), Middle East respiratory syndrome (MERS) and Ebola, costing hundreds of thousands of lives and billions of dollars to national economies worldwide. The 2014/15 Ebola epidemic for example wiped out most of the recent development gains in Guinea, Liberia and Sierra Leone, which had been the fastest growing economies in the world prior to the crisis (World Bank International Working Group on Financing Preparedness 2017). It is estimated that the three countries lost USD 2.2 billion in gross domestic product (GDP) in 2015 alone (World Bank 2015). MERS and HPAI H5N1 and its many variants continue to spread and persist in Asia and Africa in poultry and humans, compromising the growth of the poultry industry and posing significant pandemic risk to the world. Conservative estimates suggest that pandemics destroy up to 1% of global GDP (World Bank International Working Group on Financing Preparedness 2017), making them comparable to other top priority global threats such as climate change, which is estimated at 0.2–2.0% of global GDP (Intergovernmental Panel on Climate Change 2014) and other natural disasters estimated at 0.3–0.5% of global GDP (UNISDR 2015).

The ongoing COVID-19 pandemic caused by the severe acute respiratory coronavirus 2 (SARs-CoV-2) (WHO 2020a) has served to underline the importance of pandemics and emerging diseases more generally. Considered to be the worst health crisis in the world since the influenza pandemic of 1918 (Taubenberger and Morens 2006; Jeffery and David 2006), it has at the time of publication, infected over 244 million people and caused over 4.9 million deaths. The World Bank estimates in its press release that went out on 7 October 2020, that the COVID-19 pandemic will push an additional 88 million people into extreme poverty. Globally, the number of people facing acute food insecurity is also likely to double by the end of the year due to the disruption of businesses, agriculture activities and local and global supply chains. It is predicted that the economic meltdown will be worse than the worldwide economic depression of the 1930s (Jackson et al. 2020), and many of the gains made towards meeting the SDGs (UN 2015) will be reversed (World Bank 2020). The cumulative output loss of COVID-19 globally across 2020 and 2021 could be as high as USD 12.5 trillion.

Infectious diseases therefore present one of the biggest challenges to the global community in achieving many of the goals set out in the 2030 Agenda for Sustainable Development (UN 2015).

Achieving the CGIAR goals to improve nutrition, reduce poverty, mainstream gender and protect the environment are being constrained by high-impact zoonotic infections and AMR.

## **Lessons learned from COVID-19**

All of the recent zoonotic epidemics and pandemics have had their impacts mainly in certain regions of the Global South. Their impacts in advanced economies have tended to be transient and marginal. Once the disease emergency is over, the commitment for long-term international financing for prevention of zoonotic diseases has waned in these countries.

However, COVID-19 is significantly different. Both the advanced economies and LMICs are affected, impacting all of humankind. It has again

demonstrated the weaknesses of global health systems and lack of resilience in coping with a crisis of this magnitude. The benefits of investing in the construction of robust and sustainable health systems all over the world that can deal with any zoonotic disease far outweighs the billions of dollars being spent on reacting to a health crisis disease by disease when it occurs (World Bank 2017; Sands 2017).

The complex nature of zoonotic diseases and AMR that occur at the interface of humans, animals and the ecosystem has again highlighted the need to adopt a holistic, multi-sectoral and multidisciplinary approach. This approach has been defined as One Health by the Wildlife Conservation Society (WCS) (WCS 2004; King 2008), which benefits from the diverse knowledge base of different sectors and disciplines, and offers a holistic view of the complex nature of zoonoses and AMR, enabling more efficient prevention and control interventions.

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Chapter 2:

# One Health

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The dynamic nature of the close interconnectedness of humans, agriculture, animals, food systems and the ecological, social and political environment creates complex challenges that require integrated multi-sectoral and multi-disciplinary approaches. The concept of integrative thinking in addressing such challenges is not new. This was observed in the Chou Dynasty in China (11–13<sup>th</sup> century) that integrated the public health system, including medical doctors and veterinarians, or Hsü Tach'un from China in the 18<sup>th</sup> century who stated that the foundations of veterinary medicine are as comprehensive and subtle as those of human medicine and it is not possible to place one above the other (Zinsstag et al. 2011). In the 19<sup>th</sup> century, there was a strong interest in comparative medicine and the German physician Rudolf Virchow stated that 'between animal and human medicine there is no dividing line – nor should there be'. Objective, but the experience obtained constitutes the basis of all medicine (Saunders 2000). More recently, in 1964 the American veterinary epidemiologist Calvin Schwabe developed the 'One Medicine' concept (Schwabe 1964) that showed the importance of systematic interaction of humans and animals for nutrition, livelihoods and health. This concept was further expanded by the Wildlife Conservation Society (WCS) by coining the term 'One World One Health' (WCS 2004) that recognizes the interdependence of the health of wildlife in nature and the health of communities and their livestock. One Health, derived from 'One World One Health' is now the most commonly used term that identifies the inextricable linkages between the health of people, animals and their shared environment.

The One Health approach principally focuses on the close collaboration and integration of the human, animal and environmental health sectors. EcoHealth, derived from ecosystem health, focuses on adopting a systemic and participatory approach to promoting health and well-being in the context of social and ecological interactions (Waltner-Toews 2009). Similarities and overlaps between these two concepts, including transdisciplinary and multi sectoral cooperation, have resulted in an alignment and integration of these approaches to address agriculture and ecosystem-based interventions (McDermott and Grace 2012).

Increasingly, the One Health approach is finding a place to address varied and complex agriculture systems-driven problems such as malnutrition, obesity, environment degradation, land use changes, depletion of water resources and climate change. As such, the definition of One Health has

come to mean different things to different people depending on the problem being addressed.

In the context of this strategy, the One Health definition has been broadly adapted from the recommendations made in the Manhattan Principles (WCS 2004) for addressing common issues of pathogen threats of animal origin (zoonoses and AMR) using a holistic, multi-sectoral and multi-disciplinary approach, while ensuring that the shared ecosystem is not destabilized. The One Health foundational principles to which the ILRI strategy will adhere to include engaging with multiple disciplines, sectors and other stakeholders relevant to the problems resulting from the complex interactions between people, their livestock, wild animals and their ecosystems; as well as the sharing of knowledge and resources, learning across disciplines and sectors, and joint planning and implementation (Figure 1).

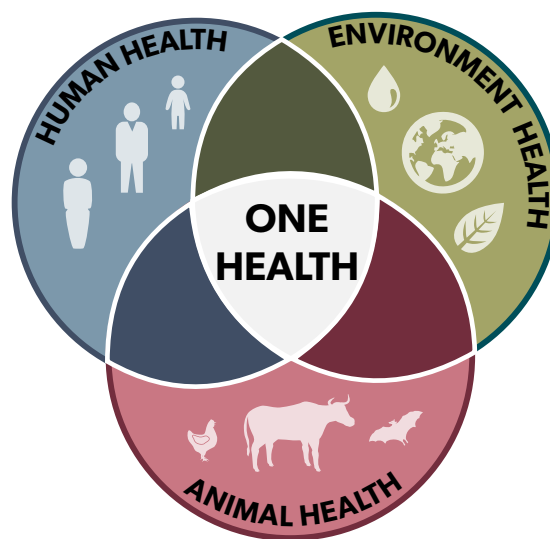


Figure 1: The One Health triad; healthy people, healthy environments, healthy animals.

## Role of ILRI in One Health research

As one of 15 CGIAR centres, ILRI focuses on LMICs with the goal of improving food and nutritional security and reducing poverty, which is severely compromised by zoonotic disease. As the only CGIAR centre working solely on livestock systems and interactions between livestock, wildlife and the environment, combined with a strong track record on zoonoses, ILRI has both a strong advantage

and an obligation to lead One Health research within CGIAR. ILRI, which has over 47 years of experience in animal health, zoonoses and food safety systems, is equipped with state of the art biosecurity laboratories and an extensive research infrastructure that includes a dedicated center dedicated to addressing environmental issues. In the context of One Health, ILRI represents two of the One Health triad's key sectors, namely animals and the environment. It benefits from an extensive network of partnerships including collaboration with a number of public health institutions globally.

## ILRI's One Health strategy

The main purpose of this strategy is to establish a One Health Research platform at ILRI that builds on its track record of multidisciplinary expertise and experience in working on sustainable and resilient livestock production systems in Africa and Asia over the last 47 years (as of 2021). The strategic objectives of the One Health platform will be to:

- Conduct multi-sectoral and multi-disciplinary research for development.
- Generate evidence to promote and catalyse One Health application and practice.
- Develop, test and promote science-based products and policies.
- Strengthen ILRI's interdisciplinary research collaboration and build One Health research capacity at a national and regional level.
- Establish strategic One Health research partnerships.

The overall mission of ILRI's One Health Research will be to grow into a centre of excellence for a collective, multi-disciplinary partnership and ownership, promoting One Health collaboration among CGIAR centres and other international and national partners to generate scientific knowledge and products approaches that address a range of development issues such as poverty, food and nutrition security, disease, climate change and environmental degradation.

In the short to medium term (5–10 years) ILRI's One Health Research will aim to specifically address the progressive rise in new and existing pathogen threats of animal origin that cause epidemics and pandemics, chronic zoonoses, foodborne diseases and reduce the emergence and spread of AMR, with a focus on early detection, early response, and

prevention and control at source, usually at the farm level and along the farm-to-fork-food chain. In the context of this strategy, pathogen threats include all disease-causing pathogens such as viruses, bacteria, fungi, protozoa and parasites originating from both domestic and wild animals.

The benefits of investing in a multi-disease approach to prevention and control (World Bank 2010) that addresses a range of zoonotic diseases rather than addressing each disease separately are wide ranging. These include cost effectiveness, enhancing the capacity of health sectors globally to address other infectious diseases of humans and livestock and contributing to the fulfilment of the development agenda of protecting the poor and most vulnerable, improving their lives, livelihoods, well-being and building a healthy and resilient society safe from disease in a globalized world.

The strategy defines priority areas of work on zoonoses and AMR and is designed to be a partnership initiative that will aim to capitalize on ILRI's comparative expertise in animal health and the livestock development sector, and collaborate with several ongoing and newer national, regional and international efforts to support the prevention and control of high-impact zoonoses and AMR. The strategy also provides an opportunity for ILRI to consolidate and build on a number of its existing, multi-disciplinary animal and human health research portfolios under the One Health umbrella and broaden the geographical and technical scope of its activities in Africa and Asia.

ILRI's One Health Research aims to principally serve the needs of the livestock communities in LMICs in east, west, central and southern Africa, and south, southeast and east Asia. The research outputs will have a wider global application that will contribute to the overall goals and impact of the CGIAR research agenda related to ensuring food and nutrition security, enhancing livelihoods, empowering women and protecting the environment.

## Vision

The vision of the ILRI One Health Research platform will be to improve the lives, livelihoods and well-being of people in the Global South by building healthy, sustainable and resilient systems at the intersection of humans, animals and the environment.

## Mission

The mission is to develop integrated, science-based, risk mitigating measures for preventing and controlling high-impact emerging and re-emerging zoonoses; endemic zoonoses; foodborne diseases; and AMR at the human, animal and ecosystem interfaces through national and regional capacity strengthening, outreach and advocacy.

The strategy describes the research that ILRI One Health Research will conduct in the short to medium term (5–10 years). It is expected that the research will generate capacity, knowledge, tools, policies, guidelines, methodologies, strategies and communication material for early warning, response, and prevention and control of high-impact zoonotic diseases and AMR that affect people and their livestock under the three main interconnected pillars, namely technical, policy and institutional.

### PILLAR 1: TECHNICAL

The Technical pillar will address agriculture associated diseases originating from both domestic and wild animals under four specific overlapping technical themes. These are:

- Outbreaks, epidemics and pandemics
- Endemic zoonoses
- Foodborne diseases
- AMR

### PILLAR 2: POLICY

The Policy pillar will utilize evidence generated from technical research and analysis of social, cultural, gender and economic factors to drive One Health policy that improves control and prevention for mitigating pathogen threats.

### PILLAR 3: INSTITUTIONAL

The Institution pillar will promote the strengthening of health capacities, particularly the animal and ecosystems health sectors that are the weakest link in the One Health triangle. This pillar will also generate an economic case for the One Health approach and promote the strengthening of government and regional institutions and their governance to support One Health action in mitigating pathogen threats from animals.

The goals and overall outcomes of the three Pillars are summarized below (Figure 2).

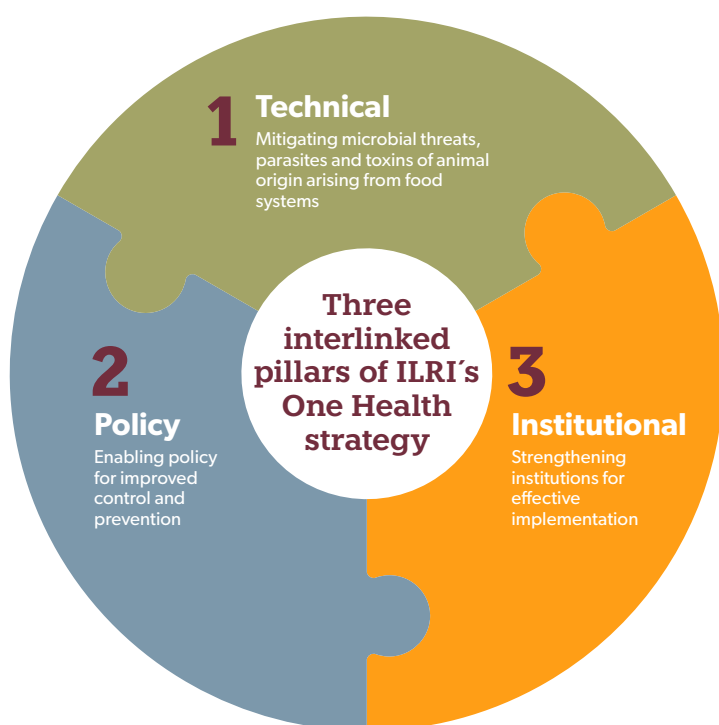


Figure 2: Overlapping three pillars of the strategy leading integrated science-innovation-policy driven One Health approaches to management of zoonoses and AMR.



Chapter 3:

# The three pillars

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# PILLAR 1: TECHNICAL

## Overall goal

The overall goal of the technical pillar is to conduct One Health research to improve understanding of the risks and impacts of zoonotic pathogens in humans and their livestock originating from animals at the intersection of humans, domestic and wild animals and their ecosystem. The focus will be to develop models early warning systems through strategic risk-based surveillance, generate data and metadata on epidemiological, social, economic, gender, cultural and environmental factors for risks, model for forecasting zoonotic diseases and identify cost-effective options for integrated disease prevention and control programs.

## Commonalities across thematic areas

Under this pillar, the four thematic areas include outbreaks, epidemics and pandemics, neglected endemic zoonoses, foodborne diseases and the mitigation of AMR risks. There are a number of common issues and challenges across all four thematic areas, as listed below.

- They are all preventable and are a worldwide problem. They have particularly high socio-economic costs in LMICs.
- There is inadequate data on the priority drivers for their emergence, spread and persistence and their impacts in different systems. For example, the role of gender, poverty, inequality and socio-economic drivers is poorly understood, and the ecosystem health sector is poorly integrated using the One Health approach, weakening prevention strategies.
- One Health approaches are difficult to implement, as sectoral silos still exist in most countries and budget allocation among the three key sectors of public health, animal health and ecosystems health is uneven, with the latter two invariably with lower budgets than the public health sector.

- Many LMICs have insufficient institutional and legislative capacity with which to implement broadly effective One Health policies and regulations.
- There is poor capacity in zoonoses and AMR despite clearly recognized economic and social benefits in prevention and control.
- However, all zoonoses and AMR emerge, spread and persist from the same systems, therefore a number of technical approaches and interventions can be similar across the four thematic areas.
- These include identifying and characterizing pathogen risks in different farming systems, understanding the factors that cause these risks, defining socio-economic impacts, developing 'best bet' prevention and control packages across all the three subcategories of zoonoses and AMR, while ensuring that they are gender and culture sensitive, environmentally friendly and economically viable.

## Technical approach

The entry point for ILRIs One Health Research to address zoonotic diseases and AMR is the livestock, wildlife and environmental sectors. Livestock food systems that interact with humans and their shared ecosystem will therefore be the main target through which all research related to zoonotic diseases and AMR will be conducted. In addressing these diseases, a risk-based approach along priority food systems will be adopted (Figure 3). This will include the following key steps:

- Defining the challenges related to various categories of zoonoses and AMR, and determining priorities aligned with ILRI's comparative advantages.
- Characterizing target livestock production systems and their interfaces where different categories of zoonotic diseases emerge, spread and persist.
- Conducting surveillance underpinned by validated diagnostic tools.
- Prioritizing key pathogens and understanding their epidemiology.

- Developing early warning systems supported by risk assessment, modelling and forecasting.
- Conducting impact assessment and developing options for 'best bet' prevention and control strategies.
- Evaluating prevention and control strategies in pilot studies, including the development of improved and new vaccine technologies.
- Developing policy recommendations, communication material and advocacy for change and increased investment.
- Developing sustainable scaling measures

The livestock production systems targeted will be predominantly mixed crop-livestock, small- and medium-scale commercial and pastoralists. Intensive large-scale production systems will be addressed where relevant, particularly in the context of emerging and re-emerging epidemic and pandemic diseases. Literature reviews, survey techniques, focus group meetings and interviews with a range of stakeholders will be key research tools to define problems, challenges and gaps as well as the understanding of target systems. Different surveillance approaches such as passive, syndromic,

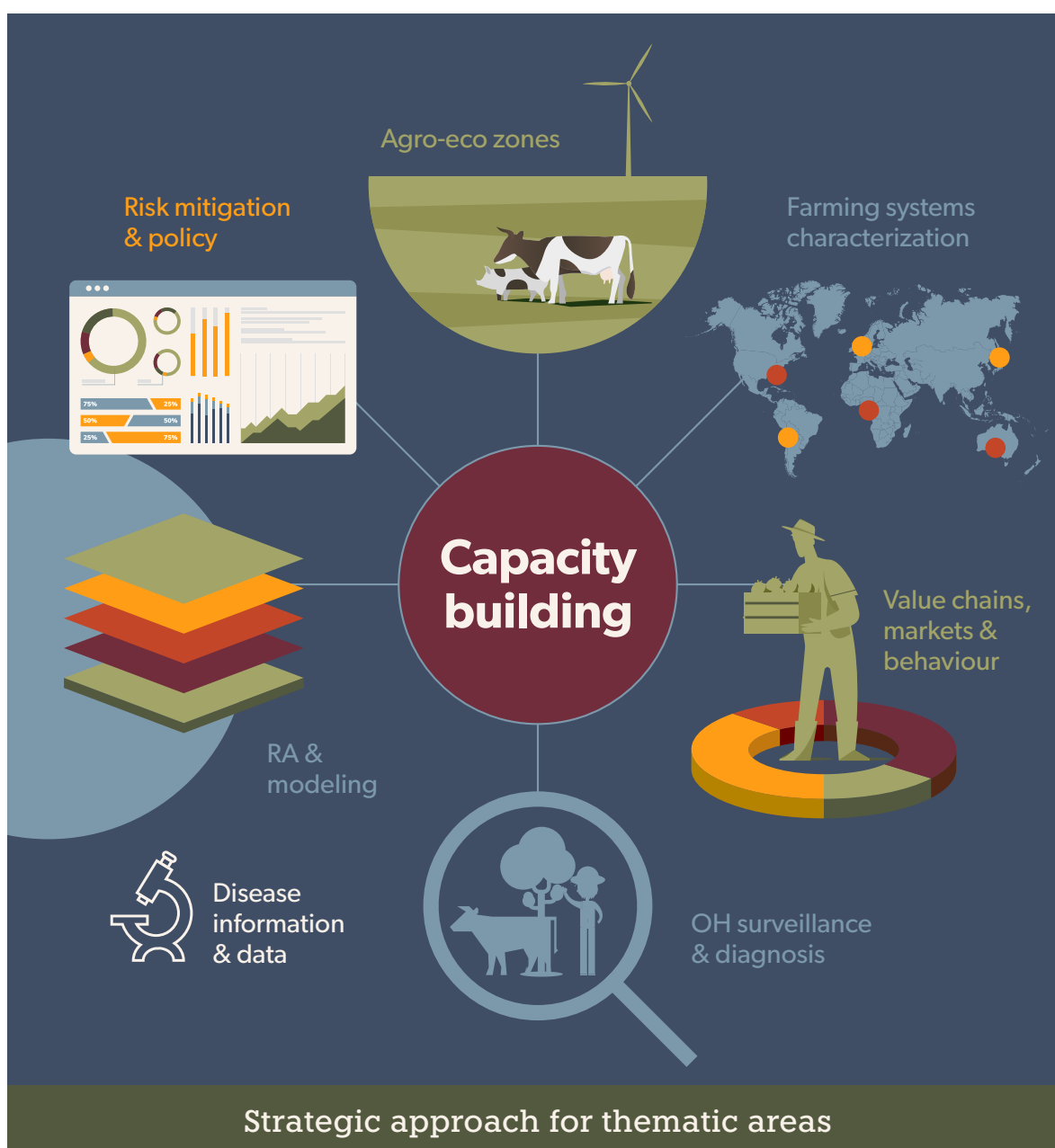


Figure 3: Risk-based systems approach to develop risk mitigation strategies and policies for zoonoses and AMR.

serological and pathogen identification will be used according to the types of zoonoses and pathogens targeted. Linked to the surveillance systems will be the generation of metadata related to breed, age and sex of animal samples, the types of farming systems, information on households, practices and behaviour and the role of gender in farming systems and animal health.

### **Utilizing technology platforms to support surveillance, development of diagnostics, vaccines and novel therapeutic targets**

COVID-19 has spurred significant interest in research and rapid development of diagnostics and vaccines and ILRIs One Health Research platform will aim to leverage its laboratory and experimental animal facilities to build on strategic partnerships with a number of commercial and public innovative vaccine and diagnostic initiatives.

The One Health platform will exploit and optimize the use of genomics, bioinformatics and molecular immunology to refine existing diagnostic tools, generate new pathogen detection and characterization systems, produce user-friendly pen-side diagnostics to underpin surveillance, improved vaccines against existing endemic zoonoses and new vaccines against emerging zoonoses to support prevention. These will include the following:

***Integrated pathogen surveillance for the early detection of zoonotic diseases and AMR:*** The approach adopted here will be to establish baselines of microbial populations linked with passive/syndromic surveillance systems to detect early new pathogen emergence or genetic changes in existing pathogens in domestic animals and humans at different risk areas and systems (e.g. forest edges, wildlife farming systems, wild meat value chains, slaughterhouses and wet markets). This surveillance approach will be applied to different categories of zoonoses and AMR as outlined below:

- **Emerging and re-emerging zoonoses:** identification of pre-emergent/emergent ribonucleic acid viruses at the interface of livestock, humans and wild animals.
- **Endemic zoonoses:** identification of priority or all endemic zoonoses in defined farming systems (various pathogens).
- **Foodborne diseases:** A range of diagnostics are widely used in many national laboratories and can be adapted for risk-based surveillance along the livestock value chain including markets, slaughterhouses and informal and formal food processing sites (various pathogens).

- **AMR:** identification of AMR and new drug-resistant pathogens in the agriculture/livestock sector (mainly bacterial pathogens).

***Developing generic vaccine platforms:*** Vaccines form an important component of a package of risk mitigation measures for building health resilience against infectious disease threats. The emergence of a number of high-impact infectious diseases has highlighted the need for rapid vaccine development. This has spurred a number of new and innovative vaccine technologies, now referred to as platform technologies (van Riel and de Wit 2020) that are different from the conventional vaccine approaches that use either live, attenuated or dead and inactivated viral and other pathogen vaccines. These conventional vaccines take years to develop and cost hundreds of millions of dollars.

These new technologies are defined as those that utilize a process where a common template or backbone is used to make many different vaccines. The main advantage of such technologies is that once a genetic sequence of a target molecule that induces an immune response is identified, it can be rapidly plugged into the previously safety-tested common backbones and delivered as a vaccine to humans and animals. These technologies are versatile, flexible and can be used for the development of vaccines against a large number of existing diseases. For example, a platform technology that utilizes a viral delivery system (e.g. modified non replicating adenoviruses) as a backbone has been successfully tested for a number of viral diseases including MERS-CoV, Ebola and Rift Valley fever (RVF). Similar progress has been made in protein vaccine design based on virus-like particles (VLPs) (Plotkin 2014; Syomin and Ilyin 2019; Lu et al. 2015), for example, using a two-component self-assembling VLP scaffold to express structurally enhanced antigens (Boyoglu-Barnum et al. 2020).

A whole range of platform technologies are being used or evaluated for development of vaccines against the ongoing COVID-19 pandemic (WHO 2020b). Within six to eight weeks of the protective spike protein antigen gene of the SARS-CoV-2 being sequenced, a number of potential vaccine candidates using the new generation platform technologies were developed. Several new, safe and efficacious vaccines based on these technologies are now being approved worldwide and their use is considered to be a major 'game changer' in halting the devastating impact of the pandemic. These technologies have the potential to be adapted to rapidly develop vaccines against



a range of other priority pathogens to proactively control future emerging and re-emerging epidemics and pandemics.

The ILRI vaccine research group has experience in utilizing some of these technologies to improve existing vaccines and contribute to the development of new ones. It is envisioned that under the One Health platform, ILRI will broaden its vaccine research to collaborate with vaccine research institutions, universities and the private sector to develop and test platform technologies for various priority zoonotic diseases.

### Management of 'big' data

Data generated from the broad technical approach as outlined above will form the basis for prioritizing pathogens, conducting risk assessments and developing early warning systems through modelling and forecasting tools. Socio-economic and gender analysis will support the development of options for optimized, cost-effective prevention and control packages. Engagement with communities at a grassroots level will enable the generation of knowledge on socio-economic drivers, behavioural and cultural practices in disease control and improved understanding of incentives and disincentives in managing health risks in people and their animals.

The One Health platform will aim to establish an integrated database that will enable the analysis and interpretation of large volumes of data generated through this research. The analysis and interpretation of these data will be supported by tools such as machine learning, artificial intelligence, modelling, foresight analysis and horizon scanning to generate science-based guidelines, protocols and evidence for policies.

The technical approach will focus on research that serves the Sustainable Development Goals (SDGs), and hence be driven by the generation of products that are directly relevant to ILRI's key stakeholders.

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## Thematic area 1: Outbreaks, epidemics and pandemics

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The overall goal of this thematic area is to develop an early warning system to pre-empt and prevent future outbreaks, epidemics and pandemics from pathogens arising from wild animals into humans that jump either directly into humans or indirectly through domestic animals at the human, domestic animal and wildlife interface.

### Problem and challenges

Epidemics and pandemics are not new, but their frequency is increasing at an alarmingly rapid rate (Smith et al. 2014). They can emerge at any time and in any place without warning; do not distinguish national boundaries; and affect the rich, poor and all levels of society (World Bank International Working Group on Financing Preparedness 2017; Sands and Chawla 2017).

All recent emerging and re-emerging zoonotic diseases have been caused by Ribonucleic acid (RNA) viruses originating in wild animals, ranging from birds, bats, rats and non-human primates (Johnson et al. 2015). These viruses are prone to mutations, recombination events and rapid evolution.

While the emergence of new pathogens is inevitable, the diseases and profound social and economic impacts that they cause are not. Pandemics and epidemics are preventable, and the economic returns on investment in prevention generate more benefits (World Bank 2012) than adopting a reactionary response to them as and when they occur. Tackling such infections is now recognized as an international public good requiring concerted global efforts (Smith 2003; Smith and MacKellar 2007), and long-term investment in basic and applied research to develop science-based prevention and control policies.

For epidemics and pandemics to occur, new pathogens from wild animals must first jump to humans and/or their livestock, amplify in their new host and have the appropriate biological, ecological and epidemiological conditions to establish, multiply and spread more widely (Morens et al. 2008). Once established in a new host they are almost impossible to eradicate because of persistence in wildlife reservoir hosts (Morens and Fauci 2013). The early detection and elimination of a new pathogen in a new host shortly after a spillover event and before it becomes a health emergency is most important in pre-empting the potentially harmful impacts of the emergent pathogen.

### Objectives and priority areas of work

#### 1. Understanding risks and refining epidemic and pandemic hotspot maps

Hotspot maps indicating where high-impact pathogens emerge, spread and persist were first published by Jones et al. (2008) and then updated (Allen et al. 2017) based on the commonly accepted drivers of disease emergence and spread. Higher definition hotspot maps at a national

and subregional level are now urgently needed to systematically target risk-based surveillance programs for early spillover events.

Building on the published 'hotspot' maps, ILRI will conduct a multi-sectoral study to identify and prioritize key drivers and risk factors at a subnational, national and regional level for spillover opportunities and the spread of new pathogens. Major activities will involve:

- Identifying environmental factors that present risks for pathogen spillover from wild animals to people and their livestock. This includes mapping extraction industries and deforestation and land use changes.
- Characterizing the agroecology, nature and diversity of farming systems evolving at wildlife, human and domestic animal interfaces.
- Determining predominant wild animal populations at the human and livestock interface.
- Understanding emerging complex animal food chains including markets linking forests, villages, towns and cities.
- Identifying critical emergence and spread points from emerging interfaces and along value chains, including characterizing water systems and shared watering points between humans, domestic livestock and wild animals.
- Determining the health and nutritional status of farmers with partners and their animals in relation to their susceptibility to new infections.
- Evaluating the impact of climate change on the emergence of new pathogens and expansion of existing vector-borne and other zoonotic diseases.
- Using data on land use change to identify high-risk areas for active surveillance.
- Developing ecological niche models which show areas where disease is likely to persist.
- Understanding the role of wildlife trade, farming and consumption and defining the social, economic and cultural drivers of this practice.
- Identifying other socio-economic factors and cultural practices that create risk environments for disease emergence, spread and persistence.
- Defining behaviour and practices that promote new pathogen spillover and spread, such as the sale and consumption of sick animals or their products.
- Collecting data at local level to validate existing hotspot maps.

These activities will be carried out in two phases and the initial phase will aim to provide a countrywide, coarse-resolution perspective followed by a focused county/district-level analysis to generate more

refined information on epidemic and pandemic risk hotspots. The One Health platform will develop risk models using large volumes of data generated from the above activities. These will include risks of emergence at wildlife; domestic animal and human interfaces; risk behaviours and practices; socio-economic factors including gender and poverty; and environmental factors such as deforestation, land use changes and climate data.

For identifying emerging risk interfaces, the role of human, animal and environmental sectors is critical and supported by a number of disciplinary groups such as veterinary medicine, animal husbandry, epidemiology, ecology, forestry, human health personnel and environmental expertise. External partners relevant to this work at a national level will be ministries of agriculture, livestock, environment and agroforestry, and the Center for International Forestry Research (CIFOR), the Food and Agriculture Organization of the United Nations (FAO), the United Nations Environment Programme (UNEP), the World Health Organization and the World Wildlife Fund (WWF) at an international level. For defining social, economic and cultural drivers, the policy, institutional and animal health sectors will be key players, with inputs from social scientists, economists and anthropologists.

## ***2. Developing early warning systems through risk-based longitudinal viral surveillance***

Most of the new epidemic and pandemic viruses in the last 20 years have been caused by RNA viruses. Their rapidly evolving genomes and diversity pose the greatest global pandemic threat (Morse 2001; Cleaveland et al. 2001; Pulliam 2008) as has been shown by the 1918 influenza pandemic, the HIV/AIDs pandemic, the H1N1 pandemic and the ongoing COVID-19 pandemic. While new pathogens spillover events occur frequently, not all spillover events result in disease. Since it is not possible to predict the rate of pathogen jumps from one system to another and which spillover event will become the next health emergency, it is necessary to detect and eliminate early spillover events as and when they occur before they have the opportunity to adapt, amplify, spread and cause significant harm to their new hosts (Karesh et al. 2012; Morse et al. 2012). This is the key to pre-empting or averting potential epidemics and pandemics. In order to achieve this, a risk-based, global viral surveillance network and early warning system need to be developed and put in place.

The current surveillance approaches rely on passive and/or syndromic surveillance systems that depend on formal and informal disease information derived

from a number of sources including the Global Early Warning System (FAO et al. 2006). While these surveillance systems are helpful in monitoring and tracking existing diseases and providing early warning of disease outbreaks, they are not adequate enough to detect early novel viral spillover events in humans and domestic animals in a timely manner to mitigate their impacts.

To supplement existing passive and syndromic global disease intelligence systems, ILRI and its partners will aim to develop a longitudinal, risk-based, viral surveillance design to demonstrate a proof of concept that spillover events can be detected early on in domestic animals and humans. The surveillance will aim to focus on longitudinal viral surveillance and will be risk-based, taking into account the risk factors and hotspots identified in Objective 1 above.

Designing such a system is not without its challenges. The sampling frame must consider a number of factors such as:

- Targeting the human and animal population to sample.
- Identifying types of biological samples to be taken from animals, humans and the environment.
- Establishing the number and frequency of sampling and types of metadata to be collected during the sampling procedure.
- Overcoming logistical challenges of collection and transportation of biological samples with stable cold chains.
- Identifying the types of diagnostic tools to be used and the development of standardized laboratory protocols.
- Training the workforce, including laboratory technicians and field workers, to conduct surveillance.
- Establishing large data storage systems and developing data sharing tools and multi-sectoral analytical approaches.
- Determining mechanisms and agreements on data sharing regionally and globally.

Samples will be tested for a number of viral families, the members of which are known to have caused previous epidemics and pandemics. These include the coronaviridae, filoviridae, flaviviridae, influenza and paramyxoviridae virus families (PREDICT Consortium 2014). The biological samples will be further evaluated for the presence of all pathogens that might be present using newer 'deep'

sequencing and metagenomics technologies enabling the detection of other new viruses beyond the priority families identified above.

ILRI will ensure that together with longitudinal viral surveillance, participatory disease surveillance and response systems will be set up on at risk farms and other interfaces with the support of trained community public and animal health workers to detect and respond quickly to any disease outbreaks and for further evaluation for new viruses.

A significant amount of metadata is expected to be generated through the surveillance program outlined above that will be further used for analysis and modelling for risk mitigation measures.

The key sectors and disciplines involved in this component will be the animal and public health sectors, epidemiologists, virologists, laboratory experts, molecular biology and genomics modelers, socio-economists, ecologists and anthropologists. ILRI will collaborate with external partners including the ministries of health and livestock, the Africa Centres for Disease Control and Prevention (Africa CDC), the Inter-African Bureau for Animal Resources (AU-IBAR), the Association of Southeast Asian Nations (ASEAN) and the South Asian Association of Regional Cooperation; international agencies such as WHO, FAO, and WOA; and other advanced research laboratories and projects involved in virus discovery in wildlife and genomics.

### **3. Developing molecular characterization and diagnostic tools**

ILRI will use the existing, low-cost, affordable polymerase chain reaction-based molecular diagnostic reagents and protocols that have been already developed and optimized for virus discovery in wildlife (PREDICT Consortium 2014), as well as develop new, rapid and cost-effective multiplex diagnostic tests to support the detection of these viral families.

ILRI will also build on its advanced research laboratory facilities to utilize newer next generation high-throughput deep sequencing technologies for characterizing baseline viral profiles of target livestock-human systems at the interface to enable the rapid detection of any new or unusual viral incursion in the system as and when it occurs (Tang and Chui 2010; Gardy and Loman 2018). Such an approach has been shown to provide high sensitivity with broad reactivity enabling the detection of both known and unknown viruses (Anthony et al. 2013). ILRI will support the storage of field samples through

the expansion of its well established biobank and will use its bioinformatics platform to support analysis of viral surveillance data.

ILRI will aim to establish partnerships with viral discovery projects (Carroll et al. 2018) that aim to identify all the zoonotic viruses present in the wildlife population. These strategic partnerships will enable ILRI to extend further its collaboration with a number of experts involved in active viral surveillance programs. Collaboration with such partners provides an opportunity to synchronize multi-sectoral viral surveillance in humans and domestic animals with virus discovery activities in wildlife at commonly agreed hotspot sites. This approach will bring significant advantages such as the comparison of viruses detected in wildlife with new viruses identified in domestic livestock and humans and an improved understanding of the ecology and epidemiology of virus infection and transmission dynamics. Sequences of newly identified viruses can be rapidly utilized to develop diagnostic tests for human and domestic animal viral surveillance projects, expanding the repertoire of viruses for early detection. ILRI will leverage its modern, state of the art laboratories, biobanks and genomics and bioinformatics facility to establish such partnerships.

#### **4. Developing platform vaccine technologies**

New vaccine platform technologies (see also Chapter 3, Developing generic vaccine platforms section) are increasingly showing promise for developing highly effective, safe vaccines against a range of viral diseases. These include well tested systems for invoking immunity against Ebola virus disease, RVF and Middle East respiratory syndrome (MERS) using a modified chimpanzee adenovirus. COVID-19 has stimulated research in accelerating platform technologies as shown by a surge in a large number of research groups and pharmaceutical companies racing to develop vaccines to halt the pandemic. The success of the messenger RNA-based vaccines to generate strong immunity against SARS-CoV-2 and a number of other viral-, DNA- and protein-based vaccines offers considerable promise for the development of generic vaccines against a range of priority viral families.

ILRI's current investment in vaccine development technologies will be broadened towards conducting research on a limited number of promising vaccine platforms, gearing up for the development of universal vaccines against a number of pathogen families, members of which cause disease in humans and animals.

This technology has application for both existing pathogens for which vaccines are not available and for emerging pathogens focusing on identified priority viral families. With ILRI's expertise in immunology and vaccine development, and particular experience in new platform technologies supported by extensive large and small animal facilities, ILRI will aim to develop experimental models for evaluating protective vaccine candidates for high impact zoonoses. Such models can be used to vaccinate animals against high-risk zoonoses, reducing the risk of transmission in humans. This work is envisaged in collaboration with many advanced vaccine research institutes and the private sector.

#### **5. Developing policies on risk mitigation measures**

The information derived from the active viral surveillance program, including the substantial amount of metadata generated and new data from research on characterizing risks for virus spillover and spread will be utilized and linked to surveillance used by ILRI's scientists and partners with expertise in bioinformatics, virology, ecology and social science to model risk of emergence, spread and persistence of new viruses. These data will be used to develop a socio-economic justification for a One Health approach to pandemic prevention and response.

The joint multi-sectoral assessment will form the basis for the development of an integrated decision support tool in the context of the response to be taken, including the monitoring and elimination of threats brought about by new spillover events in either livestock or humans or both. This analysis will support the development of policies for managing and mitigating spillover risks that might be created by various factors including new pathogens, environmental degradation, socio-economic conditions and cultural practices.

The ILRI One Health Research platform will ensure engagement with various ministries in the governments in the aforementioned regions at a national level, the regional economic communities, international agencies and development partners to provide cost-effective options for introducing risk mitigation strategies that not only look after the health and welfare interests of poor farming communities and their livestock, but also support international efforts to avert future epidemics and pandemics.

## Outputs

- Risk maps for epidemics and pandemics refined and enhanced for active surveillance.
- Multi-sectoral, targeted risk-based, longitudinal viral surveillance design developed as an early detection and warning system for spillover events in livestock and humans.
- Molecular detection tools and rapid identification of pathogens and their baselines in defined farming systems and markets developed.
- Socio-economic, cultural and ecological factors for disease emergence and spread risks defined.
- Multi-sectoral risk assessment and risk mitigation strategies developed for targeted interventions.
- Evidence-based policy guidance and decision support tools generated for the risk mitigation of emerging epidemics and pandemics globally.
- National capacity strengthened in viral surveillance, diagnostics and multi-sectoral risk assessment and intervention for epidemics and pandemics.

## Thematic area 2: Endemic zoonoses

The overall goal of this thematic area is to reduce the burden of endemic zoonoses that persist in human and animal systems and disproportionately cause high social and economic impacts on poor countries.

### Problems and challenges

Endemic zoonotic diseases are a group of diseases that have been well established in humans and domestic animals for centuries and persist in both hosts in their shared environments. They are found all over the world, but are mostly controlled in the developed world. The highest burden of endemic zoonoses is borne by LMICs, where they often cause chronic illnesses resulting in debilitation and in some cases stunting in humans. An estimated one billion resource-poor smallholder livestock farmers and pastoralists in Africa and Asia are disproportionately affected by endemic disease because of their close proximity to animals (Grace et al. 2012).

The incidence of endemic zoonoses is rising not so much because of farmers migrating but rather the growth of urban and peri-urban livestock keeping. Endemic zoonoses affect the health of animals causing diseases with various clinical symptoms including abortion, loss in productivity and death. It is estimated that these diseases cause around 2.5 billion chronic and debilitating illnesses and 2.7 million deaths per year in 148 LMICs. It is likely that this number is underestimated, as the true clinical burden and impact of endemic zoonoses in humans and their livestock has been difficult to estimate, mainly because the poor healthcare systems in many LMICs lack professional capacity and inadequate infrastructure prevents the accurate diagnosis of these diseases.

Endemic zoonoses are referred to as 'neglected zoonoses' because of poor investment by national and international development communities. There is, however, increasing recognition that greater investment in these neglected zoonoses is necessary to achieve the agreed SDGs, particularly towards reducing poverty, enhancing the livelihoods of poor livestock farming communities and the overall health and well-being of poor, marginalized families.

A range of pathogens are involved in endemic zoonoses that include parasites, protozoa, bacteria and viruses. The WHO (2006) has identified a priority list of endemic zoonoses that includes anthrax, brucellosis, bovine tuberculosis, leptospirosis, echinococcosis, cysticercosis, zoonotic trypanosomiasis, RVF and rabies. These are all prevalent in most LMICs except zoonotic trypanosomiasis which is restricted to sub-Saharan Africa. One Health reprioritizes zoonotic disease using a One Health prioritization tool developed by the Centers of Disease Control and Prevention (CDC 2017) and many of the priority diseases identified are consistent with the above list. These priority diseases are a little problematic as some have a tiny health burden and others have a very big health burden.

There are a number of challenges in addressing endemic zoonoses. These include:

- In most countries, zoonotic diseases are still managed differently and separately by the public and animal health sectors.
- The epidemiology of a number of important endemic zoonoses needs to be defined in the context of rapidly evolving livestock farming systems and their interaction with people and shared ecosystems. These include a better



understanding of infection and transmission dynamics, the role of changing ecosystems and the socio-economic and behavioural aspects of various stakeholders.

- The epidemiology of various vector-borne endemic zoonoses needs to be better understood in the context of climate change, deforestation and land use changes. Some of these factors may facilitate the spread of vectors of these diseases, while others such as deforestation and land use changes may decrease or eliminate the populations of fast-growing and reproducing disease carrying vectors.
- In many fast-growing LMICs economies, rapid growth in the livestock sector is expected to occur, including the intensification of certain livestock species such as poultry and pigs. The implications of these future trends in the context of spread, persistence and impact of endemic zoonoses need to be better understood.
- Different models for the prevention and control of endemic zoonoses that are production systems specific need to be evaluated. This may include those that are targeted solely at livestock systems or at humans and domestic animals using a multi-sectoral approach.
- Finally, in order to attract more investment in the prevention and control of endemic zoonoses, a true assessment of their social, economic and health impacts on LMICs needs to be completed and used as advocacy material for influencing investment options on health interventions at a national and international levels.

## Objectives and priority areas of work

### 1. *Evaluating the burden of endemic zoonoses*

In humans, the disability-adjusted life years burden borne by individuals affected by disease is the accepted standard for evaluating the burden of diseases. While in livestock, the principal measure is the loss of production and associated costs. In both systems, other factors such as the broader impact of chronic infections on the vulnerability of people and their livelihoods, food safety and nutrition security are usually not taken into account. This is further complicated by multiple infections with various zoonotic pathogens, other co-factors in humans and chronic non-zoonotic infections in livestock. There are also a number of socio-economic, gender, behavioural and cultural aspects that define the burden of endemic zoonotic diseases. It is important to identify these factors. The role of gender

and certain practices of handling, treating and slaughtering animals may have a significant impact on the exposure and burden of zoonotic disease.

Environmental factors, including land use changes, climate change and flooding also have an important role in the risk and incidence of various types of endemic zoonoses, including vector-borne diseases such as RVF and Q fever. Different farming systems keep different livestock species and the distribution of zoonoses is likely to be according to the farming systems.

ILRI's One Health Research platform will aim to develop metrics that include these variables in order to determine the impacts and burden of endemic zoonoses on target livestock production systems in selected countries in Africa and Asia. The key systems targeted will be the smallholder mixed crop-livestock, medium-sized commercial dairy, poultry and pig systems and pastoralist systems. The outputs of these studies will serve to generate evidence-based advocacy material for policymakers and international development partners to increase investment into the control and prevention of endemic zoonoses.

### 2. *Understanding epidemiology and the risk of endemic zoonoses*

Pilot studies will be conducted in the context of evolving livestock production systems and their associated value chains, markets and social networks. The social, economic and cultural factors that contribute to their persistence and spread will be evaluated. These studies will generate a large volume of data that will form the basis for further analysis to determine the risks of endemic zoonoses in humans and their animals.

The key production systems that will be targeted are smallholder mixed crop-livestock (dairy, pig and poultry), pastoralists and urban and peri-urban livestock production by landless farmers.

In countries where substantial investment in national livestock development plans is envisaged, the potential risk of emergence and spread of endemic zoonoses in new production systems will be assessed.

The risk assessment will inform targeted surveillance programs as well as the development of rational disease prevention and control interventions (see 3. Conducting risk-based surveillance below), which are systems specific and appropriate for the level of risk assessed.

### 3. *Conducting risk-based surveillance*

The ILRI One Health Research platform will design and support multi-sectoral surveillance programs for each of the priority endemic zoonoses. Whenever possible, these surveillance programs will be linked to existing national surveillance systems. Both active (serological and pathogen surveillance) and passive/syndromic surveillance will be included in humans and their livestock. The surveillance data and associated metadata generated will be shared and analysed jointly between sectors. The key systems targeted will be the same as those in risk assessment objectives. The analysis will provide information on the prevalence of priority endemic zoonoses in humans and their livestock and for further refinement of the risks of these diseases.

The platform will support and encourage national governments to report any epidemics that might be detected through the surveillance systems to the relevant international agencies in a timely manner. This will help to raise awareness of the importance of endemic zoonoses at a national and international level.

### 4. *Developing new diagnostic tools*

To underpin the surveillance objective, ILRI's One Health Research platform will support the strengthening of veterinary and public health diagnostic laboratories in order to maintain quality control and assurance and support these laboratories in proficiency testing exercises conducted by international agencies. Wherever possible, existing diagnostic tests that are validated and internationally approved will be used. Given the significant gaps in availability of diagnostic tests for several priority endemic zoonoses, the One Health platform at ILRI, will embark on the development of new, user-friendly, quality-controlled tests and standardized diagnostic protocols. These will include tests for a number of priority zoonotic diseases identified by various countries in Africa and Asia.

### 5. *Developing options for the prevention and control of priority endemic zoonoses*

Based on the understanding of the epidemiology, risk factors, surveillance data and information on the burden of endemic zoonoses on people and

their livestock, the One Health platform will aim to develop different cost-effective options for the prevention and control of endemic zoonoses. These options may include livestock-specific control programs that improve the health and productivity of the targeted livestock systems and contribute indirectly to the reduction of zoonotic disease transmission in humans. These may include joint multi-sectoral approaches to endemic zoonosis control requiring specific interventions in the public, animal and environmental sectors contributing to the overall reduction of the burden of zoonotic diseases in both humans and their animals.

Integrating these control programs with ongoing farm-level animal health services such as the control of endemic gastrointestinal parasitosis, routine vaccination against other non-zoonotic animal diseases such as foot and mouth disease or peste des petits ruminants will also be considered. Such approaches show a higher buy-in from farmers, as well as an efficiency and cost effectiveness of interventions (Welburn et al. 2015).

Other options such as supporting good farm management practices and improving farm-level biosecurity in poor farming communities linked with national endemic zoonoses prevention and control programs have seen success in many countries. Targeting disease control efforts in poor farming communities by addressing their actual disease as well as the problems affecting their livelihoods contributes to equity in overall health support and to national and global efforts to address other high-impact zoonotic infections in humans (Cleveland et al. 2017).

ILRI One Health Research will support pilot, best-bet endemic zoonoses disease control programs and will use evidence from these studies to generate policy and communication material for greater investment.

The key sectors involved in the above studies will be animal, human and environment. In addition to sectoral expertise, socio-economists, anthropologists and gender experts will participate in the study design, implementation and analysis.

## Outputs

- Priority zoonotic pathogens identified (systems and regions) and associated risks defined for people and animals in target systems.
- Epidemiology of priority endemic zoonoses defined and their infection and transmission dynamics better understood in the context of evolving farming systems and along their food chain.
- Socio-economic, gender, behavioural and environment factors contributing to the epidemiology better understood.
- Policy guidelines for risk mitigation developed and an appreciation of the importance of endemic zoonoses among policy and decision makers improved.
- Options for multi-sectoral disease prevention and control interventions developed and supported at a national level.
- National capacities in risk assessment, control and prevention of endemic zoonoses strengthened.

## Thematic area 3: Foodborne diseases

The overall goal of this thematic area is to reduce the burden of foodborne diseases by at-source prevention and control in domestic livestock at a farm level and reduce the contamination of animal-derived food products along the livestock value chain which includes farm inputs, consumer and waste disposal.

### Problem and challenges

Food-related illnesses derived from different types of foods such as vegetables, fish, meat, milk and eggs are common worldwide and are caused by various pathogens and chemical substances. Depending on the source of infection or contamination, clinical signs can vary from diarrhoea to chronic disease resulting in malnutrition, disability and death. The highest burden of unsafe food is borne by Africa and Asia, particularly by young and elderly people in poor communities (Havelaar 2015), undermining global efforts to improve food and nutrition security, alleviate poverty and enhance socio-economic conditions of people in LMICs.

Livestock products harbour a number of pathogens due to their high susceptibility to contamination with a variety of pathogens, accounting for 35% of all foodborne illnesses accounting for a significant amount of all foodborne diseases.

A number of other endemic zoonoses in domestic livestock such as brucellosis and tuberculosis (*Toxoplasmosis*) are transmitted to humans and are a major cause of foodborne infections and chronic illnesses in poor livestock communities. The consumption of infected or contaminated livestock products such as milk, milk products, meat offal and eggs are the major sources of illness. Like the neglected endemic zoonoses, foodborne diseases are predominantly linked to poverty, unhygienic practices and a lack of adequate infrastructure. One of the main sources of risk foods is fresh food originating in the informal sector and produced by smallholders (Grace 2015). However, unlike the endemic zoonoses, the burden appears to increase as LMICs develop and urbanize before decreasing as they enter high income status”.

Traditionally, foodborne diseases have received little policy attention or investment in LMICs, as donor focus has been on single, high-priority diseases such as malaria, tuberculosis and HIV (Grace 2015; Global Food Safety Partnership 2019). These have resulted in a number of challenges that need addressing in order to alleviate the problem of foodborne diseases. These include:

- Priority pathogens responsible for foodborne diseases need to be identified for many countries and their risks defined for a variety of evolving livestock value chains.
- Poorly developed infrastructure for safe food along the farm-to-fork animal food chain.
- Food safety standards and related regulatory mechanisms are inadequate for the diversity of farming systems that co-exist in many LMICs and the extensive, complicated food chains associated with these.
- The training of various stakeholders from farmers, transporters and wholesalers to retail market vendors, food handlers and processors is non-existent or out of date in most countries.
- The epidemiology of foodborne pathogens in various production sectors and along their value chains is not fully understood.
- The role and importance of the rapid growth of the informal sector in foodborne diseases need to be better understood.
- Wild meat food chains arising from wildlife hunting, peri-urban and urban farming and

growth in wild meat consumption need to be characterized and their role in food safety needs to be evaluated.

- A number of simple and practical intervention tools for both formal and informal livestock food chains are available, but they have not been packaged and customized to fit specific systems that exist in different countries.
- Most countries do not include foodborne diseases as part of their national goals towards food and nutrition security, as the burden of foodborne diseases and their impacts have not been fully assessed in many LMICs.
- Widespread misperceptions about the most risky foods and hazards.

It is believed that the significant burden of foodborne diseases can be reduced through simple and practical interventions along formal and informal food chains, underpinned by health policies and the application of an integrated, transdisciplinary farm-to-fork approach with the engagement of relevant public, animal and environmental health sectors (HLPE 2016). It is also essential to ensure that incentives are in place to motivate value chain actors to change their behaviour.

## Objectives and priority areas of work

### 1. *Assessing the health and economic burden of foodborne diseases*

Given the plethora of hazards involved in animal-derived food illnesses, it is important to identify major hazards and determine their relative risks to food safety in different countries and regions and in the predominant farming systems that are impacted. The target countries for this work will all be in Africa and Asia. Linked to this objective will be a number of activities that include the following:

- Mapping complex livestock value chains.
- Assessing infrastructure status in markets, slaughterhouses and food processing sites.
- Assessing biosecurity practices and food safety processes of food handlers, processors and consumers.
- Conducting qualitative and quantitative risk assessment of food hazards.
- Identifying and prioritizing key hazards in different farming systems and along farm-to-fork value chains.
- Determining consumption patterns.
- Reviewing food safety policies, regulations and standards.
- Understanding the linkages between gender and food safety along the food chain.

- Conducting socio-economic impact assessments of foodborne diseases and better defining the cost of foodborne diseases and their impacts on food, nutrition and health security.
- Identifying critical control points for mitigating foodborne hazards.

The main production sectors targeted will be smallholder livestock keepers, intensive and semi-intensive poultry and pig production systems and pastoralists, and urban and peri-urban production systems. We will cover all actors from farmer to consumer.

Various research approaches will be used that will include literature reviews for mapping farming systems and food safety policies, political science methods and gender analysis, pathogen surveillance using a range of existing diagnostics and the newer whole genome sequencing technology and economic analysis to define the burden of foodborne diseases. Various other approaches such as key informant interviews, focus group meetings, stakeholder workshops and knowledge, attitude and practices (KAP) surveys will be deployed to evaluate behaviour and cultural practices. Existing risk assessment protocols, modified as necessary depending on the target value chains, will be used to generate evidence for policy advice and intervention to manage foodborne diseases.

### 2. *Understanding the role of wild meat in foodborne diseases*

Although wildlife is being increasingly hunted, farmed and sold in formal and informal markets in Asia and Africa for consumption, data on foodborne diseases associated with wildlife in Africa and Asia are limited. Observations show that the demand for wild meat consumption is driven by socio-economic situations in different parts of the world. In parts of Africa and Asia, poor people hunt wild animals as a source of cheap meat and in certain parts of southeast and east Asia it is considered a luxury food, consumed by rich people who believe that there are additional health benefits from eating certain types of game meat. Wild meat is known to be a source of bacterial, viral and parasitic infection. One of the major concerns of wild meat value chains is the pathogen spillover of emerging and re-emerging high impact diseases such as anthrax, HIV, Ebola, Nipah, HPAI and coronaviruses (Hahn et al. 2000; Kock et al. 2019; Pulliam et al. 2008; Huong et al. 2020; Knobler et al. 2004). Non-human primates, bats and rats (Johnson et al. 2015) are considered a major source of these high-impact pathogens. The following activities will be conducted under this objective:

- Mapping emerging international, regional and national value chains, including markets associated with the trade and farming of wild game.
- Identifying consumption patterns and their socio-economic and cultural drivers.
- Reviewing food hygiene regulations related to game meat.
- Conducting pathogen surveillance of game meat from farms and markets.
- Literature review of wildmeat value chains, risks and risk mitigation.

The research methodologies applied will be similar to those used for the Objective 1. The data generated will be utilized for the risk assessment of emerging zoonoses from wild animals. This will form the basis of risk assessment and risk mitigation measures as well as policy guidance.

### **3. Developing risk mitigation strategies**

Most foodborne hazards in livestock products are derived from the animal host or result from contamination along the farm-to-fork pathway. Simple measures such as a basic infrastructure for cleanliness in markets, slaughterhouses and meat processing plants, good hygienic practices and thorough cooking of animal-derived foods by consumers can eliminate these problems.

However, there is evidence that the incidence of foodborne illnesses is increasing in LMICs (Grace 2015). One of the main reasons for this is the complexification and predominance of informal food value chains, which supply 85–95% of fresh food needs in sub-Saharan Africa. Poorly regulated slaughterhouses and the processing and retail practises associated with them can result in the extensive microbial contamination of products, which may not be sufficiently mitigated by consumer food preparation practises (Jaffee et al. 2019). Targeted interventions, based on risk assessments in this sector, are now considered to be highly strategic in reducing the burden of foodborne diseases in LMICs (Grace 2015).

Based on the understanding of priority hazards and risk assessments in various food value chains, the One Health platform will develop ‘fit-for-purpose’ strategies and conduct pilot studies that will evaluate the best options for interventions. These may include recommendations that may be different for each of the two main sectors, the formal and the informal sectors and for different value chains. For the formal sector, policy guidelines, regulatory

frameworks, infrastructure development and the enforcement of relevant legislation to maintain food standards will be the main focus. For the informal sector, increasing consumer demand for food safety by improving basic infrastructure, ensuring incentives are in place to motivate behaviour change, training of meat handlers and raising awareness of the options for improving food standards are likely to be more successful. In this sector, as well as among consumers, behaviour change will be through a ‘nudge’ approach. This seeks to modify the social and physical environment to enhance capacity for subconscious behaviours that align with the intrinsic values of an individual, without actively restricting options. For example, models specific to each sector with appropriate incentives will be developed and tested as pilots in different countries. Appropriate communication material will be included in these evaluations to reach out to various players along the food chain.

### **4. Piloting and evaluating best-bet interventions**

In order to evaluate the risk mitigation strategies in the formal and informal sectors, ILRI One Health Research will conduct pilot studies in various countries in east Africa and south and southeast Asia. The pilot studies will evaluate between 10 and 20 incentive models in both sectors.

We will focus on bulking points that include wholesale markets, abattoirs, and milk collection points as well as on ‘choke points’ such as traditional markets where produce from a large number of producers is sold by a small number of people to a large number of consumers.

### **5. Towards impact at scale**

The characteristics of food value chains in LMICs, in particular bulking points and choke points, mean that even research projects can attain impact at some scale. For example, we have worked for several years with the only officially approved pig slaughterhouse in Kampala, which by default reaches many pork consumers. Impact assessments have shown more than around 6.5 million consumers in Kenya and Assam, India benefited from safer milk as the result of ILRI projects, that focused on training much smaller numbers of milk vendors. However, ensuring sustainability and scaling horizontally to outside the project site has been challenging. We will research approaches to overcome this including partnering with development banks, focusing on low-cost interventions, building consumer demand for interventions and working with policy and decision makers.



### 6. *Supporting food safety governance*

The One Health platform at ILRI will encourage respective governments to make foodborne diseases an important component of public health priorities. In this regard, ILRI will support governments to develop national strategies for the control and prevention of foodborne diseases relevant to their country, focusing on both the formal and informal food systems. ILRI will continue to engage and partner with the WOA, WHO, FAO, World Trade Organization (WTO), World Bank and African Union to provide evidence that can support food safety.

Risk mitigation measures will be underpinned by appropriate regulations and policies as part of wider food and nutritional security programs and guidance on implementation that is not driven by a 'command and control' enforcement and policing approach, but rather by creating an enabling and facilitative environment (Grace et al. 2019; Roesel and Grace 2014) leading to the alleviation of the burden of zoonotic foodborne infections. ILRI will advocate for the integration of food safety policies as part of the national health security agenda, ensuring that national policies are mainstreamed in line with International Health Regulations (IHR) (WHO 2008).

### Outputs

- Scientific assessment of system-specific priority pathogens and their role and risks in foodborne diseases completed in selected countries in Africa and Asia.
- Health and socio-economic burden of foodborne diseases assessed in target countries.
- Evidence for priority areas for intervention in both the formal and informal sectors generated and policy guidance developed for mitigating the risk of foodborne diseases in these systems.
- Preliminary assessment of the risks and impact of wild meat farming, trade and consumption on food safety completed.
- Pilot studies to determine 'best-bet' strategies to improve food safety in the formal and informal sectors through targeted interventions completed.
- Behaviour change material generated to target both the formal and informal sectors as well as consumers to improve food safety.
- Support to partners to develop scalable and sustainable solutions to improve food safety.
- Provide evidence to national governments, and regional and international government organizations to promote food safety.

## Thematic area 4: Antimicrobial Resistance

The overall goal of this thematic area is to halt the continuing rise and spread of antimicrobial resistant zoonotic bacteria, contributing to the rational use and stewardship of antimicrobials in the livestock sector and thereby decreasing the negative impacts of AMR in humans, animals and the environment.

### Problem and challenges

Antimicrobials are commonly used to treat infections in people, domestic animals, fish and orchards caused by pathogens and other microorganisms. The clinical use of antimicrobials over several decades of modern medicine has led to many pathogens having acquired resistance to a range of antimicrobial drugs, rendering them therapeutically ineffective. The large-scale, indiscriminate and irrational use of antimicrobials is a major driver in the emergence and spread of AMR.

Antimicrobial resistance is considered a 'silent pandemic' and ranks as one of the major global health challenges facing both the developed and developing world this century (O'Neill 2016). The increasing resistance to last-resort antimicrobials and few new classes of antimicrobials on the horizon has ignited fears of a post-antibiotic era.

More than 700,000 people die each year due to an antimicrobial resistant infection, including multi-drug resistant tuberculosis. It is estimated that if the AMR situation is not alleviated by 2050 there could be as many as 20 million people worldwide dying every year of common bacterial infections and the global economic cost could be as high as USD100 trillion (O'Neill 2016). The agriculture sector (livestock, fisheries and crops) will become more vulnerable to disease and could force 24 million people into extreme poverty (UN IACG 2019). It is believed that the AMR crisis is a major threat to health, food and global security and if containment investments are not made immediately, it will hamper the achievement of the SDGs (UN 2015).

The AMR health problem is now recognized to be of such magnitude that the heads of state at the UN General Assembly agreed to make a political commitment to a coordinated approach to address the root causes of AMR across human and animal health sectors and agriculture. This is the fourth time a health issue has been elevated by the UN General Assembly; the others being HIV/AIDs, non-communicable diseases and Ebola (WHO 2015).

This level of commitment now provides an important basis for an international effort to halt the global spread of AMR.

Some of the major challenges in tackling AMR are as follows:

- Intensified production systems, particularly livestock and aquaculture, under poor animal husbandry conditions provides a conducive environment for growth and rapid amplification and spread of disease-causing pathogens.
- There is an exponential growth in the use of antimicrobials in the agricultural (crops, livestock and fisheries) sector as intensified production systems continue to expand globally in response to a growing demand for food.
- In the livestock and aquaculture sectors, the large scale use of antibiotics as growth promoters is common to enhance productivity.
- Data on the types and quantities of antibiotics used and stratified according to different farming systems are not available in most LMICs.
- There is limited evidence on the levels of AMR prevalence in the livestock/agriculture sectors in LMICs.
- The level of antibiotic residues and antimicrobial resistant hazards discharged in the environment through farm waste and along food systems have not been globally evaluated.
- Rapid diagnostics tests for evaluating the presence of AMR in animals and the environment are limited in their specificity and sensitivity.
- The rate of development of new antibiotics or cost-effective alternative chemotherapeutics for the agricultural sector is too slow to fill the major gaps in the availability of efficacious drugs to treat many common infections.
- There is increasing pressure on the livestock and fisheries sectors to reduce the use of antibiotics. At the same time, there are concerns that a reduction in their use will lower livestock production significantly, decreasing the global value of meat by as much as USD14–44 billion (Laxminarayan et al. 2015) and negatively impacting global food security.

Most UN member states have committed to develop national action plans for AMR based on the commonly agreed Global Action Plan on AMR (WHO 2015) and donors have supported a globally coordinated One Health approach to addressing AMR. This presents an opportunity for the ILRI One Health Research platform to play a leading role in contributing to these efforts. ILRI hosts the CGIAR AMR Hub that addresses the role of agriculture in

AMR and looks at how research in this sector as a whole can contribute to curbing AMR worldwide.

This is an appropriate platform for ILRI to support research in the use of antimicrobials in livestock and provide science-based policy guidance for the responsible use of antimicrobials in livestock while ensuring sustainable livestock development in target livestock production sectors in LMICs.

## **Objectives and priority areas of work**

### **1. *Understanding the drivers of AMR in livestock systems***

There is little or no information on the usage of antimicrobials in different animal-derived food systems in large parts of sub-Saharan Africa and Asia. To characterize how antimicrobials are used in these systems, define the extent of AMR and design studies to generate science-based policy advice and recommendations for curbing AMR in the livestock sector, key information is urgently needed. This includes the following:

- Types and relative quantity of antibiotics used in different farming systems.
- The purpose of their use (e.g. treatment of infection, prevention of infection, growth promoter) and method of administration (e.g. injectable, oral, feed, water).
- The source of antimicrobials and their supply chain from manufacturers, formulators, wholesale suppliers and other players involved in a formal and informal network of distribution to veterinarians, extension workers and farmers.
- The prevalence of AMR present in humans, their livestock and in the farming environment, such as farm waste and sewage systems.
- The burden of AMR on livestock and livestock communities.
- Policies and regulatory mechanisms for controlling the use of antibiotics.
- The level of intrinsic resistance in various species of bacteria and to different classes of antimicrobials in human and livestock systems.

Several studies will be designed to generate this information in selected countries in eastern and southern Africa and in south and southeast Asia. The main livestock production systems targeted will vary according to regions and countries. In Africa, the predominant systems for study will be smallholder dairy, small- to medium-sized commercial pig and poultry production, large-scale intensified pig

and poultry production and pastoralists. The main systems in south Asia will be smallholder dairy and intensified poultry production. In southeast Asia, the predominant target systems will be medium- to large-scale commercial pig and poultry enterprises.

Various investigative tools will be utilized including desk studies, key informant interviews, focus group meetings, stakeholder workshops and KAP surveys. The studies envisaged will require close collaboration with the public and animal health sectors and engagement with a range of players from the private sector, particularly livestock producers, feed producers, and manufacturers and suppliers of pharmaceutical products.

### ***Determining the prevalence and transmission dynamics of AMR***

The prevalence of AMR and its distribution in different farming systems is likely to be uneven and determined by the types, amount and frequency of antimicrobial usage. In order to determine the prevalence of AMR in different farming systems as well as the closely associated human population, a structured surveillance program will be developed based on expert knowledge and the data being generated from studies conducted under Objective 1 above.

Surveillance protocols will be designed to conduct cross-sectional bacterial surveillance in different livestock species from the different production systems as outlined in Objective 1. This will include people closely associated with livestock and the environment (water, farm waste) to determine the range of bacteria and level of AMR present in different systems.

Various detection techniques and methodologies will be used, including the isolation of bacteria by culture from animals, humans and the environment, serological testing of blood samples from livestock species and humans for antibodies to specific bacterial species and multiplex molecular detection approaches to identify a range of bacterial species present in blood, oropharyngeal and faecal samples.

In addition, new generation deep sequencing technology will be used on biological samples from animals, people and the environment to enable the characterization of the baseline microbiome and resistome of the target system and as the basis for identifying the emergence of any AMR bacteria

as and when they occur. Bacterial isolates will undergo molecular characterization to determine the mechanism of resistance. Key bacterial isolates of interest will be stored in ILRI biobanks for future reference and research.

The work on Objectives 1 and 2 will be conducted simultaneously in the same systems and with harmonized protocols to enable the comparison of results between different systems, livestock species and humans.

## **2. Mapping AMR hotspots**

Identifying risk factors will be the basis for identifying AMR hotspots in target countries. Various parameters will be used for the risk of AMR emergence and spread and will include the types of farming systems, the type, quantity and quality of antimicrobial usage, the antimicrobial value chain, the behaviour of key stakeholders around the use of antimicrobials and the information on the prevalence of AMR derived from existing data and the results of cross-sectional surveillance studies. Based on this analysis, major geographical and farming systems-specific hotspots will be identified for further studies on developing best-bet approaches to reduce AMR.

## **3. Developing policies and incentives for responsible stewardship of antimicrobials**

While there are a number of generic recommendations for rational and responsible use of antimicrobials in both the human and livestock systems, it is necessary to package these in the context of the types of systems being targeted, the socio-economic background of the farmers and their communities, established behaviour and practices and the kinds of trade-offs and their impacts on development goals.

A series of pilot studies will be conducted to test different packages of interventions for reducing AMR. These packages will be farming systems-specific and may differ significantly between the smallholder and large-scale production enterprises, and for pastoralists. These packages will be underpinned by incentives to make changes to established practices and behaviour. They will be gender sensitive, will include alternatives or supplements to antimicrobials for managing bacterial infections.

Based on the results of these studies, best-bet 'health packages' will be identified for each of the target systems to support the reduced and correct use of available antibiotics.

Integrated into this research, a capacity development component will be included for national staff and appropriate communication material will be generated to raise awareness of the dangers of AMR and promote responsible stewardship of antimicrobials among the major stakeholders from manufactures, suppliers, animal and human health professionals, and paraprofessionals and farmers. The evidence generated from these studies will be utilized to formulate policy recommendations to national governments for inclusion in their domestic AMR action plans.

## **Outputs**

- The usage of antibiotics in different farming systems in selected LMIC countries in sub-Saharan Africa and Asia characterized and major drivers of AMR determined.
- The range of bacteria present in different farming systems and the prevalence and level of AMR these populations determined, including the levels of antibiotic residues in livestock waste and the associated environment.
- The burden of AMR on livestock and livestock communities and their socio-economic impacts determined.
- Geographical and livestock farming systems-specific AMR hotspot maps developed for targeted intervention and monitoring.
- Different types of intervention packages developed, tested and supported by decision support tools.
- Support for the development of National AMR action plans provided.
- Communication material for various stakeholders developed to promote the prudent and rational use of antimicrobials in the livestock sector.
- Evidence generated to provide support for policy formulations to decision makers at a national level and for inclusion in national AMR action plans.

## PILLAR 2: POLICY

The overall goal of this pillar is to conduct and disseminate research on factors that either promote or constrain the use of the One Health approach at various levels, from household to community and country to international. It will convert evidence from research into policy recommendations for advocacy, adoption and diffusion among national governments, development partners, the private sector and other relevant actors to operationalize the intersectoral and transdisciplinary One Health approach as an essential basis for the prevention and control of neglected and emerging zoonoses, foodborne diseases and AMR.

### Problems and challenges

Existing policies for the control and prevention of zoonotic diseases, foodborne diseases and AMR in most LMICs are sector specific, addressing these diseases separately either through the public health or animal health sectors. Policies to address the multifactorial origin of zoonotic diseases require benefit from One Health policies. Such policies need to consider integrated and harmonized approaches among key sectors as well as take into account a number of interconnected and complex issues of disease ecology and their multiple drivers. They must consider evolving livestock food systems, technologies, ecological environment, politics, culture and socio-economics. The transboundary nature of these diseases and their impacts need policies that consider the regional and global context of the cross-border spread of diseases, information sharing mechanisms, the movement of people and their livestock, regional and international wildlife trade and biosecurity. These require negotiations and political agreements with regional economic organizations (REOs) as well as the relevant international agencies such as WHO, WOA, FAO and UNEP.

Despite a heightened awareness of the importance of One Health concepts since the emergence of SARS and HPAI in 2002–03, its uptake at a policy level has been patchy and uneven. To accelerate progress towards a greater national adoption of One Health concepts, WHO and WOA have developed policy to strengthen multi-sectoral health capacities in all member states through the implementation of IHR and Performance of Veterinary Services (PVS), respectively (WHO 2008; OIE 2013). More recently, IHR and PVS tools have been harmonized to strengthen the One Health dimension (WHO et al. 2014), although the environment sector is inadequately represented. UNEP and ILRI (2020) have raised the environmental policy dimension in their report to address pandemics and zoonoses by disrupting the transmission cycle of zoonotic pathogens.

More recently, a guide to implement a multisectoral, One Health approach at a country level was developed and circulated widely by the UN agencies (WHO, FAO and OIE 2019) to its member countries. This provides detailed, step-by-step operational guidelines to implement the One Health approach to address zoonotic diseases, AMR and other food safety issues at the human, animal and environmental interface. This is an important step in the direction of countries to develop their One Health policies, but these require further advocacy and research evidence to inform policymakers and politicians to invest in One Health policy reviews.

A number of factors have been identified that hinder sound policy development processes towards the successful adoption of a domestic One Health approach. These include political, financial, institutional, technical, social and cultural factors. Key among these are those outlined below:

- National governments in most LMICs have limited capacities and inadequate mechanisms and processes to develop and implement policies that can effectively address complex zoonotic disease prevention and control issues.



- A clear One Health conceptual framework that guides research priorities consistent with broad national policy objectives and includes consultation and collaboration with key sectoral actors does not exist (Coker et al. 2011).
- The One Health approach has an additional cost, to which the governments are unwilling to allocate extra budgets to already inadequately funded health sectors and against many other competing national priorities. Evidence to show the added value of One Health in increasing the efficiency of zoonotic disease control and prevention and that it is cost beneficial, requires more data, analysis and modelling.
- The traditional sectoral approach has resulted in a dearth of data at the country level on the multi-dimensional drivers of zoonoses and AMR, information on priority pathogens, their socio-economic burdens and the relative importance of different sectors in disease management.
- Knowledge and innovative tools to convince various stakeholders such as policymakers, private investors and civil society to invest in early detection, response and prevention are inadequate.
- Many of the existing national policies on zoonotic disease control in livestock food systems target formal food systems. However, in LMICs, many of these policies do not address the informal food systems that have grown rapidly. For example, it is estimated that the informal sector supplies 85–95% of food needs in sub-Saharan Africa. There is a need for more knowledge and information regarding this sector and a better understanding of the socio-economic and cultural practices that influence the increased risk of foodborne diseases.
- In countries with poor health capacities, participatory approaches and extension services play a potentially role in managing health risks. One Health policy that enables community engagement, training and support for community public/animal health workers with local knowledge of social, cultural and economic situations at a village level to address this important sector needs to be explored. Such a One Health policy, promoting joint public/animal health sector participation in early detection, reporting and enhanced biosecurity measures at a farm level has played an important role in significantly reducing the incidence of zoonotic avian influenza in poultry and humans in several countries in southeast Asia.
- There are a number of generic and cross-cutting risk mitigation measures available at a national and subnational level that not only address sector-specific health issues but address the broader cross-sectoral interests in alleviating the risk of zoonoses and AMR. Evidence for such an integrated One Health approach would support appropriate cross-sectoral prevention and control policies.
- Countries lack clear One Health guidelines on the roles and responsibilities of different sectors at a national and regional level.
- The transboundary nature of zoonoses necessitates a greater involvement of REOs in policy to help as many regions liberalize trade and movement of people. One Health regional policies on the cross-border and regional management of zoonoses and AMR such as surveillance, laboratory and epidemiology networks, biosecurity along food chains, information sharing and mechanisms for regional prevention and response collaboration are not developed in the majority of LMICs.
- A key challenge in LMICs is that even when sound policies and regulations are in place, they are often not implemented. Barriers to policy implementation are likely more important than barriers to formulation.

## Priority areas of work

### 1. *Developing a case for One Health investment*

In order to develop a case for One Health, policymakers and investors, need amongst other things, evidence of the value of this revalively new approach. This added value can be reflected in economic gains, animal welfare, social and gender equity and technical efficiency for all actors involved.

ILRI One Health Research will develop a framework and metrics for evaluating the overall benefits and value addition of the One Health approach using existing data and producing new data on various aspects, at various levels and for different actors, including for women and men separately. These will include:

- Understanding the diversity of systems and complex value chains, and different sectors and players involved.
- Determining the relative role of various sectors in medium- to long-term disease prevention and control.
- Characterizing constraints and success stories for the adoption of One Health.
- Demonstrating risks of zoonoses and AMR to all the key sectors and broader social and economic vulnerability of the society as a whole.
- Defining the national, regional and global

impacts of pandemics, endemics and foodborne diseases and AMR.

- Identifying current national and regional level investment in public, animal and environmental health sectors to address zoonoses and AMR.
- Mapping current single sector-based and One Health-oriented projects on the prevention and control of zoonoses and AMR.
- Analysing benefits and costs of these approaches and models developed to provide evidence of the added value of One Health to influence government policy into additional investment.
- Identifying trade-offs, winners and losers when applying a One Health approach.
- Better understanding the policy to implementation gap and how this can be overcome.

New and additional data generated from research in other components of the strategy will support this activity. Methodologies will involve literature searches, workshops, experiments, interviews and various survey tools. The research will ensure a multi-sectoral, multi-disciplinary planning and implementation process. The key disciplinary groups will be economists, policy experts and modellers, gender analysts, public and animal health professionals, and agriculture, environment and climate change experts. Support from other disciplinary groups will be sought as and when appropriate.

It is expected that by developing matrices and providing quantitative as well as qualitative evidence of the risks of different types of zoonoses and AMR that demonstrate the benefits of the One Health approach, it would be possible to incentivize governments and investors to inject more resources in One Health policies at different levels.

## **2. Incorporating One Health policies in national livestock development plans**

ILRI supports a number of rapidly-growing economies in several LMICs to develop their livestock master plans in response to surging demand for animal-derived food, realizing the potential of the sector to improve people's livelihoods through increased income, employment and as a pathway towards gender equality. These plans are developed through a comprehensive analysis of the existing livestock sector and future trends in demand, the evolution of farming systems and their impacts. This analysis provides necessary evidence for the development of national strategies and action plans to ensure the creation

of appropriate infrastructure and strengthening of human resources. These strategies form the basis for future investment in the sector from governments, the private sector and donor communities.

Under different scenarios of livestock growth, it is expected that a diversity of livestock production systems will evolve and co-exist in most countries, including the rapid emergence of intensified systems that generate additional zoonotic disease risks. The One Health platform will consider the inclusion of studies on how new risks of diseases emerge in response to evolving livestock sectors and the importance of investment in incorporating appropriate One Health prevention and risk mitigation measures, including biosafety and biosecurity issues, in livestock sector investment plans.

## **3. Developing policies to support the growing informal sector in the livestock food chain**

A number of endemic and foodborne diseases are preventable through existing treatments, vaccination and simple sanitary measures in livestock food systems. Despite this, zoonoses continue to be a major problem in poor communities and other vulnerable, socially and economically disadvantaged groups of people. One of the main factors is that the disease control policies are often targeted at people and their animals in urban areas where public and animal health services are easily accessible. The vast majority of people in LMICs live in rural environments or peri-urban regions where informal food systems are growing and the risks of zoonotic disease are increasing.

A One Health policy that supports the improved prevention and control measures in this stratum of the population in LMICs can significantly reduce disease risks. ILRI will conduct studies that link with research that will be carried out through other components of this strategy, particularly on endemic and foodborne diseases.

The key areas of research will include:

- Reviewing existing policies on control and prevention of endemic and foodborne zoonotic diseases in target LMICs.
- Identifying constraints in implementing existing policies on zoonoses and AMR in the formal sector.
- Assessing the informal food systems originating from different farming systems.
- Evaluating disease prevalence and risks along these systems and identifying critical control points for interventions.

- Determining system-specific, integrated control and prevention packages along the critical control points of livestock food systems and evaluating these packages through pilot studies.
- Developing One Health policy recommendations for the prevention and control of zoonoses and AMR, targeting both formal and informal systems along different livestock food systems.

#### **4. Developing One Health policies on integrated zoonoses and AMR prevention and control**

One of the major constraints of implementing One Health approaches at a national and sub-national level along food systems is a poor understanding of incentives and deterrents and a lack of technical guidelines on how multi-sectoral interventions can be deployed. Science-based multi-sectoral technical protocols and standard operating procedures with clearly defined roles and responsibilities for the early detection, prevention and control of different types of zoonoses for each of the three sectors, underpinned by appropriate policies, are necessary for a better operationalization of One Health.

While a number of broad One Health technical approaches are being developed, they need to be adapted for local conditions. ILRI will support such efforts as a basis for influencing policies that are more aligned with One Health principles for the early detection, rapid response and prevention of different types of zoonoses involving all three main sectors.

The key areas of studies to be conducted will be:

- Developing a systems context approach to determining the risks of various types of zoonoses and AMR.
- Developing joint surveillance systems that are risk-based and specific for pandemics, endemic zoonoses, foodborne diseases and AMR.
- Developing diagnostic tests and protocols for the joint collection, transport, storage, testing and interpretation of results from livestock, humans, markets and the environment (e.g. water, sewage, soil).
- Harmonizing diagnostic tests and standardized data collection systems and storage.
- Developing joint multi-sectoral risk assessment approaches of various subcategories of zoonoses and AMR and risk mitigation measures in food systems.

- Evaluating One Health participatory approaches and developing guidelines to improve good farm management practices for improving the health of farmers and their livestock.

In conducting this research, the institute will involve different ministries representing the three main sectors at a national level, as well as REOs e.g. AU, ASEAN, South Asia Association for Regional Cooperation (SAARC) and international agencies e.g. FAO-WOAH-WHO Tripartite and UNEP. This will ensure that the protocols, guidelines and other tools developed are acceptable and in broad compliance with internationally agreed standards and norms.

Products developed will be converted into policy guidelines and communication material to be used in advocacy for adoption by the three main sectors. The materials will target the technical groups in the government sectors to raise awareness and incorporate these into their existing toolbox as guidance for implementing One Health approaches to zoonoses and AMR.

The policy and communication material generated will also be used in international advocacy for the adoption and institutionalization of One Health worldwide.

### **Outputs**

- A quantitative analysis, including benefits and costs completed and the value addition of the One Health approach demonstrated for the efficient prevention and control of pandemics, endemic zoonoses, foodborne diseases and AMR.
- An analysis of ongoing One Health capacity development initiatives and their benefits quantified.
- Standardized methodologies, protocols and tools across the three sectors for various technical approaches specific for the four categories of zoonotic diseases developed.
- Policy guidelines and tools for integrated One Health approaches to addressing zoonoses and AMR generated for incorporation into national policies and programs.

## PILLAR 3: INSTITUTIONAL

In the wake of renewed interest in One Health since 2004, several new initiatives at an international, regional and country level have been launched to institutionalize and implement formally multi-sectoral and multi-disciplinary approaches to addressing zoonotic disease threats and AMR (Machalaba et al. 2018). At an international level, a formal 'tripartite' alliance (FAO-OIE-WHO Collaboration 2010) between FAO, WOA and WHO exists to strengthen multi-sectoral collaboration among themselves to address pathogen threats arising at the intersection of humans, animals and ecosystems. These three organizations support the Global Health Security Agenda (GHSA) (2016), a partnership of more than 75 countries and development agencies seeking to improve health capacities in ministries of health and livestock to detect, respond and prevent zoonotic disease and AMR threats by complying with IHR and PVS guidelines.

UN member states have made a political commitment to a coordinated response to tackling AMR across human and animal health sectors and agriculture using a One Health approach. This has already prompted most countries worldwide to have their own AMR action plan. This level of commitment now provides an important basis for international efforts to halt the spread of AMR.

Regionally, economic organizations such as the AU have launched Africa CDC that has as one of its priorities a focus on improving One Health capacities to address zoonotic diseases and AMR. Similarly, ASEAN has established the Coordinating Center for Animal Health and Zoonoses (CCAHz), a formal agreement among its 10 member states to address transboundary animal diseases and zoonoses jointly between the public and animal health sectors.

Numerous other formal and informal donor-funded One Health platforms have emerged over the last 15 years that conduct multi-sectoral and multi-disciplinary activities, from research to training to fostering regional and national collaboration on addressing zoonoses and AMR. These include:

- The ASEAN Veterinary Epidemiology Group and Field Epidemiology Network, managed by the ASEAN Secretariat ([http://www.aseanplus3fetrn.net/?s=8&j=aveg\\_fetrn](http://www.aseanplus3fetrn.net/?s=8&j=aveg_fetrn))
- The South Asia One Health Disease Surveillance Network (<https://www.saohnet.org/>) that includes participants from 18 governmental and non-governmental organizations (NGOs) of human health, animal health, wildlife, food safety and environment sectors.
- The Pan African One Health Platform for Neglected Zoonotic Diseases that aims to strengthen collaboration among scientists and health authorities concerned in addressing neglected zoonotic diseases in Africa across sectors and disciplines.
- The East African Integrated Disease Surveillance Network, which is a regional collaborative initiative of the national ministries of the East African Community Partner States responsible for human and animal health in collaboration with national health research and academic institutions.
- The Regional Disease Surveillance Systems Enhancement (REDISSE) Project that aims to build national and regional intersectoral capacities for enhanced collaborative disease surveillance and epidemics preparedness in 11 Economic Community of West African States (ECOWAS) countries.

Increasingly, One Health concepts and courses are being implemented at higher education levels through regional and national university networks and in various ministries as in-service training programs. These include:

- The Southeast Asia One Health University Network, that promotes collaboration among a

number of universities in southeast Asia in One Health training for university students.

- Africa One Health University Network, that fosters academic partnerships with governments, national and regional stakeholders, advanced research institutions, civil society and development partners to train the future health professionals in One Health principles and concepts.
- Southern African Center for Infectious Disease Surveillance (SACIDS), that links academic and research institutions in southern and east Africa and promotes partnerships with world renowned centres of research and training in One Health at graduate level.
- One Health Regional Network for the Horn of Africa, that increases research capacity in several countries in the Horn of Africa by training professionals and extension workers in collaborative approaches among three interrelated disciplines: veterinary science, public health and social science.
- FAO-supported network of national One Health platforms in eastern, western and central Africa.

There are also a number of ongoing in-service training programs open to the medical and veterinary profession to support disease investigation, reporting and response and prevention measures. One of the longest standing and most successful in-service capacity development initiatives is the field epidemiology training program (FETP), which is mainly targeted at public health professionals but includes a small numbers of animal health professionals on its courses. Based on the success of the FETP, a similar course referred to as the field epidemiology training program for veterinarians (FETPV) was developed more recently in Asia with considerable success. The early detection of zoonotic H7N9 HPAI at the farm-level in China was mainly due to government FETPV-trained staff. They demonstrated value chain linkages from farms to various poultry distribution points and markets and supported joint risk assessments with the public sector. A similar course has now been launched in Africa called the Frontline In-Service Applied Veterinary Epidemiology Training program based on FETPV but is adapted for Africa.

All these field training programs provide One Health orientation to address infectious diseases, support the identification of national needs and the development of region-specific training manuals to train trainers, mentors and health professionals from government health sectors.

While this demonstrates significant interest and progress in the institutionalization of One Health at a global and regional level, there are a number of problems that prevent full adoption of One Health, particularly at a national and regional levels (Lee and Brumme 2013). The main ones among these are:

### **Problem and challenges**

- Institutionalization of One Health in many LMICs is still hindered by the barriers that continue to exist between human, animal and environmental health sectors to address zoonoses and AMR. One of the major problems is the uneven funding between the two sectors and fear of potential loss of budgets in an already underfunded public health domain. The implications of integrated One Health approaches and how they can be achieved in practical terms are not fully defined. Clear guidelines and tools to support the formation of sustainable One Health platforms are needed to show how these can be absorbed in existing health structures, as the creation of new structures without significant disruption to the status quo is difficult to grasp for many countries.
- By far the major deficiency in One Health platforms and networks that support One Health education and training at different levels is the poor representation of the environment sector and failure to appreciate the need to address some of the root causes of pandemics and zoonoses, such as land use changes, deforestation, dwindling water resources, climate change, poverty and protracted conflicts.
- Without adequate justification, traditional health sectors are unwilling to share resources with other disciplines such as social sciences, anthropology, economics and politics. The lack of adequate representation from these disciplines compromises One Health approaches.
- Most of the One Health research and training activities in various LMICs and regions are ad hoc (McKenzie et al. 2016) and mainly funded by external agencies. Therefore, the long-term sustainability of these initiatives is not possible without a long-term commitment for human and financial resources to support One Health institutions and platforms in the Global South.

### **Objectives**

The overall goal of the institutional pillar is to provide evidence and advocate to strengthen existing One Health institutions, platforms and networks



and support inter-sectoral and multidisciplinary research and training in preventing, detecting and responding to zoonotic diseases and AMR threats.

### **Priority areas of work**

Many of the challenges listed above are either beyond ILRI's scope of work or are being addressed by a number of other players who have been involved in promoting One Health for several years. However, ILRI has particular expertise in multi-sectoral and multi-disciplinary research on animal, human and environmental health, and can contribute to strengthening One Health research and training.

#### **1. *Establishing a One Health Research platform at ILRI***

The establishment of an ILRI One Health Research platform will focus on zoonoses (pandemic, endemic and foodborne) and AMR. The strategic objective of ILRI's One Health platform will be to formally institutionalize One Health principles and culture within ILRI through the involvement of in-house expertise in livestock and environmental health and engagement of a wide range of disciplines already present in the institute.

The strategy ensures the establishment of One Health working groups and focal points from various disciplinary groups at ILRI and development of a clear framework and mechanism for prioritizing One Health research to address technical, socio-economic and policy issues related to zoonoses and AMR, and creation of an enabling environment within ILRI to conduct collaborative research. The One Health platform may also be a repository of data, guidelines and tools generated through collaborative research as a future resource.

The One Health platform will also aim to broaden its partnerships with other global, regional and national networks of One Health expertise to promote and support operational and implementation capacity of national and regional One Health institutions.

In addition, its objectives will include the identification of success stories and demonstration of good practices in integrating sectors and disciplines to address complex problems of zoonoses and AMR.

#### **2. *Supporting One Health capacity development in universities, ministries and along animal value chains***

A large number of One Health courses at university level have been developed, all of which are funded by donors. A formal policy of adopting these

successful courses both at a regional and country level and integrating them within higher education systems and ministries has not yet taken place.

ILRI's One Health Research platform will aim to work with existing partners to support the evaluation of these programs, generate evidence for cross-sectoral knowledge integration, including the value of these courses, and generate policy recommendations and communication material to raise awareness of the importance of integrating One Health concepts upstream at university level and downstream in the animal health and environmental sectors at a national level. While these courses evolve and are widely adopted, the One Health platform will use the opportunity to contribute to these courses with its in-house expertise in research in animal health, environmental health, agriculture economics and social sciences. This expertise can add value in refining existing course material and providing a number of components of One Health training online for universities, other national institutions and government services.

As part of the global efforts to strengthen health capacities under the GHSA, ILRI will collaborate with the national governments and international agencies to develop and align its training program with GHSA action packages. The key areas that ILRI will support are collaboration with the national governments and international agencies in a number of action packages. These will include AMR, zoonotic diseases, biosafety and biosecurity, national laboratory system, real-time surveillance and workforce development.

Additionally, ILRI has a significant experience of engaging with farmers and community animal health workers in disease control programs. ILRI is already doing this with a number of pastoralist communities in drylands with limited grazing availability and low availability of health services. The One Health Research platform will build on this to develop One Health courses and work with its partners to disseminate training for farmers and key stakeholders along the livestock food chains.

ILRI's considerable experience in participatory One Health approaches, particularly in the smallholder dairy and pastoralist systems, will be used to develop specific training material targeted at the grassroots level to deliver integrated One Health approaches to improve good farm management practices to contribute to the reduction of disease burden in animals and their owners.

Under the One Health Research platform, ILRI will build a multi-disciplinary competent workforce mainly recruited from national and regional systems to be part of the implementation of the strategy in order to strengthen research and implementation capacity at the national and regional levels through in-service training from ILRI's in-house expertise.

### **3. *Championing for institutionalization of One Health to governments and investors***

Absorption of One Health within national institutions has been uneven and generally slow despite large amounts of funding and a number of international, regional and national initiatives. ILRI does not foresee that there will be a radical shift in this trend. However, there is heightened global awareness of the importance of One Health following a series of epidemics and pandemics that have emerged in rapid succession over the last few years from Ebola, H1N1 swine influenza, Zika and the ongoing COVID-19. This is an opportunity to increase advocacy efforts for greater investment in institutionalizing and operationalizing One Health at national and regional levels.

ILRI will also engage in research to generate evidence for the added value of One Health from collating and analysing success stories, identifying technical efficiency and social and economic benefits of integrating in developing policies that enable integrating prevention and control programs through collaboration across key sectors and disciplines (see Objective 1 above under Policy pillar. In this regard, ILRI will also exploit its knowledge on various livestock value chains to identify other informal One Health partners.

Based on research results, ILRI will develop communication and advocacy materials to convince policy makers to bolster political commitment and urge investors to provide additional funds for greater diffusion of One Health at national and regional levels. ILRI will also join the ongoing international efforts to assist national governments to develop their One Health strategies

ILRI will increasingly become part of the global network of champions to provide advice and support to national efforts to build One Health capacities and institutions.

## **Outputs**

- ILRI's One Health Research Platform established and functional, and inter-sectoral and multi-disciplinary working groups created within ILRI to conduct research on zoonoses and AMR and build national and regional One Health capacities.
- ILRI is established as a leading One Health Research platform attracting collaboration with national, regional and international partners including the CGIAR family addressing not only zoonotic diseases and AMR but a number of other development issues such as nutrition, climate change and deforestation.
- Policy guidelines and supportive advocacy material for adoption of One Health training for integration in the public, animal and environment health sectors generated for improved control of zoonoses and AMR developed.
- One Health capacities at higher education level, ministry level and along the livestock food systems enhanced through development of training material and courses.
- Integrated One Health participatory courses developed involving the public, animal and environment sectors to support health improvement of farm animals as well as their owners.
- Progressive improvement and absorption of One Health achieved in the existing health structures as well as enhancement and consolidation of the existing One Health platform under the overall umbrella of the national health systems.

Chapter 4:

# Implementation and partnerships

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The challenges of implementing a complex, multi-country, multi-regional zoonotic diseases and AMR prevention and control research program using a One Health approach necessitates strategic partnerships and alliances at multiple levels. For this strategy ILRI will consolidate its existing, extensive network of partnerships as well as forge new alliances as and when appropriate to support research and delivery of its products.

At the country level, the key partners will be the national ministries of agriculture, health, environment, commerce, education and meteorological departments. Within these ministries some of the main departments ILRI will engage with will be the departments of livestock, forestry, natural resource management, wildlife, trade, higher education and scientific research. The purpose of higher-level engagement of various ministries is to ensure that all the work implemented at the country level is consistent and compliant with country objectives and local regulatory requirements, respectively. Early engagement at this level has also the added advantage of creating an enabling environment to influence policy with decision makers.

Integrated in the implementation of the strategy will be an in-service capacity development component for national and regional staff to ensure wider diffusion and sustainability of the research outputs. To this end, ILRI will mostly recruit national and regional staff to understudy ILRI scientists and support implementation of various components of the research program.

Additionally, ILRI will broaden its partnerships with a number of national and international NGOs that have the knowledge of local customs and practices, political connections and trained workforce. ILRI's program on Impact at Scale will utilize these partnerships to enable wider application and impact of its research products at national and subnational levels.

Country-level private sector partners, particularly farmers, livestock traders and formal and informal market owners will also be necessary for the farm-to-fork food systems approach. Rapid economic growth and increasing demand for animal-derived foods in Africa are expected to result in significant investment in livestock development plans and growth in intensified farming systems. The private sector, particularly multinational food producing companies are likely to be important players

contributing to this transformation in Africa. Thus ILRI will engage with these companies to ensure appropriate policies on biosecurity at farm level as well as along the value chains are incorporated in future national livestock plans. Their knowledge, attitude and perceptions about zoonoses and AMR and their role in introducing various interventions will be important. The other private sector players will be service providers at the farm level, particularly veterinarians and other animal health care providers and local vaccine and veterinary drug suppliers in the context of the work on prevention of endemic zoonoses and AMR.

Given the cross-border nature of the zoonotic infections and of the regional significance REO's play, these will be important group to engage at both the policy and technical levels. Implementing regional projects, conducting research along the extended cross-border animal value chains, influencing policy changes on issues such as improving biosecurity for cross-border animal movement and trade, harmonization of technical approaches, information sharing mechanisms, supporting regional networks on surveillance and laboratories, and the adoption of One Health; will necessitate engagement of REOs. The World Bank multimillion dollar loan/grant project on REDISSE is a good example of how a regional infectious disease control program in the West Africa region, is implemented. For this strategy, it is envisioned that the AU specialized agencies and institutions, AU-IBAR and Africa CDC, SAARC and ASEAN will be the key partners as they all have the mandate to promote regional collaboration on prevention and control of infectious emerging and endemic diseases including AMR.

At the international level, the key sectoral partners will be the UN organizations—FAO, WHO, WTO and WOA. These organizations have the mandate to address zoonoses and AMR through One Health capacity development and ensure food safety, food security and health security. Engagement with these agencies will ensure that scientific evidence generated by ILRI can be translated at the international policy level ensuring wider diffusion of research products internationally to over 200 constituent member states. ILRI will also establish links with the collaborating and reference centres of the three UN agencies to share information and enhance technical interaction and share capacity development initiatives in One Health. Given the importance of the environment-related drivers of pathogen emergence and spread and the importance of addressing the root causes of

zoonoses and AMR, UNEP will be an important partner in addition to the FAO-WHO-WOAH 'tripartite' partners. The recent collaborative agreement with UNEP and ILRI will be strengthened through collaboration under this strategy.

ILRI under the AMR Hub will continue to strengthen its existing collaboration with several CGIAR centres that represent important sectors related to the work on zoonoses and AMR. The key among these will be World Agroforestry Centre (ICRAF), CIFOR, WorldFish Center (WorldFish), International Water Management Institute (IWMI) and International Food Policy Research Institute (IFPRI). Research on improved understanding of emerging pandemic risk, refining hotspots and conducting surveillance of new pathogens at the interface of humans, domestic animals and wild animals will involve partnership with ICRAF and CIFOR that addresses sustainable forestry and farming in a large number of countries in Africa and Asia. The ongoing partnership with WorldFish and IMWI will be further strengthened to elucidate the emerging risk of AMR in aquaculture-based mixed farming systems and developing water management strategies that reduces the risk of AMR emergence. In future, intensive farming of fish may be an important area of interest in the context of emerging zoonoses. ILRI has an ongoing collaboration with IFPRI on food safety. This collaboration will be strengthened to better develop appropriate policy framework and policy recommendations at country and regional levels in the context of livestock food systems that exist in the Global South.

ILRI will further build on partnerships with a number of advanced research institutions worldwide to leverage its existing in-house expertise to support various levels of research activities in genomics, molecular biology, vaccinology, immunology, diagnostics, bioinformatics, big data analysis, epidemiology, socio-economics and environment sciences, machine learning, artificial intelligence, modelling and forecasting. Strategic alliances will be established with private pharmaceutical and biological companies in the context of diagnostics and vaccine development platforms.

There are a large number of new and existing One Health research centres, platforms and networks, and programs with various objectives including policy promotion, institutionalization, education and advocacy at national, regional and international levels. ILRI will aim to establish partnerships with a number of these to share, learn and ensure that its work will complement ongoing efforts and avoid duplication.

Levels of engagement with different partners will depend on the specific issues being addressed under each of the focus areas of the strategy. These partnerships will ensure that collaborative, multisectoral and transdisciplinary approaches are embedded from planning to implementation of all research activities under the strategy.



Chapter 5:

# Theory of change

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ILRI's core mandate is to support poor farming communities to produce healthy livestock in a sustainable manner so that it can generate resources to improve livelihoods, reduce poverty and provide more nutritious high-quality protein and micronutrients. One of the biggest challenges to developing profitable livestock systems is zoonotic diseases and AMR that harm both the owners and their livestock.

Over 60% of the roughly 1,400 diseases in humans are zoonotic (Heeney 2006). It is estimated that every year 2.4 million people are infected by, and 2.2 million die from, existing endemic zoonoses that persist in humans and livestock systems, mainly in LMICs. The World Bank (2010) estimated over USD20 billion in direct costs and over USD200 billion in indirect costs over a period of 10 years. New zoonotic diseases that mostly originate in wild animals and cause epidemics and pandemics in humans and animals are on the rise. Avian influenza, Nipah, Ebola, Zika and COVID-19 are all recent examples of these disease that have caused huge socio-economic harm globally and continue to threaten global health security. With the increasing use of antibiotics both in humans and livestock, the emergence of AMR in a wide range of common bacteria including zoonotic bacteria from livestock has emerged as a serious global health problem with the potential to kill over 10 million people a year.

With greater attention being paid to infectious diseases, spurred by COVID-19, ILRI has prioritized an increase in its efforts to address zoonoses and AMR occurring at the interface of humans, livestock and their shared environments.

The theory of change describes how ILRI will utilize and promote a One Health approach to reduce the risk of animal derived pathogens for better health and well-being of people.

The strategy will focus on three categories of zoonotic diseases and AMR, each with its specific objectives.

- a. **Epidemics and pandemics:** pre-empt the emergence and spread of emerging and re-emerging zoonoses with epidemic and pandemic potential at the interface of humans, livestock and wild animals and their ecosystems.
- b. **Endemic, neglected zoonoses:** reduce the incidence and impacts of zoonotic pathogens that persist in humans and livestock systems predominantly associated with poverty.
- c. **Foodborne diseases:** reduce contamination

of animal-derived foods particularly in informal livestock food systems

- d. **AMR:** reduce the emergence and spread of antibiotic zoonotic bacteria in livestock production systems.

Technical approaches will involve strategic research using a systems approach targeting priority livestock production and food systems, including their interfaces with humans and ecosystems in LMICs. The priority livestock systems targeted will be small- to medium-sized mixed livestock/crop and pastoralist systems, their associated livestock value chains, animal markets and formal and informal slaughterhouses and food processing facilities.

ILRI will deploy a multi-sectoral, multi-disciplinary One Health research approach at all levels from planning to implementation. The in-house expertise and experience related to animal and environment health, as well as various disciplinary groups that include social scientists, economists, anthropologists, epidemiologists, ecologists and modelers will contribute towards this approach. ILRI will establish partnerships with the public health sector nationally, regionally and internationally to ensure that key sectoral representation is achieved through the research.

Common to all three subcategories of zoonoses and AMR will be the integrated One Health risk-based approach using existing and newly developed research tools. This will involve characterizing the dynamic nature of the target livestock production and food systems; refining disease risks and hotspots; conducting disease surveillance; identifying priority pathogens and other hazards in target systems; and generating data on epidemiology, ecology and burdens of zoonoses and AMR on humans and livestock. The data will enable improved risk assessment and modelling and the development of cost-effective risk mitigation options that are relevant to poor farming communities.

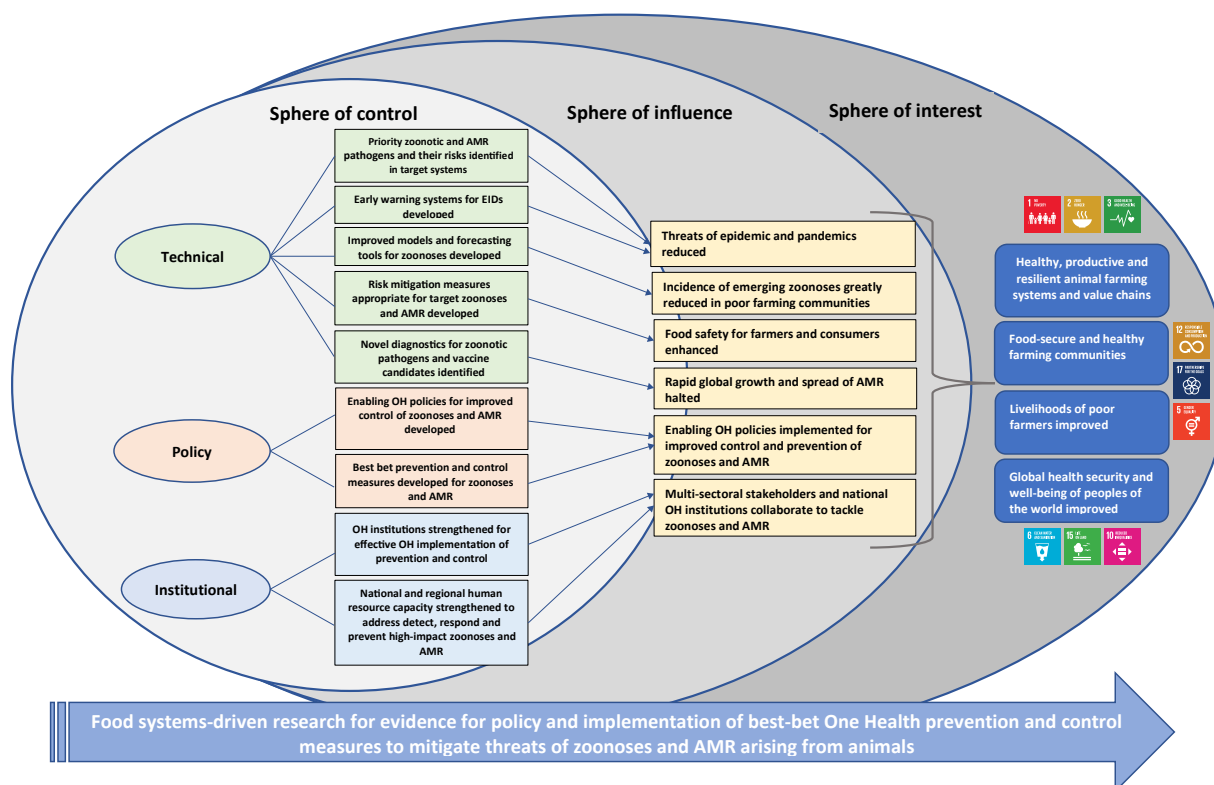
The key outputs of this research will be surveillance and early warning systems, new diagnostic and characterization tools for priority pathogens, new vaccines and fit-for-purpose prevention measures for target systems. A number of simple risk mitigation measures exist for various subcategories of zoonoses and AMR. Because of many overlaps, the strategy will aim to repackage some of these measures together with newly developed risk mitigation measures for prevention and control that apply to several types of zoonoses and AMR.

A number of scientific tools, standards, guidelines and risk communication and advocacy materials will enable government health services and farming communities to make their health systems more resilient to disease.

Through pilot studies, ILRI will demonstrate proof of concept of recommended risk mitigation measures and collaborate with a number of other partners to enable the application of these measures on a larger scale at national level. Scientific evidence generated through research will be developed into policy recommendations and ILRI will convert these into advocacy material for policymakers to support appropriate mechanisms and institutions to support disease prevention and control measures. Additional communication materials targeted at other stakeholders, particularly farmers and those associated with livestock food systems, to raise awareness of the dangers of diseases and inform them of ways to improve hygiene standards will be created.

Integrated in this strategy is a capacity development program that will ensure national and regional staff will be trained as part of the implementation to ensure long-term sustainability and enable wider dissemination of technologies and tools. The engagement with regional (AU, ASEAN, SAARC) and international (FAO, WOA, WHO and UNEP) organizations will be critical as they are important players in providing and endorsing research outputs for their wider adoption.

The principal outcomes of the successful implementation of the ILRI One Health Research platform activities will be a reduced burden of zoonoses and AMR in people and their livestock, and an increased ability of national governments to anticipate high-impact emerging infectious diseases and eliminate their threats, resulting in an overall improvement in global health security. Improved health in livestock will result in increased and more efficient production of livestock-derived foods, benefiting global efforts to enhance food and nutrition security and eradicate poverty. The outcomes will serve CGIAR targets as well as SDGs.



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