STAR-IDAZ
Global Network for Animal Disease Research

Meeting Future Research Needs on Infectious Diseases of Animals and Zoonoses

Strategic Research Agenda

March 2015

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Executive Summary

Changes in animal disease challenges are inevitable, but how these changes emerge and what the future outcomes could be are uncertain. What is important is not trying to predict what will happen, but being more prepared to engage with whatever may happen. Regional foresight exercises were conducted for the Americas, Asia and Australasia, Europe and Africa and the Middle East and developed further and integrated at a workshop in Moscow involving delegates from all four regions. The objective of the studies was to identify the scientific, technological and related needs to prevent, control or mitigate animal health and zoonotic challenges for the next 20 years. These are presented in three separate lists, Specific Research Areas, Technology and Structural changes. Addressing the specific areas and/or maximising the benefits of technological advances will be enhanced if the capacity/structural changes recommended are also addressed. The results show that many of the important drivers were common to all four regions. Important challenge areas identified include an improved understanding of the role of wild life, vector-borne diseases, antibiotic effectiveness and availability, gut health and introduction of trans-boundary diseases. The focus of technological developments should be on diagnostic tests, integrated surveillance systems, vaccine development and alternatives to antibiotics and alternative vector control methods. However development of the necessary technologies to meet future challenges requires an enabling environment with support for the basic science as well as further along the research pipeline, partnerships and collaborations and knowledge transfer mechanisms.

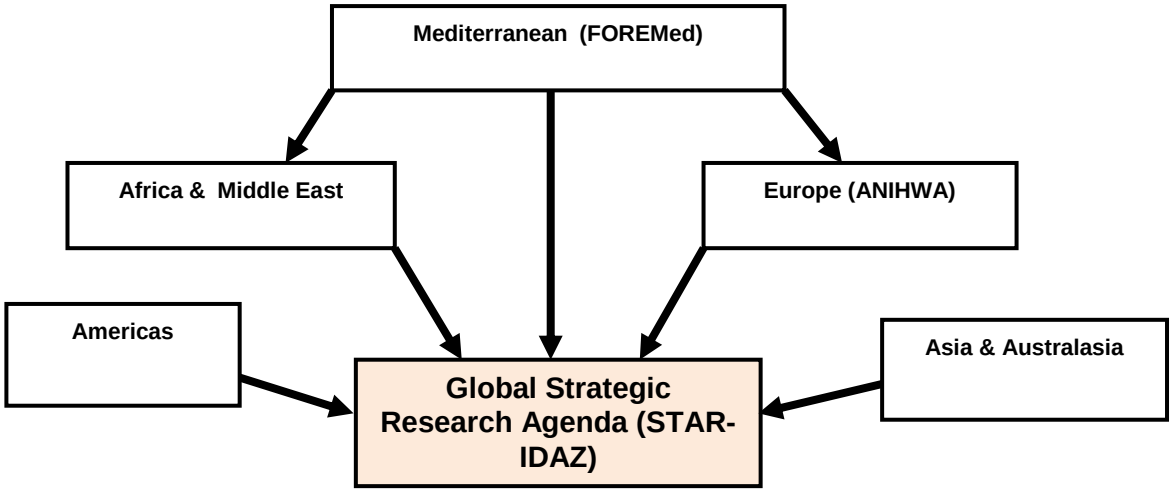
Background and Objectives

Animal diseases cause serious social, economic and environmental damage and in some cases (zoonoses) also threaten human health. Unanticipated and emerging threats are ever present and can have unwanted local, national, regional and global impacts. The disease risks have increased over recent decades, especially as a result of the increased globalisation of trade and animal product movements, and the consequent transfer of associated fast-evolving pathogens. These changes are exacerbated by interaction with environmental change, including changes to land use and the potential variabilities associated with climate change. Improved awareness of, preparedness for, and response to outbreaks are needed for the effective management of the threats of animal diseases, including zoonoses — and depend on sound science. Identifying possible future threats is essential to improve preparedness and ensure the availability of the necessary research capacity and capability to address potential needs. However, the world consists of dynamic ecosystems that influence animal health so this exercise must be repeated regularly so that research programmes can be adapted to meet changing needs.

STAR-IDAZ (Global Strategic Alliances for the Coordination of Research on the Major Infectious Diseases of Animals and Zoonoses) was a 48 month EU-funded (FP7) Coordination and Support Action (CSA) to improve coordination at international level of research activities on the major infectious diseases of animals (including zoonoses) and hasten the delivery of improved control methods. Its scope included coordination of research relevant to emerging and major infectious diseases of production animals (livestock, including aquatic animals and bees) and those animal infections that may threaten human health (i.e. zoonoses). Diseases of wildlife and other free-living animals were also considered where they were identified as reservoirs of infection of emerging and major infectious diseases of humans or production animals. The development of a Strategic Research Agenda was considered a key component of building the global network into a forward-looking coherent structure of national animal health research funders capable of cross-programme collaboration that will better serve in terms of (human and financial) resources, the research needs of the Livestock industries and animal health policy makers. The objective of the STAR-IDAZ foresight activities was therefore to identify the scientific, technological and related needs to prevent, control or mitigate animal health and zoonotic challenges for the next 20 years which, together with the Criteria for Priority Setting, provide the partners with a framework for identifying targets for investment to improve preparedness and possible areas for collaboration.

Overall Approach

An Inventory of Foresight Methodologies was initially developed. Regional foresight exercises were then conducted in the Americas (using the Fore-CAN scenarios developed in Canada), Asia and Australasia (based on Seven questions to stimulate discussion), Africa and the Middle East (disease threats, impact and research) and Europe (Scenario building and Backcasting), with a separate focused study for the Mediterranean.



Building on and pulling together these regional exercises, a workshop was held in Moscow on 17-19 June, 2014 involving 40 animal health experts from around the world. The objective of the workshop was:

To identify the scientific and technological needs to prevent, control or mitigate animal health and zoonotic challenges for the next 20 years

The workshop and preparatory online activities involved:

Pre-workshop on-line activities

- Driver prioritisation
- Consideration of the impact of the prioritised drivers on various disease categories

Workshop

- Discussion of a preferred 2034 future in respect of infectious diseases of animals and options analysis
- Back-casting to a common preferred 2034 future

The research needs identified in the regional exercises and back-casting were then classified as relating to a) Structural/Political/Capacity issues – creating an enabling environment; b) Technologies and c) Specific Topics/Diseases and further classified as urgent, less urgent and important but not urgent. Further validation and the identification of specific disease challenges was conducted in regional meetings for a) Africa and the Middle East held in Addis Ababa on 5 November, 2014; b) Asia and Australasia held in Delhi on 10 December, 2014 and c) the Americas held in Bogota on the 21 January, 2015.

Method and Results

i) Regional Workshops

Americas

The Americas regional network, at its meeting in Campo Grande, used 2025 scenarios developed by the Canadian Food Inspection Agency to consider science and technology needs to prepare for possible alternative futures. The science and technology needs were considered further, refined and prioritised at the breakout regional network meeting during the Mexico City meeting and the outcome can be seen in Annex 1a.

Asia and Australasia

The Asia and Australasia Regional Network used seven questions, designed to stimulate futures thinking, to identify the scientific and technological needs to prevent, control or mitigate animal health and zoonotic challenges for 2025 and beyond during its meeting in Beijing. A summary of the discussion is available in Annex 2a.

Europe

Following an online driver prioritisation exercise, outlined in (ii) below, a two-day foresight workshop was held in Madrid, hosted by INIA, on the 2 and 3 April, 2014 at which 39 experts from a range of different backgrounds, including animal health and welfare, social, political and economic sciences, animal production and technology, from 16 countries across Europe considered the scientific and technological needs to prevent, control or mitigate animal health and zoonotic challenges and address animal welfare requirements for 2030 and beyond. Participants first considered the implications of the high priority drivers for a range of disease groups as described in (iii) below. Workshop participants then developed scenarios based on two critical uncertainties (**the state of human contentedness and the rate of environmental change**) and a range of prioritised drivers and considered their implications in relation to animal disease challenges and the research needed to protect against these possible futures. This was followed by consideration of a preferred future "Sustainable livestock production, with healthy animals reared under high welfare standards, disease minimised or rapidly contained, ensuring a safe and secure food supply and economic development" and how we get there taking into account the barriers and enablers identified in the various scenarios. The Workshop report is available in Annex 3a.

ii) Driver Prioritisation

Drivers identified in the development of the Strategic Research Agenda by the ERA-Net on Emerging and Major Infectious Diseases of Animals (EMIDA), the FORECAN study, the APEC project on Road-mapping Converging Technologies To Combat Emerging Infectious Diseases, and the Foresight Infectious Diseases China Project were classified under a number of categories of Key Drivers and circulated to animal disease experts in Africa and the Middle East, Asia and Australasia and the Americas and to experts from a range of different backgrounds in Europe. The driver categories included Social/Human, Technological

Innovation, Economic, Environmental and Political/Policy. The experts were asked to identify and rank, in terms of potential impact, the most important key drivers likely to affect animal health and zoonoses outcomes in their regions over the next 15 – 20 years. The key drivers identified are listed below:

Asia and Australasia
Increasing population size/density
Biosecurity including surveillance and monitoring (on farm level, national level)
New science/technologies
Desired balance between economy, ecology, environmental impact, animal welfare and sustainability
Movement of animals and their products
Climate change, including extreme weather events
Political leadership including short-term thinking and loss of technical expertise
Intensification/ bigger production units and factory farming

The Americas
Climate change, including extreme weather events
Increasing population size/density
One health/Ecosystem health approach
Human – domesticated animal - wildlife interaction
Movement of animals and their products
Political leadership including short-term thinking and loss of technical expertise
Intensification/ bigger production units and factory farming

Africa and the Middle East
Increasing population size/density
One health/Ecosystem health approach
Human – domesticated animal - wildlife interaction
Movement of animals and their products
Climate change, including extreme weather events
Political leadership including short-term thinking and loss of technical expertise

Europe *(animal welfare also considered)*
Population size, density and demographic changes, including movement of people
Economics of farming including profitability and competitiveness
Balance between economy, ecology, environmental impact, animal welfare and sustainability
Climate change, including extreme weather events
Pathogen evolution, including drug resistance

iii) Impact of the prioritised drivers on various disease categories

The potential effects of the prioritised drivers for each region on various disease groups were explored in matrices at a workshop in Europe and online for the other regions. The matrices were prepared involving a number of the highest ranked drivers in the various driver categories on one axis with the different categories of disease on the other axis. Participants in the online exercise or in the workshop were asked to consider and rate (**low, medium or high**) the likely impact of the various drivers on the different disease categories. The type of technology needed to counteract the impact of the various diseases was also considered. The regional groups in Moscow then looked at the matrices again to agree on and, if necessary, add to the results. The disease groups against which the driver effects were analysed are listed below:

Disease groups
Vector-borne diseases
Epizootic diseases
Helminth diseases
Endemic bacterial/viral diseases, including disease syndromes
New diseases
Zoonoses
Fungal diseases, including mycotoxins

Driver – Disease interaction

Overall the emergence of new diseases was the area where the impact of the various drivers was considered to be greatest. Across the four regions an increasing population size/density was considered to be an important driver and its likely impact on the occurrence of most disease categories was considered to be high or very high with three of the regions rating it as very high in relation to the emergence of new diseases. Zoonoses was another area where the drivers were considered to have a significant impact. Conversely increasing technological developments in relation to biosecurity, surveillance and monitoring will have a positive impact across most of the disease categories.

Full details of the Driver – Disease interaction matrices are shown in Annex 1b (Americas), 2b (Asia and Australasia), 3b (Europe) and 4a (Africa & Middle East) and the combined driver impact on the disease groups can be seen in Annex 6a.

iv) Discussion of a preferred 2034 future in respect of infectious diseases of animals and options analysis

Participants at the Moscow workshop discussed and agreed in regional breakout groups a preferred future for 2034.

Preferred futures identified by the four regional groups

Africa and the Middle East – collaboration for healthy animals humans and the environment

Americas – To effectively predict, prevent and respond to animal diseases

Asia and Australasia – Animal health for human wealth.

Europe - Sustainable Productivity from healthy animals

Each of the four regional groups identified five research areas/activities/approaches that should be addressed in order to help them achieve their preferred future. Each group scored the items in their own list from 1-5 with 5 being a high priority and 1 being low. They then scored the items identified by the other regions with the results ranked in order of priority which can be found in Annex 6b (Options Analysis):

v) Backcasting to a common preferred 2034 future

Backcasting Exercise

The backcasting involved working backwards from a particular desirable future end-point to the present to determine the physical feasibility of that future and what policy measures are required. It involved considering the impediments vs. enablers and possible pathway to meet the vision?

The New Vision - animal disease minimised or rapidly contained ensuring a safe and secure food supply

The approach adopted involved consideration of:

1. What elements are different between our vision and today
2. What are the steps needed to meet this vision
3. What is the knowledge/research required to meet this vision

Participants were asked to identify the steps to attain the vision involved including:

• creating a time-line

• identifying key events

• identifying barriers vs. enablers

• quick scanning the research required, including blue-sky (basic) vs. applied and knowledge-sharing networks specific to the time-line events/region.

In summary, this involved identifying key factors that will support or inhibit our vision of sustainable disease control/livestock production and the key areas of research/capacity/building/knowledge transfer required to support the vision going into the future. The results from each region are shown in Annex 1c (Americas), 2c (Asia and Australasia), 3c (Europe) and 4b (Africa & Middle East).

vi) Identification of specific disease challenges

At further regional workshops held in Addis Ababa, Delhi and Bogota delegates were asked to identify:

- Which disease/zoonotic threats do you think could emerge in the next 20 years
- Why
- What is the potential impact and on who
- How do we prepare to minimise the impact of their emergence

Results for the Americas are shown in Annex 1d, Asia and Australasia in Annex 2d and Africa & Middle East in Annex 4c.

Summary of Results

Scientific, technological and related needs to prevent, control or mitigate animal health and zoonotic challenges for the next 20 years identified during regional foresight exercises and back-casting during the Moscow Foresight Workshop.

The research needs were divided into three groups a) Structural/political, relating to the creation of an enabling environment to support research, b) Technology, where opportunities could be exploited and c) Specific disease/topic challenges (see Annex 6c) and classified at a workshop during the STAR-IDAZ Delhi Consortium meeting as urgent (Priority Box 1), less urgent (Priority Box 2) and important but not urgent (Priority Box 3):

Structural/Political

Priority Box 1
Research pipeline – investment in basic research
Sound public polices relating to science and technology - Better impact assessment of new legislation
Maintenance of capacity – research capacity; diagnostic capacity; surveillance, including field professionals; capacity in parasitology; neuropathology; Better capacity to address neglected diseases; government/professional bureaucrats
Partnerships/collaborations – global/regional research alliances – sharing information between countries
Knowledge management system – Big data, GIS; Sharing Data - Integration and better use of existing data
Knowledge/technology transfer – to end-users (vets, farmers, Pharmaceutical industry) - Strategy for protecting intellectual property – Public Private Partnerships
Integrated surveillance system/ Centralised diagnostic testing - Risk-based approach to surveillance - Better surveillance of domestic and wild animals - Use of farmers for frontline for disease detection – precision livestock farming
Priority Box 2
Improved focus of research activities – gap analysis - Alignment of financial resources and research capacity with needs
Invest in new (more powerful) technologies
One health approach
Social acceptability of new technologies
Biosecurity - Management of waste - Improved inspection at borders

Operating systems in disease prevention and control - Operational research
Priority Box 3
Better monitoring of medications - Improve the control of drugs

Technological

Priority Box 1
Diagnostic tests - Express methods - routine deep sequencing methods - Real time PCR
Vaccine development/New genetically engineered vaccines – Immunology – bioinformatics - Predictive Biology - Reverse genetics – synthetic biology
Alternatives to antimicrobials – antimicrobial peptides – immunomodulators - New antibiotics
Alternative methods to control vectors - Integrated pest management - Biological control - Genetic modified insects
Biosecurity
Systems based approaches/research
Priority Box 2
Surveillance - Syndromic surveillance - Precision livestock farming/Automated disease surveillance; Big data; Risk-based approach to surveillance; More high-throughput technologies (metagenomics, sequencing and bioinformatics); Easy to use field diagnostic technology
Big data – bioinformatics
Nanotechnology – e.g. adjuvants
Animal breeding/genetics - disease resistance – local breeds - Cloned and GM engineered animals
New drug development - New therapeutics for parasitic diseases
Animal identification technologies

Specific Topics/Diseases

Priority Box 1
Improved Understanding of the role of wild life - Epidemiological studies on wildlife - livestock interaction and disease spread
Vector-borne diseases - Alternative methods to control vectors – a) Integrated pest management, b) biological control and c) genetic modification
Antibiotic effectiveness and availability - Better use of antibiotics; Alternatives to antibiotics - Host resistance; vaccine development/ Vaccinology, including HPI; biosecurity/management, antimicrobial peptides, immunomodulators
Disease introductions, including trans-boundary animals diseases - Generic detection platforms, Risk pathway identification, Traceability of animals and their products, Technology for inactivation of pathogens
Improve food safety – traceability; risk analysis; antimicrobial/Residues
Gut health - Digestive physiology; gut microbiome - pre/probiotics; Improved understanding of the interaction between pathogens and also between the pathogen and the gut
Anthelmintic resistance - Mechanisms of resistance - Markers of resistance
New diseases
Priority Box 2
Understanding disease ecology - Decrease evolutionary pressure on pathogens
Studies on the impact of diseases on ecology/environment/biodiversity
Socio-economic impact evaluation of main diseases
Sustainability of production systems - New production system; genetics - assure maintenance of biodiversity;
Priority Box 3
Alternative systems to compensate for downsizing of surveillance/detection systems - Integration and better use of existing data; Syndromic surveillance; Cost effective real-time collection of data; Risk-based approach to surveillance
Neglected diseases

Recommendations

Maintenance of the SRA

Although developed with a 20 year outlook the high impact drivers could change quite rapidly, especially in the current climate of heightened political and economic uncertainty. It should therefore be validated and updated at least every 5 years through the conduct of further foresight studies with specific research needs constantly reassessed and more formal reviews conducted on a biennial basis.

Utilisation of the SRA

STAR-IDAZ is composed of a range of programme owners and funding organisations with their own focus from basic science to applied research. Those wishing to use the outputs of this exercise will have different needs or interests, such as zoonoses or exploiting opportunities arising out of technological developments and at different points along the research pipeline, so they will have to apply their own criteria for priority setting together with specific gap analysis.

The research needs identified in the summary are at a relatively high level, but the driver disease matrix does provide a degree of focus as to broad areas of need, providing an overarching framework for identifying topics for collaborative activities. It would be unwise in a 20 year forward look to be more specific because what is important is not trying to predict what will happen, but being more prepared to engage with whatever may happen. Needs were classified as i) Structural/political, addressing the needs for maintenance of capacity and an enabling environment generally, ii) technological, recognizing that technological change is progressing rapidly and the opportunities this provides not just for disease control but also in their exploitation for economic growth and iii) specific topics or diseases.

As to immediate research needs, specific topics were identified in regional workshops. Many of these had already been identified in Work Package 3 as priority diseases or issues for collaborative activity and specific research gap analysis exercises were conducted or taken from the DISCONTOOLS project and presented in a format to allow sharing of information as to what areas are currently being conducted or should be addressed. Critical path analysis should be utilised to prioritise the research gaps as a sequence of activities presented in a logical framework.

Action Plan

Why? To achieve the agreed vision:

Animal disease minimised or rapidly contained ensuring a safe and secure food supply

What	How	Who	When
Capacity	Create an enabling environment – funding, collaboration, knowledge exchange, foresight	STAR-IDAZ Members	Continuous
Disease/issue identification and prioritisation	Stakeholder consultation – establish working groups Host, pathogen and vector biology, genomics, immunology, pathobiology, virulence, evolution	Country > Region > Global Industry	Step 1
Research gap analysis	Literature reviews, expert elicitation, critical path analysis, review of current and planned research programmes	Priority Disease/Issue Working Groups, researchers, experts	Step 2
Coordination of funding	Align programmes – who funds what?	STAR-IDAZ Members	Step 3
Research delivery	Basic and translational research. Host/pathogen interactions, resistance factors, protective antigens, correlates of protection	Research institutes, universities	Step 4
Research delivery	Applied research. Disease control tools, vaccines, diagnostics, risk factors	SMEs, livestock industry, pharmaceutical companies	
Technology transfer	Disease control tools to end users	Industry	Step 5

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Annex 1: The Americas

Annex 1a - Regional foresight workshop

The Americas Regional Network, at its meeting in Campo Grande, used the four scenarios for 2025 that were developed by the Canadian Food Inspection Agency in their Fore-CAN study to consider the potential implications for animal health. They then identified, refined and in a follow-up workshop in Mexico City prioritised the science and technology needed to prepare for those possible alternative futures.

SAFE FOOD INCORPORATE

(*Characteristics:* Back to business; Human focus, not One Health; New pathogens, outbreaks; Outrage; Industry and government split; Consolidation; Safe, secure large scale operations)

Key implications for disease prevention
Sterilise food and eat – as only interested in safe food and no concern for production
Intensification of livestock production
Supermarkets and producers ensuring safety and traceability
No control on animal movements
Much stronger controls
Passive surveillance
Scarcity of information about food chain
Food inspection less
Profit over quality/
More availability of human health care
Food sourced from wherever it is cheapest
Introduction of any animal diseases
High sensitivity tests needed for food contamination

Key messages
Make sure the information about the food system is available for everyone
Surveillance needs to change in order to monitor threats – constant monitoring
Build quality along the food chain
Big brother will take control
Bioethics
Systems to dispose of sick animals – don't really care what they died from

ONE WORLD ONE HEALTH

(*Characteristics:* Confidence in system; Diseases stable; Collaboration; Focus on improving whole system; Industry engaged and proactive in developing solution; Market AND regulatory approaches complementary)

Key implications for disease prevention
Who will pay – expect the consumer will
Utopia – people will get lazy
Common rules for all countries
Managing expectations – people expect too much
Produce as close as possible to where consumed
Health risks are under control. Less work for doctors

Food security/safety
Safer food?
More available (I would say the opposite)
Cheaper or more costly?
Animal welfare will increase prices
Price increase due to animal welfare environment etc. or price not affected
More exported food (more prosperity) – as less control due to improved standards

Key messages
More access to expertise worldwide
Small farms impacted
International funds to address common problems
S&T cooperation - Higher level of coordination needed
Remote sensing technologies for diagnosis

ASLEEP AT THE WHEEL

(*Characteristics:* Global growth; Disease contained; Consumers confident; Animal health is low priority; System is unprepared)

Key implications for disease prevention
Susceptible animal populations in relation to disease
Risk of epidemics
Increased risk of bioterrorism
Risk of disease introduction
Less stability in the market
Less research funding -Loss of research expertise due to decreased funding

Key messages
(What needs to change)
Universal vaccines + DNA chips
International agreement on regulations
Better insurance
Better cooperation in research
Cost recovery to maintain the system
Make society take responsibility
Industry takes more responsibility
Society has a right to know information
Public education

IN MY BACKYARD

(*Characteristics:* Fear, distrust of system; Uncontained disease outbreaks; Disinformation; Eradication not acceptable; Lack resources and professional;
Two tiered agriculture: large (export), small (local))

Key implications for disease prevention/control/mitigation
Increase in market protection – protectionism
Better organisation to overcome bureaucratic obstacles and allow S & T to develop
Need more robust/resistant animals especially for small scale production systems
Local production
Decreased/optimised consumption of animal proteins

Increased investment in S&T (needed)
Lack of animal disease information systems
Panic by consumers and market prices collapse – market collapses
Animal health response only in crises
Equity in food security / inequality in access to food

Annex 1b - Driver/Disease Group Interactions

A matrix was developed with the highest ranked drivers on one axis and a number of different categories of disease on the other axis. Participants in the online exercise were asked to consider and classify (low, medium or high) the likely impact of the various drivers on the different disease categories and consider the type of technology needed to counteract the impact of the various diseases (see table on next page).

The Americas		Disease Groups						
Drivers		Vector-borne diseases	Epizootic Diseases	Helminth diseases	Endemic bacterial/viral diseases, including disease syndromes	New diseases	Zoonoses	Fungal diseases, including mycotoxins
Climate change, including extreme weather events	Impact:	High	High	Medium	High	High	Very High	Medium
	Comments:	Climate change driving new emerging and re-emerging diseases . Predictive tools are needed as well as effective preventive tools.						
Increasing population size/density	Impact:	High	High	Medium	Very High	High	High	Medium
	Comments:	Internal migration is an issue and higher density populations make it harder to control vectors.			Internal migration.		Availability of diagnostic test.	
One health/ Ecosystem health approach	Impact:	High	Medium	Medium	High	Very High	Very High	Medium
	Comments:	Poor coordination of field services and increasing agricultural borders is an issue. Also social problems such as poor eduction make vector control difficult at the home level e.g. dengue and malaria.	Epizootics are "animal" disease outbreaks and have therefore less impact on one health except in developing countries where the impact affects global food security and the livelihood of people.			Poor intersectoral coordination. Ownership/ responsibility.		
Human – domesticated animal - wildlife interaction	Impact:	High	Medium	Medium	Medium	Very High	Very High	Low
	Comments:	Many vector borne diseases come from wildlife so more interaction between domestic and wild animals increase the risk of the appearance of new diseases.				Most new diseases are zoonoses from wildlife so this interaction is critical.	Most new emerging diseases are zoonoses from wildlife so this interaction is critical. Poor services coverage/surveillence is a problem.	
Movement of animals and their products	Impact:	High	High	Medium	Very High	High	High	Low
	Comments:		Animal movement is one of the main drivers for turning a simple outbreak into an epizootic disease.					
Political leadership including short-term thinking and loss of technical expertise	Impact:	High	High	High	High	High	High	Medium
	Comments:	An influential driver for almost all diseases. A loss of technical expertise/capacity and short-term thinking would leave us severely vulnerable to non-science based disease control decisions. Also important for vector borne diseases with a public health impact.	An influential driver for almost all diseases. A loss of technical expertise/capacity and short-term thinking would leave us severely vulnerable to non-science based disease control decisions.	An influential driver for almost all diseases. A loss of technical expertise/capacity and short-term thinking would leave us severely vulnerable to non-science based disease control decisions.	An influential driver for almost all diseases. A loss of technical expertise/capacity and short-term thinking would leave us severely vulnerable to non-science based disease control decisions.	An influential driver for almost all diseases. A loss of technical expertise/capacity and short-term thinking would leave us severely vulnerable to non-science based disease control decisions.	An influential driver for almost all diseases. A loss of technical expertise/capacity and short-term thinking would leave us severely vulnerable to non-science based disease control decisions.	An influential driver for almost all diseases. A loss of technical expertise/capacity and short-term thinking would leave us severely vulnerable to non-science based disease control decisions.
Intensification/ bigger production units and factory farming	Impact:	Medium	High	High	High	Medium	Medium	Medium
	Comments:			Incrementation and intensification of animal production is directly correlated with increased incidence of helminth diseases.	Intensification of animal production is a major driver for respiratory and reproductive syndromes.	Many examples of intensification and factory farming and the emergence of new diseases or the re-emerge of variants of already known diseases (Pandemic Flu, H5N1 flu in southeast Asia, etc.).	Intensification of production leads to more close contact between animals and humans which supports the emergence and maintenance of zoonoses and reverse zoonoses.	The cause of most mycotoxin problems. Conservation and management of crops for animal feed free of mycotoxins is especially critical and is a common problem in larger and intensive animal production (swine, avian, feedlot, etc.).

Across the range of drivers identified as potentially having the most impact on animal disease challenges in the Americas, new diseases, zoonoses and endemic bacterial/viral diseases, including disease syndromes, were the disease groups seen as most likely to be affected.

Annex 1c - Moscow Workshop Backcasting

1. Differences between now and future

Enablers

	Enablers	Research needs
1	International Collaboration – to achieve or expedite achievable goals. Intellectual/core competencies and financial resources brought together focusing on specific priority projects will enable our ability to achieve our vision. It allows multidisciplinary approach.	• construct global/regional research alliances around major animal diseases. • Funding to ensure completion of all project milestones • Interdisciplinary research
2	Investment in basic research – to enrich the research pipelines.	• Improved animal models • Improved risk assessment • Critical for driving developments and opening new frontiers and paradigm shift needed in vaccine development • Critical to develop tools for curtailing diseases
3	Improved technology transfer • Scientific information Need to get information in the hands of stakeholders. Public-private partnerships. • Protecting intellectual property. Need processes in place so that the innovation is transferred to a pharmaceutical company.	• Translate (communicate effectively) scientific information to improve disease management and on-farm biosecurity by linking science education and knowledge transfer to end users. • Scientists with the help of experts in information services will write articles in trade journals and present reviews where stakeholders receive information • Need to help scientists with transferring technologies that require intellectual property to be protected. • Need to develop mechanisms such as gap analysis that will identify what technologies need to do – vaccines/diagnostics profile • Strong linkages with stakeholders and public-private partnerships
4		Better and continuous gap analysis for priority animal health projects
5		Immunology
6		• Predictive Biology ○ Molecular epidemiology
7		Big data – bioinformatics

3. Timeline 2034 – key events

Time lines: (key events in the region) Requirements:

In the short-term

1. Gap analysis
2. Alignment of financial resources and capacity

3. Build global alliances

In the mid-term (2024)

1. Building mechanisms to transfer scientific information to stakeholders
2. Strategy for protecting intellectual property

In long-term

1. Translating scientific achievements and improved knowledge transfer
2. Building linkages with stakeholders in Public Private Partnerships

Continuously

1. Gap analysis
2. Basic research

4. Key Areas for the region to meet key events

1. Invest in basic research that will feed the research pipeline
2. Better and continuous gap analysis for priority animal health projects
3. Immunology
4. Predictive Biology
5. Predictive biology – molecular biology /bacteriology/molecular epidemiology to indicate drivers of pathogenesis (Corona viruses are emerging – why).
6. Need a paradigm shift in how we approach vaccinology(move from the Pasteur approach to a systems pathology to design new vaccines)
7. Big data – need to build databases around pathogens
8. Operator research or field research. Production systems differ between countries and also between field and isolation facilities where vaccines developed.
9. Antimicrobials – alternatives to antibiotics
10. Focusing on regional needs (e.g. poisonous plants)
11. Technology – nanotechnology, reverse genetics
12. Need to select technologies for the purpose of solving problems and not just for the technology sake e.g. using nanotechnology to improve adjuvants for local

Annex 1d - Disease threats, impact and research needs – Bogota workshop

What disease/zoonotic issues will be of the greatest importance in the Americas in next 20yrs?	**Why?**	**What is the impact? (who, economic or social)**	**What research/actions do we need to minimise the impact?**
Animal influenza viruses	Characteristics of viruses - recombine easily. Dynamics around world - animal/human interface, increasing commerce. Migration of wild birds. More outbreaks? More able to detect. Also in bats		Improved understanding of pathways from wild to domestic birds and humans. Refer to gap analysis. Need to include/consider all affected species incl. humans.
Chagas	biting bugs. Family dogs to people	Humans - cardiac, long term. Difficult to treat	Vector control. Improved diagnostics
Chikungunya	Wildlife. Migration		

Leishmaniasis	biting flies. Family dogs to people. Contaminated food	Humans. long term. Difficult to treat	Vector control. Improved diagnostics
VBD - Epizootic haemorrhagic disease, bluetongue	Moving from wild species to livestock(EHD); Extending range, New strains emerging (BT), recombination	Economic	See gap analysis - epidemiology, disease dynamics, vaccines(EHD), no stockpile of BT vaccines. Vector competence. Diagnostics
rift valley fever	Extending range	human	Vector competence, diagnostics, vaccines
FMD	Rapidly spread - 7 serotypes and 60 serotypes, don't know what is circulating; SAT strains are hypervariable	Economic, trade, loss of animals	Improved Vaccines- mulitvalent; What viruses are circulating in endemic countries; disease ecology; improved understanding of persistence; vaccination to live strategies
Helminths	Drug resistance	Economic, residues in food	biological control; improved production systems; diagnostics for resistance; improved use to prolong efficacy; alternative therapies
Flavi virus - Japanese encephalitis	RNA viruses - mutations, vector transmission - mosquitoes; spreading geographically (Venezuelan encephalitis);	Human health,	Diagnostics (discriminatory among encephalitis viruses); vaccination;
TB	Antibiotic resistance in M. tuberculosis; wildlife reservoirs (wild boar, deer,); cats get infected	human health, economic	
Bat lyssaviruses (rabies)	Climate change - increasing temperature so bats found at high altitudes; Areas with infected bats expanding; bats migrating to urban areas from rural parts	Human health	Pathogenesis in bats; vector control; disease ecology and modelling;
New Emerging corona viruses	Changing tissue tropism, RNA viruses-mutation; Jumping species barriers	Human health; economic	Understand what is driving their emergence - host range specificity virulence; diagnostics; emergency corona virus vaccine platforms; lactogenic immunity in pigs in relation to PED; basic research on virulence
antibiotic resistance/availability	widespread resistance;	Economic; welfare; potential human health issues	Alternatives to antibiotics
Toxoplasma	wild and domestic cats; uncooked meat; immunosuppressed		
Fish viruses - Infectious Pancreatic Necrosis; ISA virus	intensification of fish-farming	Economic; food security	Vaccines; vaccine delivery; good production practices/biosafety; GM fish; Diagnosis; environmental change and disease occurrence
Viruses of crustaceous e.g. white spot	intensification of fish-farming	Economic	Immunomodulators; good production practices/biosafety
Leptospirosis	Problem of public health; loss of expertise	Economic, zoonotic,	Rapid easy diagnostics; diagnostic platform
Respiratory disease in poultry, pigs and cattle		Economic	better understanding of pathogenesis; better bacterial vaccines (Mannheimia and mycoplasma)
Brucellosis		economic, public health	
Diseases of bees			

Annex 2: Asia & Australasia

Annex 2a - Regional foresight workshop

The Asia and Australasia Regional Network used seven questions (shown in **Annex 2a (i)),** a method designed to stimulate futures thinking, to identify the scientific and technological needs to prevent, control or mitigate animal health and zoonotic challenges for 2025 and beyond during its meeting in Beijing. As well as looking at possible future challenges, participants discussed the animal disease events that had occurred in the region over the last 20 years, the common features and drivers for their emergence and whether they are likely to occur again.

Thinking back over the past 20 years, what animal health challenges emerged in your country and internationally?
Were there common features about them?
What drove their emergence?
Social
Technological
Economic
Environmental
Policy/Political

1990
Tryps spread (Indonesia); increasing problems with helminths (including Fasciola)
PRRSV; NCD (Indonesia)
BSE (UK)
CSF; Hendra

1995
0157

WNV
Nipah (Malaysia)

2000 FMD (Japan); PRRSV;
BSE (Japan)
Nipah (Bangladesh)
HPAI
PMWS

2005
PRRS-HP; HPAI;
Anthrax
CSF (Japan)
H1N1

2010 FMD (Japan)
Brucellosis increased prevalence
PrV; H5N1 (duck in Indonesia); PRRS

2015

Other diseases that emerged which we might have included are:
White Spot of prawn, infectious salmon anaemia.

Common Features and What drove their Emergence

Intensification of production systems (economies of scale) – increasing demand for food (including protein) – industrialisation (Density and size of cities). (Eco)
Increased density of animals (contributing to FMD in Japan) (Econ)
Mixed farming (swine/poultry including ducks) – but now combined with industrialisation (Econ)
Movement of people/animals/materials – easy transportation
Trading (international) (Eco; S)
Increasing urbanisation – loss of land; demand for food; movements; intensification of agriculture around urban areas (Eco; S)
Increasing contact with wildlife (Env; Eco)
Technology Related (New disease detections – e.g. PRRS and PCV2) (Tech)
Highly pathogenic (common feature) (Tech)
Evolution of pathogen. (Tech)
Breeding for production/Selection for production parameters – narrowing of genetic pool (Tech: Eco)
Emergence of AMR(Technical driver) – large scale use of antibiotics in production (Tech)
PPR emergence when rinderpest vaccination stopped (Tech)
Change of feeding (BSE) (Tech; Econ)

Climate change (Env)
Unbalanced environment/Ecosystem Change (Env)
Changing diets (move to non-vegetarian diets) (S; Econ)
More pet birds (S)
Governments more open in reporting (not a driver but an explanation) (P)
Policy issues (disease eradication) (P)

The same drivers, especially intensification, apply for the fish diseases mentioned.

Are these drivers likely to continue and level at which they are acting:

Interaction with wildlife – yes – acting at level of the source of infection. (Env; Econ)
Intensification – yes (but could decline in some areas?) – acting at level of the source of infection(pathogen evolution), transmission and outcome. (Econ)
Increasing animal population density – acts at the level of transmission. (Econ)
Economic – yes
Movement of people/animals/products – yes - acting at level of the transmission, source of infection, and outcome. (Econ; S)
Trade - acts at both the level of the infection source and transmission (Econ)
Urbanisation – yes - acting at level of the outcome (Econ; S)
Conflict – (e.g. Spread of SAT2 FMD in North Africa) – acts at both the level of the infection source and transmission (P; Econ; S)
Climate Change – yes – amplifier, acting across the other drivers – acting on source (increasing range) and transmission pathways. (Env)
Extreme Events – yes - acting at level of the transmission, and outcome. (Env)
Animal breeding – there is a move to look at preserving genetic resources (Tech)

Technology – yes - acting at level of the source of infection

AMR - acting at level of the source of infection (Tech)
Pathogen evolution – yes - acting at level of the source of infection (Tech)
Technology – decreased vaccination – increased transmission. (Tech)

From an economists point of view important issues would be the supply chain and costs. Supply chain would include handling, food safety and production systems (looking at the movement of imports as well as products)

What might upset these trends/assumptions (wild cards)

Small scale farms merge to form larger ones and so people become dependent on food from further away so susceptible. (Econ)
Big companies become bigger – monopolies (Econ)
Supply chain disruption - war, political (e.g. global economic balance), natural disasters (flood, hurricanes, drought), market /economic crash. (Econ; P; Env)
Big disease outbreaks (pandemics)
GM is an opportunity as well as a threat (e.g. to biodiversity) (Tech)

Are there current and near-term challenges facing animal disease research and control that could have significant impact on longer-term outcomes?

Public/policy research cooperation – difference in interests, public good versus commercialisation. (P)
Government priorities often don't include animal health – driver is reallocation of funds by government (e.g. subsidised food prices). Democracy – populist measures. (P)
Policy makers not aware of importance of animal health in relation to human health and food security. (P)
Solution? Convince politicians – marketing
Invest money in animal disease research
Agriculture is low priority as is animal health (P)
Crops get more priority than animals (P)
Animal health research lower profile than human health research (P)
Government policy should look at long-term effects (P)
Lack of technical innovation for animal disease research (T)
Continued pathogen evolution – vaccine development is difficult with current technologies. (Tech)
Defective Surveillance/monitoring systems (T)
Develop effective vaccines – eradication is a driver but vaccination is a control measure. (Tech)
Need to develop competency of researchers
- ability to use knowledge (T)

Networking to share information – need a standardised format (T)
Price and quality of technologies (Econ, T)
Specialisation requires more people – share information – avoid duplication (T, P)
Too much additives/antibiotics in feed (T, Econ, P)
Technology transfer without impact assessment, e.g. on environment
Air and water pollution to animal health – driver deforestation (E)
Climate change – can't be prevented – long term disease effects (E)
Animal welfare

What technological developments are needed for a good future with respect to animal health

1. Rapid diagnostic technologies that are specific and sensitive
2. Disease monitoring and early warming (sensory technology)

- epidemiological analysis; modelling

3. High quality vaccines
   - effective, long-lasting, safe, DIVA, low cost, multivalent, ease of administration (oral and aerosol); thermostable
4. Broad-based immunomodulators
5. Breeding
6. Improved embryo transfer technologies
7. Breeding disease resistant animals
8. Explore traditional technologies
9. Alternatives to anthelmintics and antibiotics
10. Animal identification technologies
11. Less residues

Annex 2a (i) Regional Foresight Workshop, Beijing – Seven Questions

Objectives: "To identify the scientific and technological needs to prevent, control or mitigate animal health and zoonotic challenges for 2025 and beyond"

('what is important is not predicting what will happen, but being more prepared to engage with whatever may happen")

"The questions below are designed to trigger your thoughts about the future. They are intended to guide, not limit, the conversation. Other topics may emerge; some questions may not be covered. The discussion is an opportunity for us to gather insights and hear what you think is important. From it we will prepare a report summarizing the key ideas as input to a larger scenario development exercise. All discussions will be strictly anonymous. No response will be attributed to any individual. We hope you will find the questions interesting, even intriguing, in raising your thinking about the future. We look forward to talking with you.

- Past Challenges – Thinking back over the past 10 – 15 years, what animal health challenges emerged in your country and internationally? Were they part of a continuous trend or were there discontinuities? Were there common features about them? What drove their emergence? Are these drivers likely to continue?

- Lessons from the Past – Reflecting on past challenges, was the available technology fit for purpose in relation to detection and control? Are there lessons to be learned – what worked well; what didn't work well?

- Current Constraints – What things need to be changed for animal disease and zoonoses research to be successful in the future? Are there barriers to innovation and change that need to be addressed?

- Challenges – Are there current and near-term challenges facing animal disease research and control that could have significant impact on longer-term outcomes? What are the challenges and what is driving these challenges?

- Dark Spot - There is a dark spot on the horizon perhaps a wild card that seems unlikely but could have a high impact. It is not here now but could have a major impact on animal health in the future. What is it?

- Good Future – Suppose you were looking back 10 - 12 years from now and you were telling a story in which animal disease and zoonoses control had done extremely well.. How would the story go? What does a good future look like? What societal and technological developments are needed for that good future to occur?

- Oracle - The future is unknowable, but suppose you could ask two questions of an oracle who could predict the future, what would you ask about animal health threats? "

Annex 2b Driver – Disease Group Interactions

A matrix was developed with the highest ranked drivers on one axis and a number of different categories of disease on the other axis. Participants in the online exercise were asked to consider and classify (low, medium or high) the likely impact of the various drivers on the different disease categories and consider the type of technology needed to counteract the impact of the various diseases.

Asia & Australasia		Disease Groups						
Drivers		Vector-borne diseases	Epizootic Diseases	Helminth diseases	Endemic bacterial/viral diseases, including disease syndromes	New diseases	Zoonoses	Fungal diseases, including mycotoxins
Increasing population size/density	Impact:	High	Very High	High	High	Very High	High	Medium
	Comments:	↑ in VBD as will the chance of infected vector finding susceptible hosts. Negative impact on environment will also ↑ VBD.	↑ in epizootic disease occurrence.	Mainly transmitted via oral route e.g. contaminated water, pastures and fodder and all of these will face pressure from increased demand of the human population leaving animals more vulnerable.	The mobilisation of the additional man-made and natural resources required to maintain levels of animal production and health will be a challenge and is likely to provide completely new problems with respect to endemic diseases. Insufficient feed/fodder/health cover, mutations/drug resistance might also increase endemic disease occurrence.	May lead to emergence of new pathogens, particularly when farm species are mixed and graze in wildlife reserves thus making encounters more likely - situations which are common in some developing countries. Increased demand will also lead to increased imports of live animals and products.	Likely to significantly increase the occurrence of zoonotic diseases because of increased human-animal (inlcuding wildlife) interaction.	Likely to increase the occurrence of fungal diseases including mycotoxins.
Biosecurity including surveillance and monitoring (on farm level, national level)	Impact:	High	Very High	High	High	Very High	High	Medium
	Comments:	Early detection of VBD leading to technology-backed control and prevention to minimise spread	Big impact in epizootic disease prevention.	Recent increase due to drug resistance, non-availability of helminth-egg-free pastures and clean fodder. Farm-level and national surveillence and monitoring will improve understanding of helminth (seasonal) distribution in animals and pastures.	Improved measures will have a positive impact.	Early detection of new pathogens is crucial in preventing their spread.	Early detection improves the ability to put in place preventative and control measures.	Unlikely to have a significant impact.
New science/ technologies	Impact:	High	High	High	Very High	High	High	High
	Comments:	Control driven by new generation, safe and effective vaccines and new diagnostic platforms. Better understanding of vector biology incl. host-pathogen interactions will have a high positive impact on VBD control.	Big impact in epizootic disease prevention.	Will have a positive impact. Knowledge gaps in host-pathogen interaction, mechanisms of emergence of resistance, and immune response. New science on different aspects of helminth diseases will lead to new drugs, vaccines and more sensitive diagnostics.	Will help understanding of host-pathogen interaction, evolution of pathogens and their ability to spread. New science will also lead to better vaccines, drugs and diagnostics thus having a positive impact on endemic disease control.	Important in understanding how new pathogens emerge and spread in order to track new disease situations. New drugs, vaccines and diagnostics.	Better vaccines, drugs and diagnostics as well as new technology for large scale real-time communication.	Effective fungicides, improved detection methods and proper storage of feeds and fodder will help minimise the occurrence.
Desired balance	Impact:	Medium	High	High	High	High	High	Medium

between economy, ecology, environmental impact, animal welfare and sustainability	**Comments:**	Intensive animal farming is a big cause of greenhouse gas emissions. Pursuit of economic development to meet human needs has negative impact on environment which also contributes to climate change. Achieving a balance will reduce envirnomental impact and reduce VBD.	Positive impact.	Maintaining a balance under unavoidable economic development is a great challenge. Without a balance there is likely to be a negative environmental impact and consequences for availability of clean water, land, feed etc. Animal welfare is also increasingly important. Balance will be beneficial for helminth control.	Increased demand on resources including infrastructure will be a big challenge so a well thought out strategy to strike a balance the drivers will have a positive impact.	Positive impact.	A balance would be beneficial for control of zoonotic diseases but is very difficult to achieve, particularly in developing countries.	Balance could help reduce the burden of fungal diseases including mycotoxins.
Movement of animals and their products	**Impact:**	**Low**	**Low**	**Medium**	**High**	**Very High**	**High**	**Medium**
	Comments:			Unlikely to have a major impact.	Movement without proper measures can see diseases spread to new, previously unaffected regions.	Easy spread of diseases to new regions so tracability is very important in determining origins of new diseases.	There is a lot of movement of animals and their products in Asia without proper testing and regulations with a negative impact on zoonoses.	Unlikely to have a significant impact.
Climate change, including extreme weather events	**Impact:**	**Very High**	**High**	**High**	**High**	**High**	**High**	**High**
	Comments:	Spread of VBD to new areas e.g. Bluetongue. Excessive rain can have unforseen consequences and droughts can decrease vector population. Reduced food production can cause malnourishment and susceptibility to VBD.	Will increase occurrence of epizootic diseases	Excessive rains and flooding may allow perpetuation of helminths on farm land and pastures. Likewise, droughts may see a decline.	High negative impact on occurrence of endemic diseases and their spread to different parts of the world.	Likely to contribute to the emergence and spread of new diseases.	Impacts on the environment and ecology which could to increased spread of zoonoses.	Likely to increase the occurrence of fungal diseases and mycotoxins.
Political leadership including short-term thinking and loss of technical expertise	**Impact:**	**High**	**High**	**Medium**	**High**	**High**	**Very High**	**High**
	Comments:	VBD control requires multi-sectorial collaboration which requires political committment and vision and financial resources.Short term thinking and loss of expertise will have a serious negative impact.	Lack of political leadership and expertise will increase likelihood of epizootic disease spread.	Lack of political leadership and expertise will have a negative effect on dealing with helminth diseases.	Poor leadership and loss of technical expertise will seriously affect the control of endemic diseases which cause huge economic loss.	Political leadership and management is very important in the case of new disease outbreaks.	Informed and technically supported leadership is important in controlling zoonoses.	Lack of political leadership and expertise will have a negative effect on dealing with fungal diseases including mycotoxins.
Intensification/ bigger production units and factory farming	**Impact:**	**Medium**	**High**	**Medium**	**High**	**High**	**Low**	**High**
	Comments:	Does not appear to be sustainable in developing countries and results in huge waste to be treated and released in the environment - breeding ground for vectors. High number of animals means more chance of infection by VBD.	Increase chance of more rapid spread.	Likely to increase the problem of helminth diseases as indirect consequences of such practices.	Likely to negatively impact the control and management of endemic diseases.	Likely to create situations where new diseases/pathogen mutations occur.	Likely to negatively impact the control and management of zoonoses.	Could have a positive or negative impact depending on management practices but is likley to decrease the occurrence in the long term.

Across the range of drivers identified as potentially having the most impact on animal disease challenges in Asia & Australasia, new diseases, zoonoses, epizootic diseases and vector-borne diseases were the disease groups seen as most likely to be affected.

Appendix 2c - Moscow Workshop Backcasting

Zoonoses – need some focus – not captured clearly in vision

For this region neglected zoonoses are a priority – TB, Brucellosis, Rabies, JE, Leptospirosis

Differences (2035)

Less disease in the future
Better control of disease
Rapid control of disease

Less land allocated to animal production → small holders →more ecologically sustainable
Sustainability → factory farming will be different.
→ welfare – small farms, 25 animals/farm
Small holders – good biosecurity (now very poor biosecurity)
Closed systems – factory farms

Zero waste → energy
Segmented markets– both big and small
Labelled products → reflects quality issues

- Residues / antibiotics
- Organic
- Lifecycle analysis → energy footprint
- Small niche markets

2014

2017 Severe drought in India → animal movements
2018 FMD pandemic

2020
2021 New AI virus
2022 novel disease detected
2023 GM plants/crops widely available
2024 hurricane Disease resistant poultry breeds
2025
2026 New AI virus
2027 plant disease outbreak – soya beans → cuts global supply

2030 Routine – GM animals without specific receptors for pathogen

2035 Disease resistant pigs to swine fever

Barriers

	Barriers	Research needs
1	FMD, Influenza etc	
2	New diseases	
3	Acceptability of new technologies	
4	Lack of resources - $	
5	Lack of harmonisation of registration regulation	
6		**Target areas of Research/capacity building, knowledge transfer**
7		Developing genetically engineered animals - Rate of progress fastest for poultry → pigs → small ruminants → large ruminants
8		New genetically engineered vaccines for some diseases – BTV, FMD
9		New therapeutics for parasitic (coccidiosis) and bacterial diseases
10		Express methods – deep sequencing
11		Technologies and surveillance. Need for sharing of information across countries
12		Transfer of technology and resources (e.g. adjuvants)
13		Public – private partnerships involving industry
14		Capacity building in government
15		Data management and transfer issues

16		Regional collaboration – trans-boundary sharing
17		Transfer of technology • From one part of the world to another (e.g. available adjuvants) • From scientist to stakeholder – (terrestrial and aquatics) • Forming partnership – industry and research e.g. Pfizer, Merial (Same as Americas)
18		Capacity building – for professionals in the field and lab.
19		Capacity building of professional bureaucrats (leadership) Important basis for disease control Safe food Secure food

Enablers

	Enablers	Research needs
1	Social acceptability of new technologies	
2	Breeding of animals resistant to pathogens	
3	New vaccines – some could be from genetic engineering – multiple along timeline	
4	Knowledge transfer	
5	Express methods for detection	Using express methods more generally/routinely for detection i. e.g. sequencing; routine deep sequencing methods; Real time PCR ii. Immunochemistry. iii. Histology Linking deep sequencing and surveillance
6	Harmonisation of registration	

Annex 2d - Disease threats, impact and research needs

Which disease/zoonotic threats do you think could emerge in the next 20 years?	Why?	What is the potential impact? (who, economic or social)	How do we prepare to minimise the impact? Actions/structural/policy/science
Rabies	Continuing problem but in decline as increased effort on control (India). Welfare lobby against control of stray dogs is a problem. Dogs interaction with wildlife. Decrease in hunting means more foxes. Hunting dogs Infected) brought into other countries.	Human health	One health approach needed - cooperation between ministries of agri, environment and health. (min ag because dogs infect cattle in Philippines). Political issue. Bring human and veterinary governance structures inline.

Leptospirosis	Climate change and extreme weather - erratic - flooding. More interaction between humans, wildlife and domestic animals. Fractured ecosystem e.g. roads cutting through forests. Movement of people.	Important zoonosis. Undiagnosed deaths. Increased treatment costs. Public health issue. One of many diseases with fevers with similar symptoms.	Diagnostics to determine cause of fevers. Multiplex PCR for multiple causes of fever.
Avian influenza	New strains re-emerging. Mutation - can be bad but can also result in less virulent strains. Migratory birds e.g. in Kerala - ducks contaminate water bodies which spreads virus. Virus survives in sediments of rivers, lakes, ponds. Govt restrictions on sharing info (particularly for AI) - only govt. can declare outbreak so initial investigations kept secret. Also issue of sharing info within a country e.g. between industry and government and scientists.	Trade, pandemics - culling, zoonosis	Monitoring. High biosecurity. Understand characteristics of the virus that allow it to jump between species i.e. wild birds to ducks to chickens. Early sharing of information e.g. virus survival capacity in water and sediment.
Schistosomiasis	In certain region of Philippines for humans. Transmitted by snails. Environment - more water bodies due to flooding, extreme weather.		
Liver fluke	Immunomodulation and impact on mycobacterium.		
Filariasis			
Salmonellosis	Use of antibiotics restricted. No Abs leads to more chickens and human infections.		Alternatives to Abs incl. vaccines. New breeds/poultry lines resistant to salmonella.
Antimicrobial resistance			
Tuberculosis (M. Tuberculosis)	Passing from humans to cattle and back again, Crowding and close contact between humans and animals. Skin test reagents expensive. Emergence of resistance to antimicrobials. One health		One health approach. Diagnostics to distinguish between M. bovis and m. tuberculosis in cattle. Vaccines
IBD	Strain differences		
ILT	Current vaccines ineffective.		
Infectious bronchitis and other coronaviruses	New strains evolving.		
Chicken anaemia	Supresses immune system		

Marek's Disease	Evolutionary pressure resulting from vaccination		New vaccines that prevents viral replication and shedding. Monitoring viral evolution in vaccination.
ND			
African Swine Fever	Detected in bats in Bangladesh		
PRRS	Spreading new strains. Live vaccines recombining with field strains.		
Bat-borne viruses/Nipah/Hendra	Bats - India and Bangladesh. Hendra in horses in Australia. Zoonotic		
Porcine circovirus	Vaccine not available in India. Multiple strains prevalent.	Pig farmers	
PED			
Trichinella in pigs	Exports - strict. Public health impact		
HS in buffalo	Buffalo dies within 2 days. Related to stress		
Surra in buffalo	No preventative treatment. Biting flies - multiple species		
Lentivirus CAE, MV			
Ovine progressive pneumonia			
Haemonchus			
Paratuberculosis	No good diagnostic.		
Bluetongue			
Schmallenberg			
CCHV			
IBR			
BVD			
Brucellosis			
Chlamydia	Ducks, abortion in sheep		

Annex 3: Europe

Annex 3a Regional foresight workshop

As part of the European Animal Health and Welfare ERA-NET (ANIHWA), a two-day foresight workshop was held in Madrid at which 39 experts from a range of different backgrounds, including animal health and welfare, social, political and economic sciences, animal production and technology, from 16 countries across Europe considered the scientific and technological needs to prevent, control or mitigate animal health and zoonotic challenges and address animal welfare requirements for 2030 and beyond. The workshop involved the development of four scenarios based on two critical uncertainties; the level of human contentedness in society and the rate of environmental change. The group also considered a fifth scenario – a preferred future in which there is sustainable livestock production, with healthy animals reared under high welfare standards, disease minimised or rapidly contained, ensuring a safe and secure food supply and economic development. Backcasting was used to identify what is needed in terms of research capability to get from the present situation to the ideal future taking into account the possible challenges identified in the scenarios development exercise. One group looked at barriers and enablers 'within our control' and the other looked at those 'outside of our control'. The results of these exercises can be found in the report on the Madrid Workshop.

Report on the Madrid Foresight workshop, i

Annex 3b - Driver – Disease Group Interactions

A matrix was developed with the highest ranked drivers on one axis and a number of different categories of disease on the other axis. Participants in the online exercise were asked to consider and classify (low, medium or high) the likely impact of the various drivers on the different disease categories and consider the type of technology needed to counteract the impact of the various diseases.

Europe		Disease Groups						
Drivers		Vector-borne diseases	Epizootic diseases	Helminth diseases	Endemic bacterial/viral diseases, including disease syndromes	New diseases	Zoonoses	Fungal diseases, including mycotoxins
Increasing population size/density	Impact:	Low	Low	High	High	Very High	High	Very Low
	Comments:	West Nile, Chikungunya, Bluetongue, Nipah, Lyme, TBEV	African Swine Fever, Influenza	Taenia	Herpes	Wildlife diseases, SARS, SIV, MERS	Brucellosis, Campylobacter, Samonella, Q fever; Hep E, MRSA	Manganese, toxins from pollution
Attitudes/ expectations relating to production systems and animal welfare	Impact:	Medium	Very Low	Medium	Medium	Medium	Low	Very Low
	Comments:			Related to outdoor production	Organic systems			
Attitudes and expectations	Impact:	Very Low	Medium	Medium	Medium	Very High	Medium	

relating to food security, including cost, and food safety	Comments:				Also consider endemic prion diseases.		Toxoplasmosis, Taenia	
Biosecurity including surveillance and monitoring (on farm level, national level)	Impact:	Very High	Very High	Very High	Very High		Very High	
	Comments:	Lyme disease, Cryptosporidium, Histomoniasis, Liver fluke	Brucellosis, FMD, Avian Influenza, CSF					
Desired balance between economy, ecology, environmental impact, animal welfare and sustainability	Impact:	Medium						Very High
	Comments:							Fish farming
International trade including movement of animals within and across borders	Impact:	Medium	High	Low	Low	High	Very Low	Very Low
	Comments:		Vesicular diseases	Drug resistance			Trichenalla, Taenia	
Economics of farming, including profitability and competitiveness	Impact:	Very Low	Medium	Very High	High	Medium	Medium	Medium
	Comments:		Cost of biosecurity	Gastro-intestinal parasites	Mastitis, BVD	Prion diseases	Cost of biosecurity	Economies and feeding, water quality, mycotoxins, metabolic
Alternative sources of protein for both humans and animals	Impact:	Very Low	Medium	Very Low	Medium	Very High	Medium	High
	Comments:							Plant related toxins or byproducts
Climate change, including extreme weather events	Impact:	Very High	Medium	Very High	Medium	Medium	High	Very High
	Comments:	Tick-borne diseases	African Swine Fever	Flukes, PGE			Leptospirosis	Undernutrition
Disturbed ecosystems including invasive species	Impact:	High	Very High	Very High	Very Low	Very High	Medium	Very High
	Comments:		Bee diseases, ASF	Bees			Tick-borne diseases, Echinococcosis	Fish metabolic
Human - domestic animal - wildlife interaction	Impact:	High	High	High	Medium	High	Very High	Very Low
	Comments:	ASF, West Nile; vector-borne diseases with a wildlife reservoir	Influenza	Fish	TB		TB, West Nile, Echinococcosis, Lyssaviruses	
Waste management, including recycling as animal feed	Impact:	Very Low	High	Medium	Low	Medium	Medium	High
	Comments:			Protozoa e.g. Giardia		Prion diseases	Salmonella, Taenia, waste from abattoirs/ human waste	Fish - hormone disruption Oher animals - heavy metals; poisoning, amplification of chemical contaminants by recycling
Harmonisation, effectiveness and impact of regulations and policies (including EU agriculture policies)	Impact:	Medium	High	Medium	Medium	Very Low	High	Medium
	Comments:	BTV vaccination	FMD, TB and other statutory diseases	Coccidiosis	Availability of medicines	Prions	Inter-departmental harmonisation - One Health - Public Health	High - phosphorous deficiency, mycotoxins
Pathogen evolution (including anti-microbial/drug resistance)	Impact:	Very High	Very High	High	Very High	High	High	Medium
	Comments:	Pathogen adapting to new vector and host; Schmallenberg, BTV				Pathogen evolution could lead to new diseases	Wildlife diseases	Mycotoxins might increase
Intensification/ bigger production units and factory farming	Impact:	Medium	High	Very High	High	Medium	Medium	Low
	Comments:	Intensification potentially decreases contact with vectors; ticks, mites, fleas	Affects larger numbers of animals due to intensification	Coccidia in pigs will increase and parasites needing pasture for their life cycle will decrease	BVD	Decrease		
Alternative animal husbandry practice	Impact:	Medium	Medium	Very High	Medium	Medium	Medium	Medium
	Comments:							Nutritional deficiencies - amino acids

Across the range of drivers identified as potentially having the most impact on animal disease challenges in Europe, new diseases, vector-borne diseases, epizootic diseases and helminth diseases were the disease groups seen as most likely to be affected.

Annex 3c Moscow Workshop Backcasting

Elements of the future vision that differ from present

Current situation: we can provide safe food for all

Anticipated future changes - increase of antibiotic resistance
Increased of anthelmintic resistance

Russia Threat from wild fauna
Increased threat from travelling populations

Europe Surrounded by buffer-zone (buffer-zone has control, centre is looked at less as control concentrated on buffer zone.

Currently the focus in on large disease outbreaks and less attention to problems that are relatively small but very costly

Biosecurity prevents animal disease → on farm

Food fraud → consumers do not perceive as safe/secure. Fraud causes loss of production due to consumers' loss of confidence. Need for transparency

Future:

Increasing size and concentration of animal populations (Big farms with increased biosecurity)
Biosecurity is key at all levels
Policy level important
Loss of effectiveness of antibiotics in the future
    Biosecurity provides conditions for reduction of antibiotics
Local breeds often provide genetic resistance
    Change in breeding management
    Cloned and GM engineered animals
Aquaculture more important
Governmental veterinary services are shrinking
Greater focus on Disease prevention/Early warning
Consumers want shorter supply chains

Neglected zoonoses?
Ensure animal health status in Europe area – add buffer zone
    Closed system is not easy to sustain
    Boundary system – develop security

Barriers

	Barriers	Research needs
1	Antibiotic effectiveness and availability	Host resistance; vaccine development/ Vaccinology, including HPI; biosecurity/management; Epidemiology – integrated disease control; Alternatives – antimicrobial peptides, immunomodulators, New antibiotics
2	Anthelmintic effectiveness	Mechanisms of resistance; Markers of resistance; Others as in 1 above. Capacity in parasitology – shortage.
3	Gut health including problems related to feed (particular problem with fish, poultry and pig production)	Digestive physiology; gut microbiome; feed including sources; pre/probiotics; Improved understanding of the interaction between

		pathogens and also between the pathogen and the gut
4	Vector-borne diseases	Alternative methods to control vectors – a) Integrated pest management, b) biological control and c) genetic modification
5	Trade in food (and somewhat in animals) including from far countries	Standardised traceability systems – technology Detection systems, Data coming together in real time Technology for inactivation of pathogens
	Transport prices	
	Footprint (sustainability)	
6	Weakness of the system/ downsizing of veterinary services/ lack of control	Integration and better use of existing data Syndromic surveillance (get data of search engines of people looking at say FMD) Using production or food/water consumption data Cost effective real-time collection of data Risk-based approach to surveillance
7	Politics – transfer of ownership/responsibility for dealing with problems from government to industry. Transfer of responsibility of research on certain animal diseases (PED (how to define))	
8	Immigrants - bringing disease; ethnic practices (Ritual slaughter)	
9	Migrant workers - education	
10	Economic – economic pressure not to maintain research capacity in areas where no immediate need e.g. BSE	
11	Regulatory barriers	
12	Intellectual Property rights	
13	Nguoi Agreement/ convention on biodiversity - limitation on importing biological materials	
14	New Diseases	
15	Management of by-products/waste	Waste → by-product safety – detection systems; Assessment of risk of reintroducing disease; research on food sources that are health for animals
16	Costs	
17	Gap between farmer needs and proposed research	
18	Loss of overall Research capacity – countries looking to others to cover gaps e.g. neuropathology; Loss of Parasitology expertise	collaboration
19		

Enablers

	Enablers	Research Needs
	Better use of antibiotics	
	Pressure to make livestock production more sustainable/pressure to innovate	
	Traceability	
	Good controls e.g. testing	
	Integrated surveillance system/ Centralised diagnostic testing	Research on tools for surveillance
	Automated systems	
	Big data – data sharing	

	Biosecurity - at all levels	
	One health approach	
	Management of by-products/waste	
	Precision livestock farming/Automated disease surveillance	
	Policy	
	Personalised technology	
	Translation of regulatory changes, KT to farmers Information to vets and farmers Education of farm helpers	
	New drug development	
	Improved inspection at borders (new concept, more global)	
	Improved vector/biological control	
	Early data interpretation	
	Early pathogen research related to parameter surveillance Biosecurity	
	Alternative protein sources	

Annex 4: Africa & Middle East

Annex 4a - Driver – Disease Group Interactions

A matrix was developed with the highest ranked drivers on one axis and a number of different categories of disease on the other axis. Participants in the online exercise were asked to consider and classify (low, medium or high) the likely impact of the various drivers on the different disease categories and consider the type of technology needed to counteract the impact of the various diseases.

Africa & Middle East		Disease Groups						
Drivers		Vector-borne diseases	Epizootic Diseases	Helminth diseases	Endemic bacterial/viral diseases, including disease syndromes	New diseases	Zoonoses	Fungal diseases, including mycotoxins
Increasing population size/density	Impact:	Medium	High	Medium	High	Very High	Very High	High
	Comments:	Many diseases affecting African populations are vector borne both for humans and livestock and kill in large numbers e.g. malaria for humans (mosquitoes) and theileriosis for animals (ticks).	Increased population compounded by altered ecosystems, climate change, movements of people etc would lead to emergence of epizootics.	Increased population compounded with poverty could lead to increase of helminth diseases.	Increased population could compound poor sanitation and weak health systems to increase incidence of endemic water borne and food borne diseases.	Altered natural ecosystems due to increased demand for resources and intensified human-animal interface would lead to new host-pathogen relationships and evolution of new diseases e.g. Ebola.	Increased human-wildlife-domestic animal interactions leading to greater occurrence of zoonoses.	Increased consumption of grain compounded by poor storage will lead to increased mycotoxins.
One health/ Ecosystem health approach	Impact:	High	High	Medium	High	High	Very High	Medium
	Comments:							
Human – domesticated animal - wildlife interaction	Impact:	High	High	Medium	High	Very High	Very High	Medium
	Comments:							
Movement of animals and their products	Impact:	Medium	Very High	Medium	High	Very High	High	Low
	Comments:	Allows vector borne diseases to spread to susceptible, less affected populations.						
Climate change, including extreme weather events	Impact:	High	Medium	Medium	Medium	High	High	Medium
	Comments:							
Political leadership including short-term thinking and loss of technical expertise	Impact:	High	High	Medium	High	Very High	High	Medium
	Comments:	Politics and leadership are important with regard to the programmes responsible for controlling vector borne diseases.						

Across the range of drivers identified as potentially having the most impact on animal disease challenges in Africa & the Middle East, epizootic diseases, new diseases and zoonoses were the disease groups seen as most likely to be affected.

Annex 4b - Moscow Workshop Backcasting

Present situation:
Most of production systems are extensive. Surveillance in rural zone is critical. Major diseases are endemic.
Lack of policy, inadequate resources allocation, poor capacity of VS to detect, prevent and control AH and D.
Crucial role of wildlife associated with poor interest in investigation/investment in this area.
Presence of different Countries with very different cultural and social background produce severe difficulties in harmonization.
Insufficient investment or interest in host/pathogen interaction for some typical and local species that instead could represent vector or reservoirs for some D. (Es. Camelidae).

Preferred (realistic) future:
The key to obtain resources and due attention is the increase and development of the international trade.
Increase trade opportunities can lead to an increase of resources with opportunities of investments in all sectors and compliance with a long list of standards (positive effect on food safety, production system).
Some regions can become autonomous (food security). Free from 3-4 major diseases.
Improve profitable also from small scale farms (export but also internal market).
Sustainability. Investment in capacity building, VS, can lead in a reform of policy.

Time line 15-20 yrs.

Enablers (not for importance):
Understand role of wild life to better control of diseases
Improve diagnostic capacity of labs
Improve governance
Certified diagnostic centres / increase number and capacities of national vet labs (Es. Africa)
Training VS and farmers
Improve regulation for quarantine (Es. Iran)
Increase compliance with international standards
Increase partnership/collaboration/twinning (ie among professional association boards of vets)
Data collecting and sharing
Increase dissemination of scientific production
Facilitate access of scientists to main paper

Barriers (not in order of importance):
Some countries still in war or complex political situation, this impair communication and transparency of data.
No harmonization among different countries/regions.
Too many social/religious/cultural differences.
Poor resources.
No enough knowledge on ecological systems.

Main research area, indication of short/medium/Long time (time of realization) and of priority/urgency (from 1-to 5 score):

Area	Time of intervention (Short, Medium, Long term)	Priority (1-5)
Vaccine production (priority for thermostable vac.)	S/M	5
Epidemiological studies (with priority on wild; host-pathogen interaction, Local species)	S	5
Validation of diagnostic tests and evaluation of safety and efficacy of vaccine used in different local species (es. Camelidae vs cattle)	S	4
Socio-economic impact evaluation of main diseases	S/M	4
Studies on the impact of diseases on ecology/environment/biodiversity	M/L	4
Research on sustainability of production (also new production system; genetics; assure maintenance of biodiversity)	M	3-4
Knowledge management system (GIS; Sharing Data base)	S/M	4
Improve food safety of production: traceability, compliance with standards, risk analysis; antimicrobial/Residues	M	4
Enforce investments in applied research: demand driven/focus on practical needs (international and private-public partnership)	S/M/L	5
Technology transfer	M/L	5
Research Gap analysis	M/L	5
Invest in capacity building	M/L	5
Studies on traditional Vet Medicine (added by African part.)		

Annex 4c - Disease threats, impact and research needs

At a workshop in Addis Ababa, the Africa & Middle East Regional Network identified the most important disease/zoonotic threats they thought could emerge in the next 20 years, why they might emerge, the potential impact and actions or research needed to minimise the impact. The results of this exercise can be found in the table below:

Which disease/zoonotic threats do you think could emerge in the next 20 years?	Why?	What is the potential impact? (who, economic or social)	How do we prepare to minimise the impact? Actions/structural/policy	How do we prepare to minimise the impact? Scientific research
Rift Valley Fever	Egypt. Israel - Have a lot of sheep. Risk of spreading. Zoonoses - causes deaths. High demand for small ruminants. Increasing extreme weather events. Flooding, BSL 3. Virus in vector eggs in water	Zoonotic. Socio-economic. Affects trade in live animals - restrictions of convenience. Loss of animals from abortions.	Surveillance, early warning, early detection, risk analysis, rapid diagnostics & education of farmers and animal handlers.	Vector control. Carrier state of animals. Emergency vaccine development and validation of the same. Where does the virus hide (cyclic - dormant in dry and active after rain etc.) - epidemiological studies. Vector competence studies What happens to the virus during inter-epidemic periods? What is the true impact of environment and cattle trade on the disease evolution/emergence? Could we develop predictive models to predict the future emergence? What is the impact on human health since there seems to be an under estimation of human cases? What could be done to better understand the situation through field surveys including vector trapping, wild reservoirs (bats, rodents, buffaloes) ? What are the risk perceptions for the population and what tools could be used to better tackle RVF in our countries (social sciences)?
Lumpy Skin Disease	Endemic in Africa - appears every 5-7 years. Threat to Middle East and probably to Europe. Need for effective vaccine (pox one not working in Ethiopia). What is the vector?-unknown. Biological or mechanical transmission?	Economic loss due to damage to hides, death of some stock, drop in milk production during viraemic period, loss in damaged skins.	Early detection systems, vaccination, stamping out of early cases, combination vaccines to encourage uptake	Establish insect species involved in transmission and their role - as vectors or mechanical transmission. Improved vaccine

CBPP	Moving to new areas with displaced populations. Cost of treatment drugs expensive. Vaccines no good - short immunity and localised reactions, side effects. Improved diagnostics, pen side tests. Diagnosis of sub-clinical disease important. New treatments?	Loss of affected animals and damage to trade	Testing animals before importation. Risk analysis, develop chemotherapeutics that can get rid of carrier state	Development of improved vaccines and the development of penside diagnostics
FMD	Indigenous breeds more tolerant. Increasing problem because of cross-breeds. Different strains cause many problems. Epidemiology/role of wildlife. Vaccines - better ones required (multivalent). Need to identify areas of high prevalence and have more cost-effective surveillance there. Expensive to test individual animals. Serotyping - matching vaccines to strains is a problem. Vaccines are expensive. Too expensive to produce if African countries all do it individually - need to agree who does it for mass production to achieve economies of scale. Need to address (socio)economics of vaccine production (not only FMD - general need). Socioeconomic study on impact of FMD and control methods. Establish fact based risks of FMD on human health so that minimum / necessary standards to be met by producers in order to comply with foreign markets.	Loss of some young animals, drop in production, especially milk production. Trade. Intensive livestock producers. Draught livestock	Need to address (socio)economics of vaccine production (not only FMD - general need). Socioeconomic study on impact of FMD and control methods. Good biosecurity at a national level. Access to Rapid typing system. Risk analysis. Establish factual / scientifically based risks of FMD on human health so that minimum / necessary standards to be met by producers in order to comply with foreign markets.	Improved vaccines. Establish the role of wildlife - reservoirs or spill-over hosts. Non-invasive survey methods in wildlife. Establish factual / scientifically based risks of FMD on human health so that minimum / necessary standards to be met by producers in order to comply with foreign markets. Research on the typing of the different viruses for a match of the vaccines (with implications on efficacy and cost effectiveness of the vaccination).
Rabies	Settlement/Urbanisation. Stray dogs and cats coming together increases likelihood of epidemics. Much cheaper to control/prevent in animals than to treat humans. General inaction to the situation. Need to improve quality and availability of vaccine for animals - rabies	Deaths Ministry of Health expenditure on post-exposure treatment of humans.	One health approach to overcome division of responsibility (min of agriculture and min of health); Regular vaccine campaigns; Removal of stray dogs	Bated vaccines for stray dogs and wildlife. Improved/faster diagnostics

	vaccination campaigns? Diagnostics.			
Tryps	It is expected that The Human Tryps. will be eliminated in the next 10 years. However, animal Tryps will remain for a longer time and especially the non-Tsetse transmitted type will remain even for a longer time. Climate change and movement of people and livestock will also be among the reasons. Wildlife also contributes as carriers.	Production losses; human infections	Tsetse control programmes over larger areas. Provide intensive support for the existing PATTEC Initiative and broader advocacy to sustain Gov. and donors commitment.	Alternative methods of vector control - genetically modified sterile male
Haemorrhagic fevers (Ebola, Marburg, Crimean Congo HF, Epizootic Haemorrhagic Disease	Human encroachment. CCHF transmitted by ticks to people. Zoonotic. Surveillance of bats and monkeys. Systems for wildlife monitoring. One health approach. Ebola in pigs. Transmission pathways from bats to monkeys to people.	Creates panic response - affects movement of people with consequent impact on economic activity	One health approach. Monitoring/reporting systems and wildlife surveillance	Surveillance of bats and monkeys. Establish transmission pathways from bats to monkeys to people. Rapid diagnostic tests including for wildlife
ASF	Epidemiology, transmission cycles, characterisation of strains. Wild pigs. Ticks. Vaccine needed. Won't report infection if not compensated - explore incentives for control. Been gone for 30 years and has reappeared. Hides somewhere? Ticks, pigs, environment?	Economic impact. Value chain risk analysis. Impact on trade	Won't report infection if not compensated - explore incentives for control.	Characterisation of strains. Need for vaccines, including for use in wildlife. What surveillance system could be set up to better identify the outbreaks? Risk assessment to assess the risk of introduction from an infected area to a free one?
PPR	Moving to new areas, including with the movement of people for religious festivals taking small ruminants with them. Different strains in different areas	Considerable loss of small ruminants.	Having vaccine available and organising vaccination campaigns	Heat stable vaccine What is the risk of introducing the PPR virus from an infected to a free area? How to strengthen surveillance to limit such an introduction? What are the socio-economic impacts of PPR on farmers? What are the major risk factors for infection and what recommendations

				could be made to limit the spread of the virus? What is the real impact of live animal trade? Could it be useful to develop transmission models to test different means of control? How do we assess the role of wild fauna as reservoirs of PPRV
East Coast Fever	Expanding habitat - becoming warmer. Moving north. Spreading - why? Ticks already present.	Impact greatest where animals moved from highlands into endemic areas	Ensure cattle treated with acaricide before they are moved into clear areas, adopt the Infection and Treatment Method of Immunisation in areas of endemicity.	Need for improved vaccines on current infection and treat method. Establish the competency of other tick species. What is the impact and the spread of the vectors involved in ECF (abundance, spatio-temporal analysis, species diversity? Could we develop new tools helping a better control and improving the diagnosis?
CCPP	Big economic losses to small farmers	high mortality in small ruminants, impact on food security and income	vaccination policy	good vaccines, improved diagnostics
TB	Spreads within a herd if not controlled at farm level, especially in intensive dairy herds. Particular problem to control if present in wildlife. Human population may be more susceptible - Aids patients, transplant patients	Zoonotic, especially in immunosuppressed people. Particularly dangerous where cattle infected with M. tuberculosis and current diagnostic(skin test) test doesn't differentiate M bovis infection from M tuberculosis infection. Loss in production	Policy of pre-movement testing of animals. Organised testing campaigns. Policy as to what happens to test positive animals - possible compensation for animals removed. Information campaigns on the importance of pasteurising milk	Need improved diagnostics, especially for early detection. Need for rapid detection methods to differentiate mycobacterium species present. Development of an effective vaccine/establish the efficacy of the BCG vaccine. the role of wildlife in the spread of the disease. Development of a better system to certify the animal status before exportation?

Brucellosis	Continuing important condition that has been eradicated from some areas of the developed world	Zoonotic, an important cause of fevers in people in affected areas. Debilitating chronic sequelae in infected people. Production losses due to loss of offspring	Organised vaccine campaigns, organised testing	Improved (safer and more effective) vaccines, including ones that allow differentiation of infected and vaccinated. Validated, faster (pen side) diagnostic tests. Public education concerning the use of unpasteurized milk.
Infectious Bursal disease	Poultry industry getting bigger so becoming more important. Strain differences cause problems with vaccination	Severe losses where vaccine not protecting against strain circulating	Provision of vaccines (at cost to producers). Monitoring strains circulating so correct vaccines procured	Easier techniques to establish appropriate age of vaccination (when maternal antibodies wean in chicks of particular country)
Marek's disease	Different serotypes. Strains becoming more virulent with the possibility that vaccines may not be protective. Disease appearing at a younger age with possibility of broilers being affected	Very high if current vaccines no longer protected.	Programme to monitor efficacy of vaccines against circulating strains	An improved vaccine that induces sterile immunity - (preventing infection of and excretion of the virus by vaccinated birds)
Young stock mortality	30% in camels. Up to 25% mortality in small ruminants - newly born			
Animal influenzas	New strains constantly evolving and rapidly spreading -	Zoonotic - enormous impact with the development of pandemic strains. Very severe economic losses due to HPAI.	Early detection. Locating poultry houses away from places frequented by migratory birds. Limiting density of poultry production in an area	Pan-influenza vaccine or vaccine platform for use in farmed species. the role of wildlife and migratory birds in the spread of the disease.
Dermatophilosis	Becoming a greater problem in Amblyomma variegatum infested areas where tick control has broken down . Also a greater problem where improved breeds used	High in affected areas where tick control is not maintained due to damage to hides and loss of animals, especially high producing exotic breeds.	Programmes to improve local stock by promoting the use of exotic breeds/crossbreeds should be accompanied by information packs on appropriate tick control	Establish the most cost effective approach to tick control for the cattle breeds being utilised. Improved tick control methods - vaccines against ticks
Unknown camel diseases				
Q Fever	The causative organism is very virulent. The disease spreads by both contact and by tick bites. Affects ruminant livestock and man. Clinical signs are similar to those of brucellosis.	Abortions and neonatal mortality. Severe danger of zoonoses.	vaccination.	

MERSV	Disease spreading to new areas through importation of camels			
Salmonella spp.	Especially important in poultry and pig production, epidemiology of the disease unclear	Human infection - time off work	As production losses in poultry and pigs due to salmonella are not that great there is need for incentives to justify vaccination	Improved vaccines, especially for pigs
Fish diseases (Aeromonas; Columnari; Edwardsiella	Aquaculture in Lake Victoria. Tilapia, catfish	economic impact		Epidemiology
Trichinellosis in pigs	Disease important in pig production	Zoonotic. Losses due to condemnation of tissues	Testing of hunted wild boars before consuming.	Epidemiology/ sero-prevalence studies/ isolation/ control
Cysticercosis in pigs	Backyard systems. Causes epilepsy	zoonotic impact	Public awareness on proper cooking of pork	Improved policies for control
Classical swine fever	Can easily pass borders with infected food or garbage	Severe damage in affected farms	Vaccination	
Newcastle disease	Predicted that future demand for poultry will increase a lot.	Production losses. Losses in export	Having vaccines available	Thermostable vaccines, best vaccine protocols
New diseases	Irrigation systems. Used as a political tool to block trade. Danger of over-reactions internationally. Need long term measured approach			
Bee diseases	Diseases of bees are the major cause of economic losses to farmers in the apiculture industry.	Source of financial income for bee farmers in the rural areas and peri-urban areas.	Building capacity for diagnosis and treatment of diseases of bees	Development of rapid diagnostic tools for diseases of bees and development drugs for treatment of bee diseases
Drug resistance	Drug resistance is an increasing problem in animal and human medicine and in the case of antimicrobial resistance there is the possibility of transfer of resistant organisms between people and animals and also the transfer of drug resistant plasmids between different bacteria. Anthelmintic resistance had got to the stage where, until the introduction of a couple of new compounds, there was no available effective	Loss of effective treatments. New antimicrobials are likely to be restricted to human use	Policies (bench marking) to encourage improved management so as to reduce the need for use of antimicrobials. Monitoring drug efficacy/ resistance	Development of tests (especially pen-side tests) to detect resistance in parasites thus allowing appropriate medication. Establishment of the most appropriate dosing regimen to prevent development of resistance in parasites. Development of new antiparasiticides. Development of alternatives to antimicrobials. Development of

	medicine for some parasite species on some farms.			syndromic diagnostic platforms to identify most appropriate treatments
Food-borne pathogens	Numerous outbreaks of FBD in the Region. Zoonoses (Salmonella, Campylobacter)	/ Economic impact / Resistance to antibiotics is considered a crucial public health issue (WHO, OIE)		What are the pathogens involved in FBD in eastern Africa and the Indian Ocean zone? What are the risk factors of infection and contamination for animals and animal products? What is the susceptibility of these pathogens to antibiotics? What kind of resistance is mostly found in the region?
Toxoplasmosis		Economic impact - abortion storms is small ruminant flocks. Zoonotic - Congenital abnormalities in children, encephalitis in immunosuppressed		Epidemiology/ sero-prevalence studies/ isolation/ control
Mycotoxins in stored feed		Causes economic loss in poultry production due to liver damage. Carcinogens transferred in milk to humans	Advice on storage of feed	Detection systems
PEDV	Highly virulent strain of the causative corona virus emerged ~4 years back in China, moving to north and central America since then	Very high death rate of piglets on infected farms. Appears to recur in waves as herd immunity declines	Improved biosecurity at a national level to try and keep it out. Information to encourage producers to improve biosecurity at a farm level	Establish the transmission pathways. Vaccine
African Horse Sickness				
Bluetongue	new strains - serious threat to Middle East and Africa	Production losses	Relevant vaccinations	Development of vaccine that can vaccinate against all the strains

Annex 5: Mediterranean

Download report at:

http://www.star-idaz.net/wp-content/uploads/2015/04/SECOND-report-FORE-MED.pdf

Annex 6: Global

Annex 6a - Combined driver impact on disease groups

Driver Impact on Disease Groups	Regions				Mean Impact Level: 1 (Very low) – 5 (Very high)
Disease Groups	Africa & the Middle East	The Americas	Europe	Asia & Australasia	
New diseases	4.7	4.1	3.6	4.4	**4.2**
Zoonoses	4.5	4.3	3.3	3.9	**4.0**
Epizootic diseases	4	3.7	3.5	4	**3.8**
Endemic bacterial/viral diseases, including disease syndromes	3.8	4.1	3.1	4.1	**3.8**
Vector-borne diseases	3.7	3.9	3	3.6	**3.6**
Helminth diseases	3	3.3	3.6	3.6	**3.4**
Fungal diseases, including mycotoxins	3	2.7	2.9	3.5	**3.0**

Annex 6b - Moscow Workshop

OPTIONS ANALYSIS: The four STAR-IDAZ regions described their preferred future and identified five research areas/activities/approaches that should be addressed in order to help them achieve their preferred future. Each group scored the items in their own list from 1-5 with 5 being a high priority and 1 being low. They then scored the items identified by the other regions with the results ranked in order of priority and shown in the table below:

Options Analysis	Regions				Mean Score 1 (low) – 5 (high)
Research Areas/Activities/Approaches	Africa & the Middle East	The Americas	Europe	Asia & Australasia	
Prioritisation & gap analysis	5	5	4	5	4.8
Collaboration and networking	5	5	4	5	4.8
Transfer of technology and data sharing	4	5	5	5	4.8
Research pipeline	5	5	4	4	4.5
Fund global research collaborations	4	5	4	5	4.5
Identification of need for futures research	5	3	4	4	4.0
Effective management of research	3	5	3	5	4.0
Prioritisation of horizon scanning and harmonising targets	5	2	5	4	4.0
Applied research	3	5	2	5	3.8
Reducing duplication of research costs	5	2	5	3	3.8
Disease risk assessment	5	2	2	5	3.5
Communication and advocacy	4	4	3	3	3.5
Public private partnership	3	4	3	4	3.5
Harmonisation for product licensing requirements	4	3	3	4	3.5
Policy reform	4	4	1	4	3.3
Harmonisation of surveillance methods and strategies	4	3	2	4	3.3
Invest in basic research	3	5	2	3	3.3
Networks of excellence sustained by funders	3	2	3	4	3.0
Ecological impact of disease	3	2	3	3	2.8
Research into food and animal modelling systems	2	2	3	3	2.5

BACKCASTING: The groups then agreed on the following global vision and performed a back-casting exercise:

"Animal disease minimised or rapidly contained ensuring a safe and secure food supply"

This involved working backwards from the desirable future end-point (global vision) to the present to determine the physical feasibility of that future and what measures are required and aimed to determine:

4. What elements are different between our vision and today
5. What steps are needed to meet this vision
6. What knowledge/research is required to meet this vision

In summary, key factors that will support or inhibit our vision of sustainable disease control/livestock production were identified and the key areas of research/capacity/building/knowledge transfer required to support the vision going into the future.

Annex 6c - Combined results

Scientific, technological and related needs to prevent, control or mitigate animal health and zoonotic challenges for the next 20 years as identified in regional workshops, scenario building and backcasting.

Structural/political

- Sound public polices relating to science and technology - Better impact assessment of new legislation
- Maintenance of capacity – research capacity; diagnostic capacity; surveillance, including field professionals; capacity in parasitology (Europe); neuropathology (Europe); Better capacity to address neglected diseases(Americas); government/professional bureaucrats.
- Improved focus of research activities – gap analysis - Alignment of financial resources and research capacity with needs
- Invest in new (more powerful) technologies.
- Partnerships/collaborations – global/regional research alliances – sharing information between countries
- Harmonisation of registration regulation (Africa) - Increase compliance with international standards (Africa)
- One health approach.
- Knowledge management system – Big data, GIS; Sharing Data - Integration and better use of existing data(Europe)
- Knowledge/technology transfer – to end-users (vets, farmers, Pharmaceutical industry) - Strategy for protecting intellectual property – Public Private Partnerships (Asia and AA).
- Social acceptability of new technologies (Asia and AA)

- Integrated surveillance system/ Centralised diagnostic testing - Risk-based approach to surveillance (Europe) - Better surveillance of domestic and wild animals (Americas) - Use of farmers for frontline for disease detection – precision livestock farming
- Biosecurity - Management of waste - Improved inspection at borders
- operating systems in disease prevention and control - Operational research
- Better monitoring of medications - Improve the control of drugs (Americas)

Technology

- Research pipeline – investment in basic research
- Vaccine development/New genetically engineered vaccines – Immunology – bioinformatics - Predictive Biology (Americas) - Reverse genetics – synthetic biology
- Vaccine approaches - Thermostable vaccines (Africa and ME) - Evaluation of safety and efficacy of vaccine used in different local species (Africa and ME)-
- Big data – bioinformatics
- Nanotechnology – adjuvants
- Animal breeding/genetics - disease resistance – local breeds - Cloned and GM engineered animals
- Alternatives to antimicrobials – antimicrobial peptides – immunomodulators - New antibiotics
- New drug development - New therapeutics for parasitic (coccidiosis) diseases
- Alternative tools to control disease – better alternatives to complement vaccines - Broad-based immunomodulators; traditional technologies (Asia and AA)
- Alternative methods to control vectors - Integrated pest management - Biological control - Genetic modified insects
- Diagnostic tests - Validation for local species (Africa and ME); Express methods - routine deep sequencing methods - Real time PCR;
- Biosecurity
- Surveillance - Syndromic surveillance - Precision livestock farming/Automated disease surveillance; Big data; Risk-based approach to surveillance; More high-throughput technologies (metagenomics, sequencing and bioinformatics); Easy to use field diagnostic technology
- Systems based approaches/research
- Animal identification technologies

Specific topics/disease

- Improved Understanding of the role of wild life - Epidemiological studies on wildlife - livestock interaction and disease spread
- Understanding disease ecology - Decrease evolutionary pressure on pathogens
- Studies on the impact of diseases on ecology/environment/biodiversity
- Socio-economic impact evaluation of main diseases
- Sustainability of production systems - New production system; genetics - assure maintenance of biodiversity (Africa and ME);

- Improve food safety – traceability; risk analysis; antimicrobial/Residues
- Studies on traditional Vet Medicine (Africa &ME)
- Antibiotic effectiveness and availability - Better use of antibiotics; Alternatives to antibiotics - Host resistance; vaccine development/ Vaccinology, including HPI; biosecurity/management, antimicrobial peptides, immunomodulators;
- Anthelmintic resistance(Europe) - Mechanisms of resistance - Markers of resistance;
- Gut health - Digestive physiology; gut microbiome - pre/probiotics; Improved understanding of the interaction between pathogens and also between the pathogen and the gut
- Vector-borne diseases - Alternative methods to control vectors – a) Integrated pest management, b) biological control and c) genetic modification
- Alternative systems to compensate for downsizing of surveillance/detection systems - Integration and better use of existing data; Syndromic surveillance; Cost effective real-time collection of data; Risk-based approach to surveillance
- New diseases
- Neglected diseases