Key Certainties and Uncertainties in Animal Health and Welfare

Using horizon scanning and sense-making to consider drivers of change

World Organisation for Animal Health

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Foreword

It is my privilege to introduce this publication, summarising the multifaceted changes that are impacting animal health and welfare worldwide. It comes at a poignant juncture, aligning with our 100 years of leadership in providing a global framework for animal health governance. Amidst this celebratory moment, we recognise the profound changes impacting animal health and welfare worldwide: ones requiring continued vigilance and action.

Amid such changes, both challenges and opportunities arise as we pursue our collective efforts to reinforce the resilience of animal health systems, enhance global collaboration, fortify Veterinary Services and prioritise innovation and research. These strategic pillars, encapsulated within the 7th Strategic Plan, form the cornerstone of our endeavours towards a sustainable future for animals and humanity alike.

Enabling the future necessitates foresight, adaptability and preparedness. As we navigate the evolving landscape of animal health and welfare, it is imperative that we remain agile and proactive. This publication not only reflects upon some of the changes currently impacting our Organisation, but also guides us towards futures in which the health of animals remains central to our global priorities.

I extend my deepest appreciation to all the contributors, including select WOAH Delegates, experts from within the WOAH network and partners who participated in the 100th Anniversary Participatory Foresight Project. The contents of this publication were largely derived from the insights and collaboration fostered through this project, which was conceived, developed and promoted with the strong support of former WOAH Director General Dr Monique Éloit.

Thank you to everyone for the dedication and collaboration that have made this publication possible. Your commitment to advancing animal health and welfare is indispensable as we collectively strive towards a more sustainable and harmonious world.

Dr Emmanuelle Soubeyran
Director General
World Organisation for Animal Health (WOAH)

Acknowledgements

The 100th Anniversary Participatory Foresight Project, including the research, drafting, and coordination of this report, was supported by the German Federal Ministry for Economic Cooperation and Development (BMZ).

The report was written by colleagues at Jigsaw Foresight Ltd. and by Tianna Brand, Foresight Advisor, World Organisation for Animal Health (WOAH).

Gratitude is extended to colleagues across WOAH staff and wider network who participated in the horizon scanning exercise as part of the 100th Anniversary Participatory Foresight Project. This exercise identified changes occurring at the margins and in the intersections of WOAH's mission to improve animal health and welfare.

Finally, special thanks to participants in 'sense-making' workshops for this Project: your collaboration, contributions and critical questions were inspirational for this publication.

Executive summary

In celebrating 100 years of efforts to improve animal health and welfare, the Organisation also stands at the crossroads of an ever-evolving landscape of change that directly and indirectly affects animal health and welfare. This publication, the first of its kind to be published by WOAH, highlights a set of key changes that are influencing and shaping today's decisions and tomorrow's outcomes – presented here as 'change cards'.

Among the emerging changes presented here are those that participants assessed as 'key uncertainties' during sense-making workshops for the 100th Anniversary Foresight Project. Such changes were considered 'key uncertainties' because while their impacts might prove significantly disruptive or transformative, it is difficult to assess the probability and full range of those impacts over time. Their potential for disruption suggests that decision-makers should begin contingency planning to anticipate potential impacts and consequences, monitor their evolution and devise adaptive or mitigative actions.

Examples of key uncertainties include:

- **the growing influence of food manufacturers on the public and decision-makers** (Food, Inc., card No. 33);
- **how the feed sector is considering other protein sources (e.g. insects, microalgae, seaweed and yeasts), in the face of difficulties and rising cultivation costs (cereals and silage)** (Reinvention of the feed sector, card No. 35);
- **how artificial intelligence (AI) may influence animal health; welfare inputs and outcomes** (Can AI do everything?, card No. 16);
- **the possible widespread consumer uptake of lab-grown meats, insects and algae** (The future of surf and turf, card No. 21);

  and finally,
- **how blocks of nations are shifting patterns of power in the geopolitical arena and redefining multilateralism** (New powers in the world, card No. 34).

Workshop participants also classified certain critical changes as certainties: that is, both highly probable and yielding foreseeable impacts. These changes require an immediate response plan.

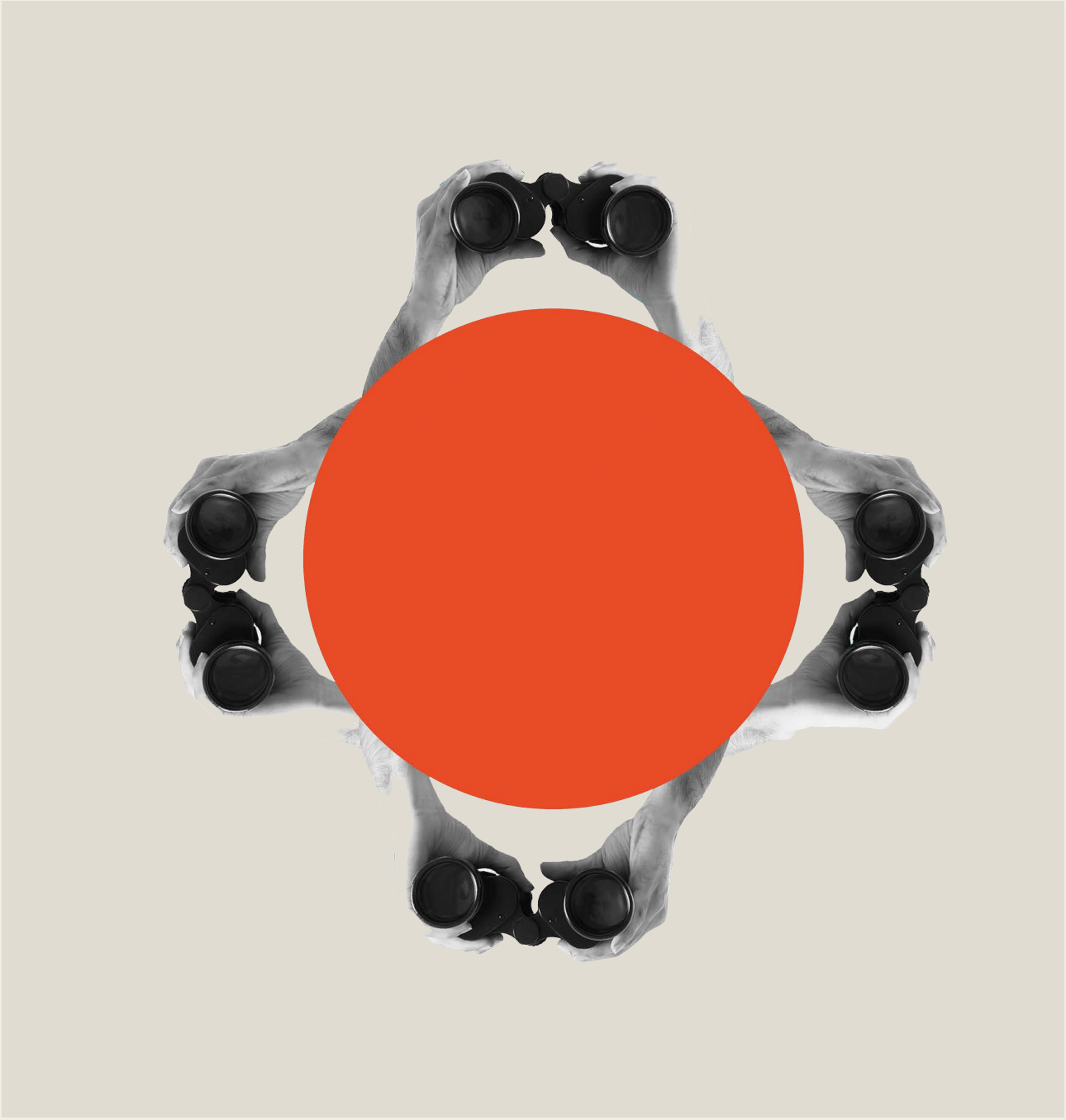
Examples illustrating key certainties include:

- **access to pharmaceuticals is geographically unequal**
  (North–South medical divides, card No. 13);
- **the persistence and speed of misinformation is an everyday challenge**
  (Handling infodemics and myth-busting, card No. 31);
- **climate change impacts are largely clear and present, so the capacity to address or mitigate impacts of extreme weather events on animal health and welfare needs to be prioritised**
  (Heating up, card No. 8);
- **the challenge of regulating health risks posed by wildlife trade**
  (Regulating the illegal trade in wildlife, card No. 32);
  and finally,
- **the convergence of two known factors: shortage of veterinary professionals and the evolution of technology, especially AI and telemedicine**
  (AI and virtual vets, card No. 29).

Considered together, uncertainties and certainties can suggest possible future scenarios to assist in contingency planning. Extrapolating alternative possible futures from interconnected changes and their longer-term impacts enables critical conversations around current assumptions. What needs to be rethought today to better prepare for a range of future contexts? In a future very different from today, what knowledge, current and new resources are required to thrive? How can current networks or communities be bolstered to address the challenges and opportunities posed by these changes? What new legislation or international agreements may be required?

Depending on how these changes unfold, they could significantly alter the trajectory of societies and economies, including current and future farming practices. Identifying and understanding change is paramount for effective contingency planning and strategic decision-making. To foster an anticipatory mindset and encourage self-assessment, the change cards include questions readers might ask themselves. These encourage readers to critically evaluate an organisation's preparedness, adaptability and strategic positioning in the face of constant change.

1 Introduction



Why this publication?

25 January 2024 marked the 100th anniversary of the World Organisation for Animal Health (WOAH). Founded as the Office International des Epizooties (OIE), the Organisation began as a small collective of 28 Members working in a less complex landscape for animal health and infectious diseases. Over the decades since its founding, it has established a diverse membership of 183 Members to date; they have established numerous efforts and programmes to address the increasing complexity and disruption to animal health and welfare.

In comparison to 1924, WOAH and its current Members are faced with a dizzying pace of change in the animal health and welfare landscape. Rapidly changing climates, altered environments, political, social and economic tensions, as well as increasing accessibility to technological innovations and scientific advances render improving animal health and welfare a complex challenge.

While the Organisation can reflect on and celebrate its 100 years, how can it act with the future in mind, and anticipate what might come? This question spurred the 100th Anniversary Participatory Foresight Project, where the foresight methods of horizon scanning, scenario building and scenario exploration were employed by a diverse group within WOAH's network of expertise. The first step in grappling with change is acknowledging that change itself evolves, and so the first step in foresight is the constant monitoring of change, or 'scanning'. This publication highlights a selection of the trends and drivers of change identified during a six-week horizon scanning effort at the beginning of the project.

All foresight work should be continuous; hence this publication also encourages futures-focused, proactive approaches to decision-making (for policies, programmes, guidance, etc.) and anticipating and monitoring evolving changes and their potential impacts and consequences.

Within this context, the first time WOAH and many of its staff and Members experienced foresight methodologies and futures thinking was during a presentation from the Technical Item, entitled 'How external factors (e.g. climate change, conflicts, socio-economics, trading patterns) will impact Veterinary Services and the adaptations required' [1] at the 87th OIE General Session of the World Assembly of Delegates in 2019.

The implementation of the 100th Anniversary Foresight Project stems from the Resolution of the aforementioned Technical Item, which specifically notes that 'The OIE should continue to make efforts to strengthen the resilience of Veterinary Services against the impact of external factors, such as climate change. This would include … developing best practices, recommendations and guidelines, tools and training programmes to build their capacity in Foresight …' [1]

To partly fulfill that Resolution and the project funding requirements, a broad range of participants and Members from within WOAH's network were assembled to share their insights on 45 key changes impacting animal health and welfare. They participated in a series of online workshops employing a range of foresight methods. These included importance/uncertainty matrices to explore key changes, and scenario-building to imagine possible futures; participants then used the scenarios to consider what sorts of resources, knowledge, skills, infrastructure, etc. would be required to face the future.

Over the short, medium and long term, WOAH faces the same volatility, uncertainty, complexity and ambiguity (VUCA environment) as its Members. WOAH's use of foresight can expand the Organisation's capacity to operate strategically and enhance its resilience in the face of change. Foresight also allows WOAH to further cultivate its situational awareness of the changes, opportunities or disruptions that are present and/or emerging both in the animal health and welfare domains and externally.

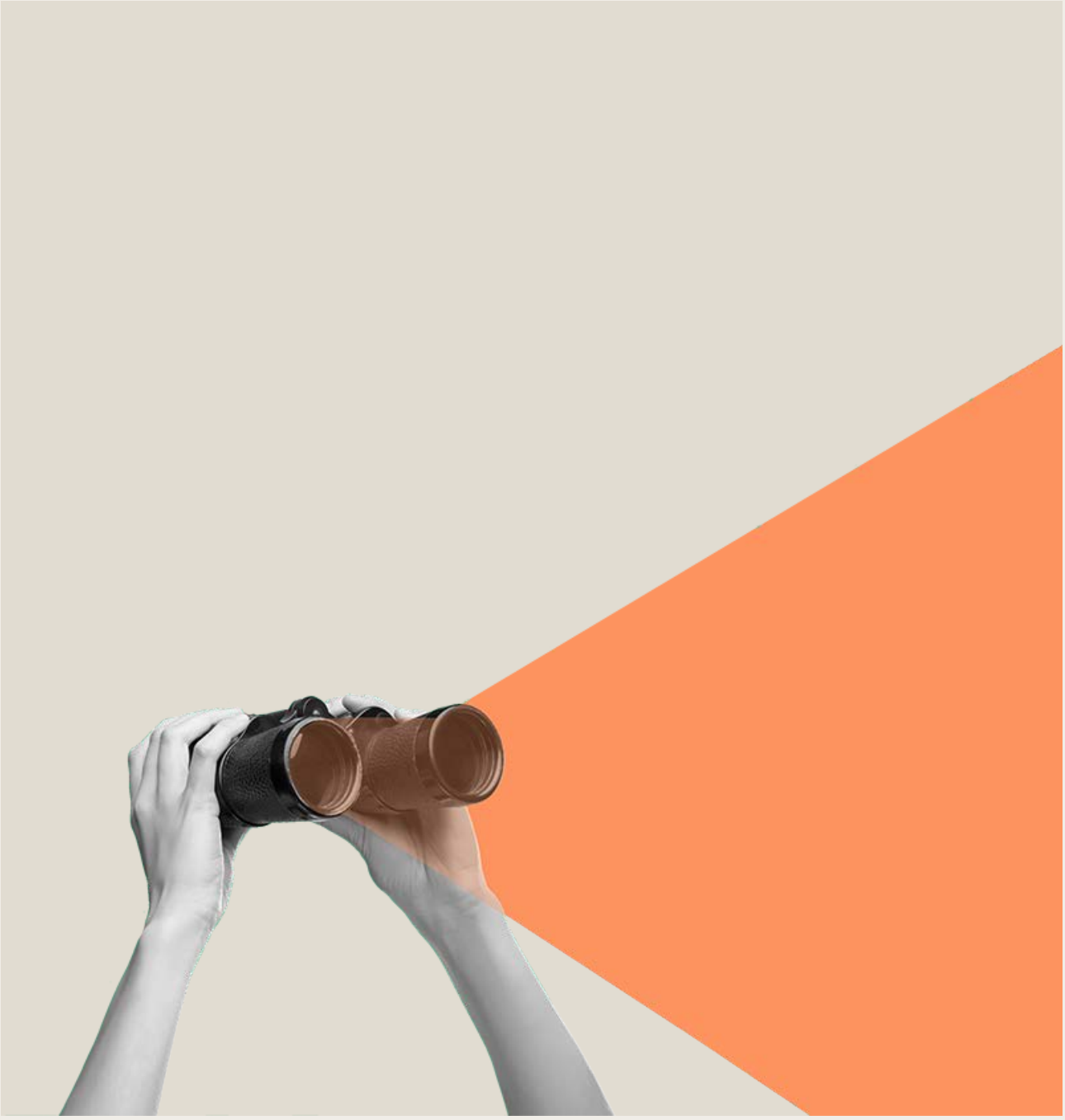
What is foresight?

Futures research and foresight help people, organisations, communities, businesses and governments explore and manage change. This does not mean predicting change, however. Instead, futures research and foresight focus on heightening awareness of change, spotting emerging changes early, and exploring their implications. Where might certain trajectories of change take us? How do those possible paths align with our values and preferences? The earlier we think through the implications of transformative and disruptive changes, the better our options for response, whether through action or adaptation. What can we do to shape our futures and achieve preferred outcomes, avoiding undesirable ones?

There are many definitions for foresight research, ranging from the popular to the practical and scholarly. Since this document employs foresight to foster futures thinking, two definitions of foresight are used throughout: one that reflects the practical aspects of foresight methods and one that outlines foresight as building an anticipatory cognitive capacity:

> A field of study that provides a framework to identify emerging trends and issues, then uses this insight to map out possible futures to support decision-making in the present [1].

Foresight is the capacity to think systematically about the future to inform decision making today. It is a cognitive capacity that we need to develop as individuals, as organisations and as a society. In individuals, it is usually an unconscious capacity and needs to be surfaced to be used in any meaningful way to inform decision making, either as individuals or in organisations. It's a capacity we use every day [2].



Foresight begins with framing, a conversation that defines the questions, concerns and aims that will focus the project. What is the critical issue? Why are you concerned about how change might unfold? What problem or challenge are you addressing? What is the time horizon that concerns you? What is the topic of your proposed foresight work? One useful approach to framing is to engage stakeholders in creating a 'systems map' of the critical issue or topic and its components.

With the critical issue clarified, futures research and foresight encompass five key activities:

1. **Awareness of change:** what changes do you and your team currently track? How do you identify, monitor and document trends and emerging changes? What methods do you use to organise and make sense of emerging change?

2. **Impacts of change:** you've spotted trends and emerging changes you think might be important – either because they present opportunities or challenges. How do you identify and map the potential impacts of those changes? How do you determine what the changes might mean for you, your team, your organisation, your community, your nation or the world? Who will enjoy the benefits or feel the impacts?

3. **Alternative futures:** as changes and their impacts unfold, they create possibilities for alternative outcomes or futures. Thinking strategically means creating contingency plans that are useful in a wide variety of possible outcomes. Scenarios – narratives, images or artefacts depicting alternative futures – can allow you to explore how your goals, and the strategies to meet them, might play out in different conditions. Scenarios can also help you brainstorm initiatives, policies, goods or services by challenging your assumptions and preconceptions, and help you reframe a given issue.

4. **Preferred futures**: a vision is a clearly articulated statement describing a preferred outcome, a highly desirable future, for which specific goals can be set. Preferred futures help us escape from fixating on past and present problems, widening our sense of possibilities and scope for future action. How do you engage people to come together and articulate a preferred future?

5. **Creating change:** how do you 'become the change you want to see in the world'? How do you identify key stakeholders? How do you assess your strengths, weaknesses, opportunities and challenges? What steps are needed to 'get from here to there' in achieving your goals? Do you have a method for testing your strategies in the face of uncertainty and turbulent change?

Futures research and foresight offer a range of methods and frameworks for each of these core activities. This project adopted practices of horizon scanning, exploring impacts and imagining alternative possible futures, and considering actions to adapt to those futures. In the context of this publication, the first step was scanning for emerging changes that might challenge or transform Veterinary Services, veterinary practices, and WOAH's mandated areas of concern.

2 Horizon scanning and sense-making: process overview

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2 Horizon scanning and sense-making: process overview

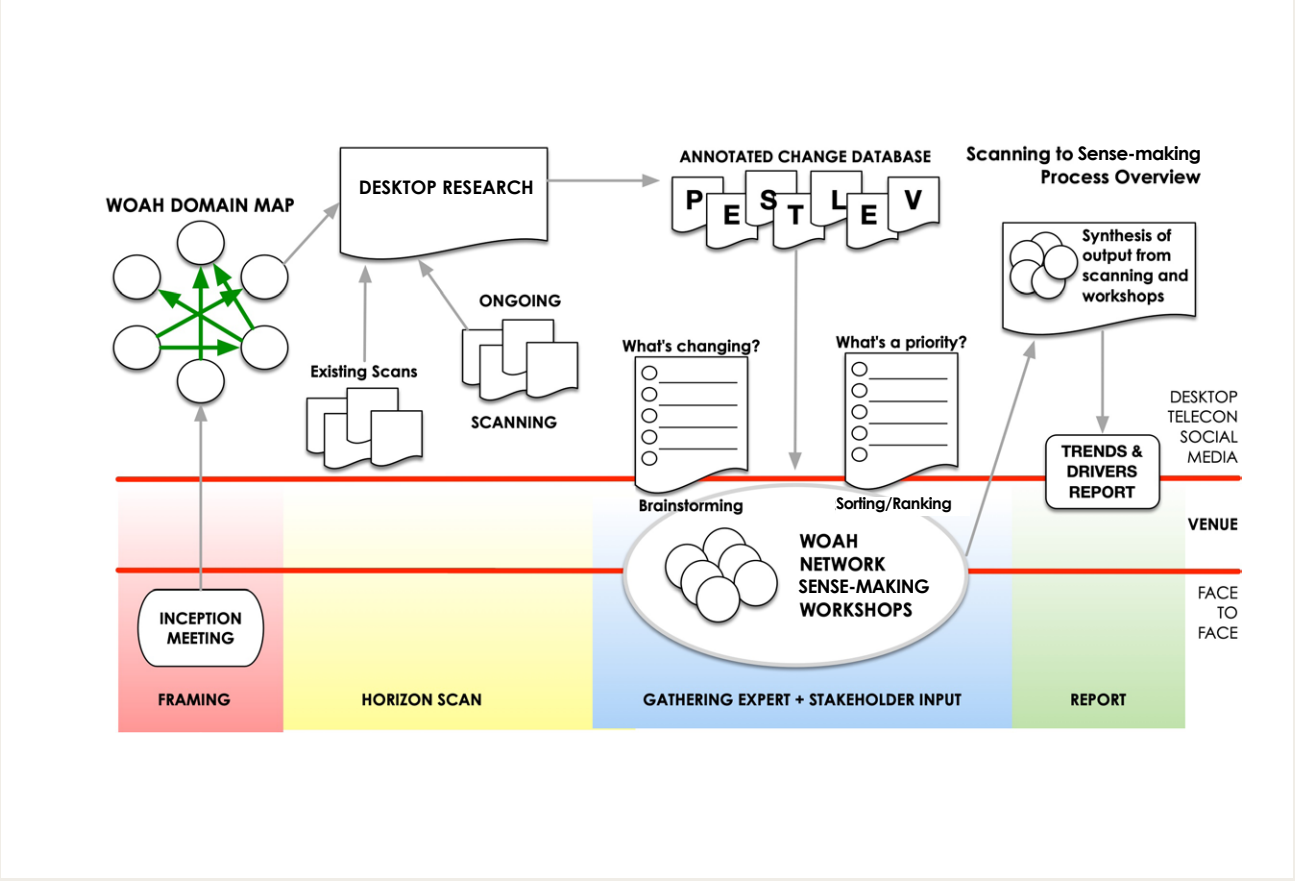

Figure 1. WOAH 100th Anniversary Participatory Foresight Project scanning and sense-making process

Figure 1 visually summarises the scanning and sense-making process for the 100th Anniversary Participatory Foresight Project. The first step is understanding the Organisation, its network and its context: what are the primary concerns of WOAH, its staff, Members and affiliates? For this project, a review was launched of existing research on relevant change; this included a two-month process of reviewing current publications, science reports and news streams for observations of emerging change. These results were categorised by 'PESTLE-V' (Politics, Economics, Society, Technology, Law, Environment and Values) and annotated to characterise their potential impacts. A selected group of 45 potentially high-impact emerging changes were summarised to share with participants during two online sense-making workshops. The participants added changes they had observed in their local contexts, then worked to sort and prioritise the changes according to level of impact and uncertainty.

Horizon scanning: identifying critical emerging changes

Framing

During a project initiation meeting, researchers from Jigsaw Foresight facilitated discussions with WOAH staff to understand the contexts within which WOAH works, as well as its range of mandated responsibilities. Mapping the operations landscape helps focus scanning on those changes most relevant to the Organisation. This framing work is expressed as a 'systems map' of the issue context and its various components, shown below in **Figure 2.**

WOAH's core responsibilities are animal health and animal welfare (shown as nodes on the lower left of the systems map, **Figure 2**). Specific WOAH activities, which include standards for disease prevention, disseminating available science, capacity building, information sharing, etc., are plotted on the map adjacent to their closest concerns, which include veterinary medicine, disease-specific standards, and regulations regarding animals.

From these core activities, the topics of interest where changes are present or emerging are:

- aspects of **laws, regulations and policies** (disease-specific and animal welfare standards; regulations regarding animals; policy initiatives for disease control);
- **categories of animals** (domesticated animals; domestic livestock; wildlife; aquatic animals);
- **animal services and research** (veterinary medicine; Veterinary Services; animal epidemiology);
- **animal diseases and pathologies** (animal diseases; aquatic animal diseases; emerging diseases; existential risks);
- **components of the human food system** (animal production systems; global food trade; farm-to-fork food chains; alternative proteins; aquaculture; hunting & fishing);
- **components of the economic system** (global trade);
- **aspects of geopolitics** (global relationships).

These topics represent an initial exploration, and as such are not exhaustive. The map includes topics that lie at the intersections of WOAH's main activities, ones that WOAH does not directly address but that nevertheless influence its main activities, such as animal rights, species conservation, global relations, etc.

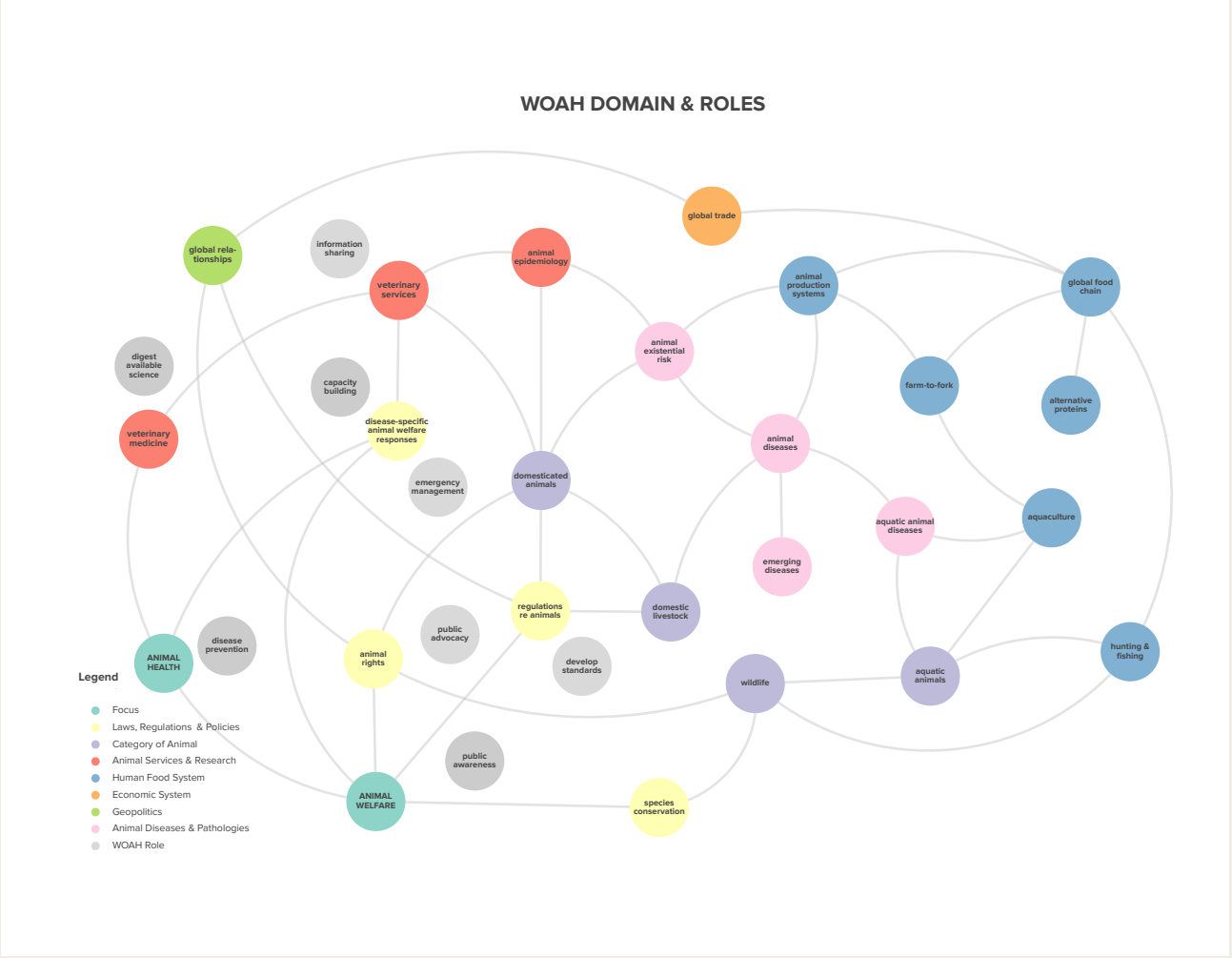

Figure 2. WOAH animal health and welfare operating context – systems map

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Scanning

Horizon scanning begins by reviewing existing research on trends and drivers of change relevant to the core issue. Researchers then identify a wide range of sources including professional and scientific journals, government white papers and policy papers, think tanks, research from related non-profit and non-governmental organisations, periodicals, newspapers, blogposts and topic aggregators. The scanning team sought reports of novel or emerging changes, whether environmental, societal, political, or related to policymaking, scientific observations and discoveries or technological innovation. The aim is to spot changes as they emerge, allowing stakeholders sufficient time to discuss their implications before the impacts hit.

Because scanning involves reviewing a wide variety of data sources, it must be team-based and collaborative to adequately assess relevant materials. This project involved diverse technical expertise including foresight researchers and WOAH staff to identify and share relevant emerging changes. The team reviewed the emerging data against the key WOAH domains of interest, summarised as a systems map, to ensure the scanning was identifying changes with potential to affect all the system components. The collected information flagged as significant was put into a database.

The team also identified potential gaps to ensure that a broad variety of changes were covered. For example, if the scanning output included a majority of environmental and technological changes, but very few political, legal and regulatory changes, the team would refocus the scan search to fill that data gap. These initial discussions also explored how changes might interconnect to potentially amplify either the speed of change or the magnitude of impacts, in addition to carrying out informal thematic clustering.

Cataloguing scanning data

Since horizon scanning reviews and collects a wide variety of change data, keeping results organised requires establishing a system to effectively categorise identified changes. For this project, primary tagging identified the origin of a given reported change using the 'PESTLE-V' taxonomy: does the change originate in the Political system, the Economy, Society, Technology (including science and innovation), Law, the Environment, or in a Value shift? Horizon scanning ideally watches for changes emerging in all these categories. Other tags built into the scanning database include:

- **Change S-curve (level of change maturity):** emerging (early signals, ideas still debated, few cases or observations); advancing (growing awareness and understanding, converging agreement, more occurrences); resolving (widespread public awareness, conceptual convergence, everyday occurrence);
- **Potential impacts:** potentially enabling animal health and welfare; potentially disrupting animal health and welfare; potentially both enabling and disrupting;
- **Article keywords:** helping readers to quickly understand the change topic;
- **Domains of interest systems map:** elements of the WOAH domain map (see **Figure 2** above) that the change might impact.

At the time of writing this publication, the scanning database contained 606 change topics logged using the Notion platform.

Sense-making workshops

Making sense of emerging change for an intergovernmental organisation like WOAH demands diverse perspectives. The project team connected with over 50 people from across WOAH's network in sense-making workshops to review and prioritise 45 changes from the scanning database. Sense-making these emerging changes occurred in two online workshops scheduled to accommodate participants in different time zones. The team included participants with widely diverse roles and connections to WOAH who were widely distributed geographically.

During the workshops, participants were asked to reflect on the changes they had recently observed in their work and communities, alongside the 45 key changes presented in this document. This enabled participants to both engage with the changes from the horizon scanning research and fill in any gaps with additional changes they had observed in local and professional contexts. They next worked to rate the importance of changes based on their pertinence to WOAH and its activities, classifying where each of the 45 changes fell in a matrix of uncertainty and importance (**Figure 3**).

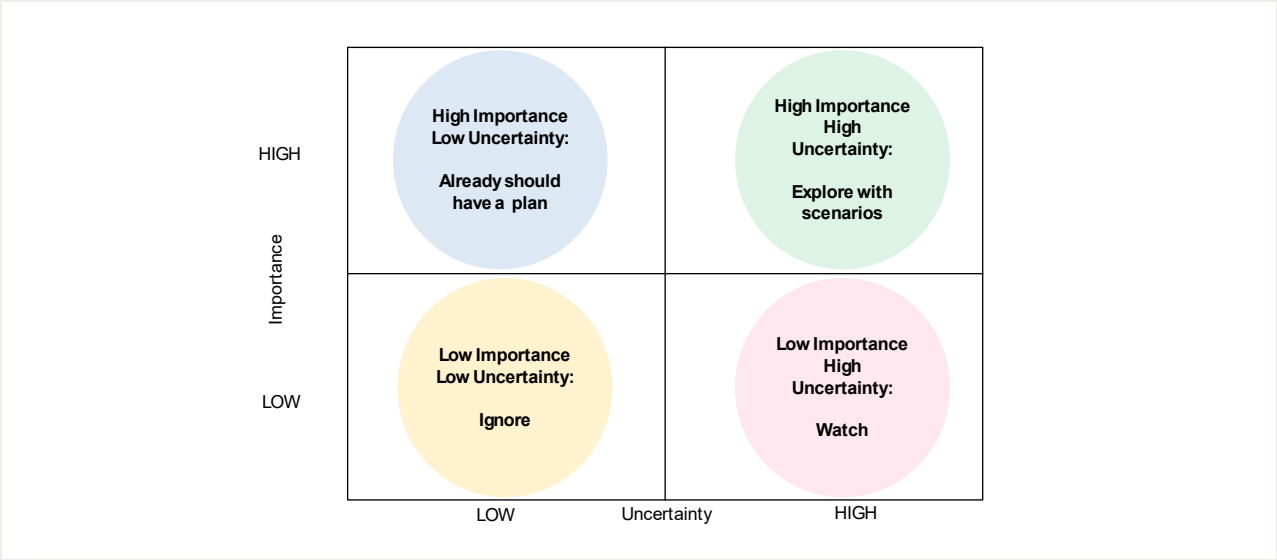


Figure 3. Uncertainty/importance matrix

This is essentially a decision matrix with four quadrants:

- **Low importance and low uncertainty:** we understand this change and where it's going, but it isn't important to us – we can ignore it.
- **Low importance but high uncertainty:** this change is not currently important to us, but its trajectory and outcomes are uncertain; we should watch it.
- **High importance and low uncertainty:** we know this change is important to us, we understand it and know where it's going – so we should already have a plan to address it.
- **High importance and high uncertainty**: we know this change is important to us, but we are unsure how it will evolve and what its range of outcomes might look like – so we need to explore it with scenarios of alternative possible outcomes.

While the 45 changes emerged from all the PESTLE-V categories (**Figure 4**), the selection of changes skewed towards the technological (15 out of 45) and environmental (10 out of 45) categories; this was not unexpected given the topic of animal health and welfare. The 'Summary of the importance/uncertainty' pie chart in Figure 4 shows that 80% of changes were ranked as highly important, and these were categorised evenly as either highly important/low uncertainty *(should already have a plan*) or highly important/high uncertainty (*explore with scenarios*).

Examining the bar graph labelled 'percentage of importance/uncertainty per category' and rating differences by PESTLE-V category highlights how much more uncertain participants were about economic outcomes and economic changes, with nearly two-thirds of economic changes requiring exploration via scenarios. In contrast, only a third of technological changes were rated as benefitting from scenario exploration, with around a quarter classified under 'high importance/ low uncertainty'. People were most certain about political changes, with almost 60% falling under the 'high importance and low uncertainty' quadrant – perhaps because participants felt that major related policies and programmes were already in place.

Futures research and foresight often emphasise uncertainty, highlighting volatile conditions and the emergent aspects of the complex systems in which we work. Yet some changes that have evolved from emerging trends to become conditions of daily life can be considered highly certain. Participants in the sense-making workshops highlighted a selection of changes as highly important certainties: that is, both highly probable and resulting in foreseeable impacts. These require that a plan be in place for immediate response.

Examples illustrating key certainties include the following:

- access to pharmaceuticals is geographically unequal **(North–South medical divides, card No. 13)**;
- the persistence and speed of misinformation is an everyday challenge **(Handling infodemics and myth-busting, card No. 31)**;
- the challenge of regulating health risks posed by wildlife trade **(Regulating the illegal trade in wildlife, card No. 32)**.

As changes evolve, some remain highly volatile and uncertain, others collapse into irrelevance and some stabilise into certainties. Ongoing foresight monitors such evolutions and helps individuals and organisations understand when to incorporate a new certainty in the operating environment into everyday planning and action – and when to explore a possible range of outcomes by extrapolating potential impacts.

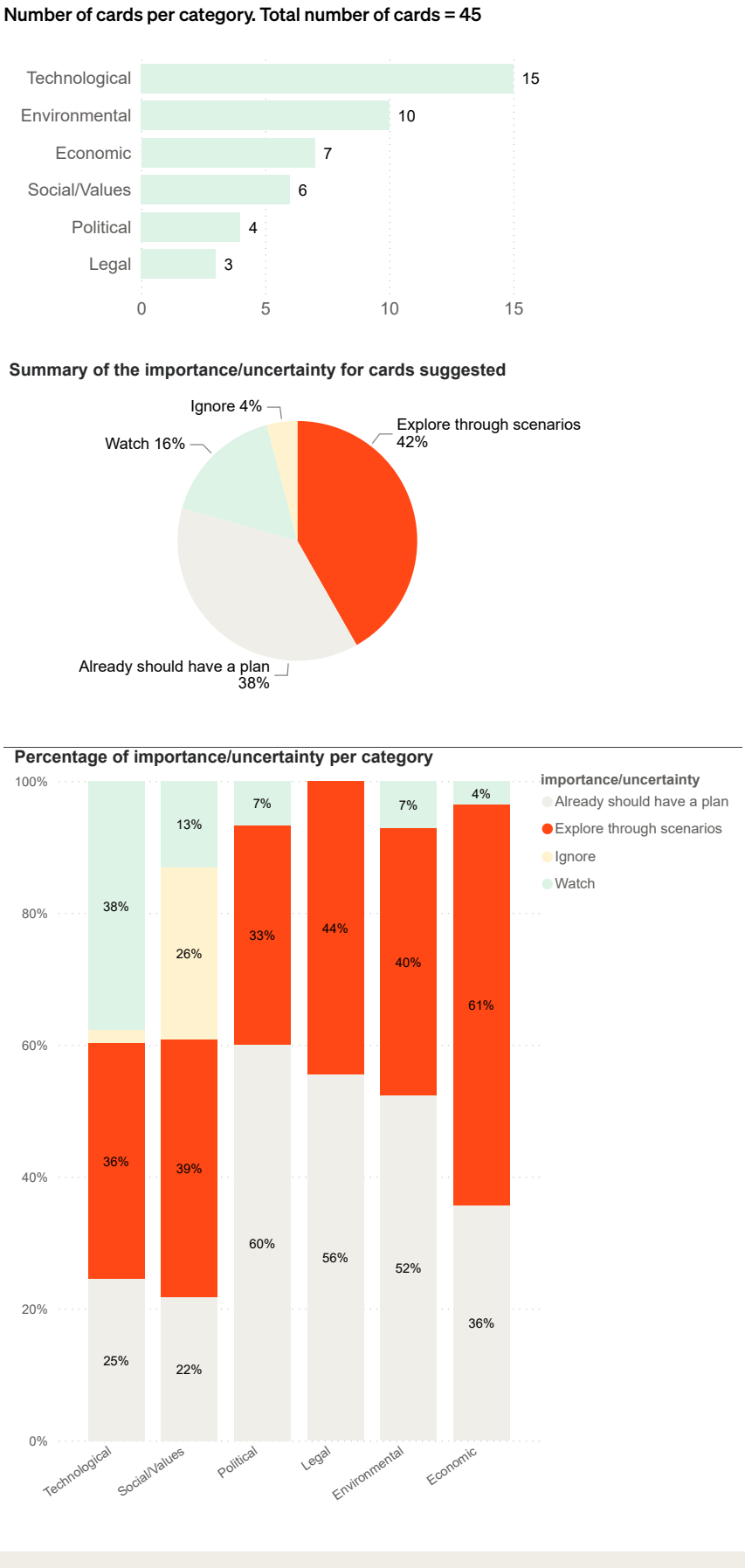


Figure 4. Summary of how change cards were categorised and ranked

3 Drivers of change

3 Drivers of change–the 'change cards'

> "Learners inherit the earth; the learned find themselves beautifully equipped to deal with a world that no longer exists."
>
> Eric Hoffer

The following section summarises the 45 changes that participants reviewed, discussed and categorised during the sense-making workshops. They are clustered into ten themes. As you survey them, consider how they would be categorised in the context of your own work and local environment: *Ignore? Watch? Plan? Explore with scenarios?*

Changed climate and environments

The rapidly changing climate is transforming our environment. From surprising ecosystem adaptations to the alarming consequences of potential ocean current tipping points, ecological interconnections are evident. Positive changes are also arising. Sustainable practices, e.g. in aquaculture and bee preservation, reflect the need for environmental stewardship. Potential climate change impacts on our ecosystems and health are prompting innovative solutions, from urban agriculture to reimagining food production.

CARD #2

Life in unexpected places

Environmental

©Omkar Rane/Unsplash

Corresponding article: 'An Unexpected Haven: North Pacific "Garbage Patch" Teems With Life (scitechdaily.com)' [4]

Natural ecosystems might adapt in unexpected ways to human-polluted environments. The North Pacific Garbage Patch, a large mass of floating plastic waste, has been found to have more sea creatures in the centre of the patch, than at its edges.

Will some elements of the natural environment be less fragile than others? And what will that mean for our approaches to animal health (risk assessments, surveillance, etc.)?

CARD #3

Aquaculture and climate change

Environmental

©Lucut Razvan/Unsplash

Corresponding articles: 'Meet the 7 sustainable aquaculture stars of the future' (foodnavigator.com) [5]

'Climate Change Effects on Aquaculture Production: Sustainability Implications, Mitigation, and Adaptations' (frontiersin.org) [6]

Promoters of aquaculture practices believe that water-based food sources are healthier and more sustainable. Should aquaculture farms expand their operations, this could deeply impact the global food industry. However, increasing ocean temperatures present challenges for producers to maintain food supplies.

What might rising ocean temperatures mean for maintaining farmed fish health and welfare in aquaculture and implications for food security?

CARD #8

Heating up

Environmental

© Josh Berende/Unsplash

Corresponding article: 'Hot weather and potential risks to health and welfare (defra.gov.uk)' [7]

Extended periods of extreme heat are now commonplace worldwide because of climate change. This not only has implications for water security; it is also thought to promote and spread disease among livestock. Pastoral farming may therefore become unsustainable in some regions.

Can we prevent or mitigate heat-enhanced disease spread? How can farmers and Veterinary Services adapt? How can WOAH assist them?

CARD #9

Plagued by ticks

Environmental

©Erik Karits/Unsplash

Corresponding articles: 'Deadly virus spreading across Europe's biggest threat to public health' - World News - Mirror Online' [8]

'A meat allergy caused by tick spit is getting more common, CDC says' [9]

Warmer temperatures are promoting the spread of a tick-borne virus across the world, including in Europe, Africa and the Middle East. An urgent health warning has been issued in what has been described as the largest public health threat, and climate change might be accelerating it. Another virus with greater potential impacts on livestock trade is the tick-spread red meat allergy: as many as 450,000 Americans are estimated to be affected.

What if this allergy spurred a new type of pandemic?

CARD #39

Ocean circulation tipping point approaches

Environmental

©Dhruv/Unsplash

Corresponding article: 'Gulf Stream could collapse as early as 2025, stud Dhruv y suggests' (*The Guardian*) [10]

The collapse of vital ocean currents, the Atlantic Meridional Overturning Circulation (AMOC), may have extreme climate impacts. New analysis estimates a timescale for a collapse between 2025 and 2095, with a central estimate of 2050, if global carbon emissions are not reduced. Evidence from past collapses (including during the Ice Ages) predicts potential temperature changes of 10° C over a few decades.

How might rapid climatic shifts affect animals and their ability to adapt? How might they impact farmers and animal husbandry of all kinds? How might WOAH respond to such a crisis?

CARD #42

Hivewashing and trophy bees

Economic

©Damien Tupinier/Unsplash

Corresponding article: 'The Beekeepers Who Don't Want You to Buy More Bees' (*The New York Times*) [11]

Researchers have found that many species of wild bees are declining. However, hobbyists, corporations and social media influencers are typically drawn to only the seven or so species of honeybees – the one group supported by a multibillion-dollar agribusiness, and that is not under threat.

What are the potential impacts on bee husbandry as well as the health and welfare of wild bees?

CARD #12

A prairie on every house, a cow in every courtyard

Environmental

©Erik Karits/Unsplash

Corresponding articles: 'Chinese Ghost Town Of Mansions Reclaimed By Farmers' (*Barron's*) [12]

'Planting Tiny Indoor Farms In Strip Malls and Office Parks' (*Ambrook Research*) [13]

The separation of urban and agricultural space may soon become less clear. Existing case studies already underline innovative uses of urban areas for farming, such as reclaiming abandoned or under-used urban spaces. For example, courtyard-based cooperative farming development within residential apartments proposed for American cities that incorporates permaculture and animal husbandry.

How might these trends impact animal health and welfare? What are the social, economic and ecological potentials for cohabiting with animals in urban spaces? Might we radically reduce the transportation of animals through an urban approach to agriculture? What does this mean for One Health approaches, veterinarians and animal health practices?

Many of these changes are interconnected and amplify each other. For example, atmospheric heating not only affects human and animal health; it also accelerates the melting of polar ice and glaciers. The resulting influx of fresh water into seawater in the North Atlantic contributes to the potential slowing of Atlantic deep ocean currents. This would in turn affect the Gulf Stream's transfer of heat to northern Europe, transforming regional conditions for agriculture, farming, livestock and aquaculture. The warming climate could also raise populations of pests such as ticks, and lower both human and livestock resistance to infection. As industrial farming becomes more vulnerable, more households might engage in backyard or rooftop farming and gardening as insurance against food chain vulnerabilities.

Participants in the sense-making workshops observed related changes from their communities and workplaces, underlining how climate change and its resulting wildfires, extreme weather, drought, floods, coral bleaching and other impacts are contributing to transient food chain instabilities. These disruptions would in turn, they suggested, drive the migration of wild animals to new locations, with new diseases and pests emerging in new areas. Participants also highlighted melting glaciers and the potential impacts on fresh water supply for certain communities and impacts on polar ecosystems and currents more generally.

Scramble for natural resources

In a resource-strained world, competition for essentials like water creates crises. Climate-induced water scarcity highlights vulnerabilities in global food supply chains, which trigger political and economic tensions. The role of transnational corporations in reallocating water resources becomes evident amid poorly regulated tensions over water rights. Concerned decision-makers turn to experimental solutions like cloud seeding, as recent investments in that technology attest.

Simultaneously, the illegal wildlife trade raises global governance and pandemic concerns. The COVID-19 pandemic exposes regulatory gaps, with critics highlighting the urgency needed in addressing these issues.

CARD #10

Rain gods

Technological

©Dave Hoefler/Unsplash

Corresponding article: 'Mexico steps up rain-making project amid intense heatwave and drought' (*The Guardian*) [14]

Dramatic decreases in water supply due to climate change will have catastrophic implications for food production. Cloud seeding has been offered as a potential solution to water insecurity. The Mexican government recently announced more investment into cloud seeding and claimed it is '98% effective'.

Is cloud seeding really the solution? How might it impact animal health and welfare?

CARD #1

Exporting water

Economic

©Laura Nyhuis/Unsplash

Corresponding article: 'How a Saudi firm tapped a gusher of water in drought-stricken Arizona' (*The Washington Post*) [15]

Water accessibility might profoundly alter political and economic systems. Tensions around water rights are causing political unrest and revealing weaknesses in global food supply chains. Transnational corporations play a major, but poorly defined, role in reallocating global water resources. The total virtual water flow worldwide increased from 43 billion m^3 to 100 billion m^3 between 2004 and 2018. Transnational corporations have a critical role in achieving water stewardship, water resource security and sustainable supply chains at municipal and international scales.

Can WOAH contribute to water stewardship through advocacy, given that water is a necessity for animal health and welfare, not to mention global stability?

CARD #32

Regulating the illegal trade in wildlife

Legal

©Wade Lambert/Unsplash

Corresponding articles: 'Wildlife crime' (interpol.int) [16]

'CITES, Wildlife, and Pandemics: Failure to Grasp the Nettle' (*SDG Knowledge Hub*) [17]

The illegal wildlife trade has an estimated annual worth of up to USD 20 billion. The COVID-19 pandemic highlighted serious gaps in the wildlife trade regime, yet efforts to fill these are lacking a sense of urgency. Critics point out shortcomings in how we globally regulate risks posed by wildlife trade and markets

Will we remain unnecessarily exposed to the risk of future emerging zoonotic diseases?

Increased drought has had immediate impacts on farming and long-term impacts on the replenishment of aquifers, from which farmers and communities draw water. Water scarcity reduces crop yields, which determine whether crops are used for human consumption or for animal feed. These resource pressures increase the possibility of political conflicts over water rights and access to water, which increase inequities in water access. While not directly related, the inability to control the illegal wildlife trade highlights similar challenges, pitting local use or abuse of resources against weak and ineffective regional and global regulatory regimes.

Adopting local perspectives, participants in the sense-making workshops also raised issues of resource competition, such as climate change-driven drought and its impact on animal husbandry in alpine grazing lands; competition over fish stocks and risks of overfishing; and even concerns over exploitation of wild animals from trade in exotic companion animals.

Farming and food production systems under stress

Climate change, environmental degradation and geopolitical conflicts are intersecting to form a worldwide 'polycrisis'. The agricultural sector is grappling with unprecedented challenges that intensify mental health struggles for livestock farmers as they experience extreme weather events, labour shortages and stringent regulations. Global diets are shifting, influenced by environmental awareness and veganism, creating more market uncertainty for farmers' products. The industry is adapting to climate change with innovative cooling methods for animal production and remains pressured by regulatory and legislative initiatives to ban animal transport.

Challenges in cultivating essential crops are prompting feed companies to explore alternatives for animal nutrition. Amidst these shifts, transnational food and farming companies are shaping discussions on the future of food, while frequently overlooked threats of crime and terrorism on animal health impact public health and food security. Finally, extreme weather threatens global food security, raising the spectre of widespread harvest failures.

CARD #4

Farming during the polycrisis

Environmental

©Karsten Würth/Unsplash

Corresponding article: 'Priority areas for investment in more sustainable and climate-resilient livestock systems' (*Nature*) [18]

Researchers predict that the polycrisis – the combined impacts of climate crisis, environmental degradation, pollution, war and social conflicts – will particularly affect the farming practices of certain countries. China, Brazil, Sudan, Pakistan and India have been identified as the most vulnerable countries.

What investment is required (and where) to allow vulnerable countries to continue farming activities? What could this mean for animal health and welfare concerns?

CARD #11

Hard emotional labour

Economic

©Rajesh Ram/Unsplash

Corresponding article: 'Mental health in pork production' (nationalhogfarmer.com) [19]

Labour shortages, increasing biosecurity regulations around animal diseases and lower profit margins have led to increasingly poor mental health among livestock farmers.

What are the implications for the farming industry and Veterinary Services if perceived job-related stress negatively impacts recruitment?

CARD #15

Eco-values and farmer livelihoods

Social/Values

©Rafael Hoyos Weht /Unsplash

Corresponding articles: 'What share of people say they are vegetarian, vegan, or flexitarian?' (*Our World in Data*) [15]

'Notes on Progress: An environmentalist gets lunch' (worksinprogress.news) [21]

Changing diets affect the future of food supply. More young people are saying they're vegan and vegetarian. Environmental awareness is also changing diets, with the high carbon footprint of meat making it less desirable.

If more young people eschew meat, what does the future look like for farmers and livestock, and for Veterinary Services?

CARD #17

Keeping animals cool

Technological

©Bradley P. Jones/Unsplash

Corresponding article: 'Pig cooling pads and weather forecasts for cows are high-tech ways to make meat in a warming world' (*AP News*) [22]

Climate change is forcing pastoral farmers to seriously rethink livestock cooling methods. Extreme heat not only stresses livestock but also increases mortality risks.

How should WOAH respond in terms of its animal welfare standards?

CARD #27

Transport challenges: too hot to handle?

Political

©Benjamin Gremler/Unsplash

Corresponding articles: 'Heatwaves and animal welfare: The ethics of livestock farming on a warming planet' (*Euronews*) [23]

'Why Australia banning live sheep exports may be a net loss for animal welfare' (theconversation.com) [24]

Increasing global temperatures make live transport of animals more dangerous and costly. Some countries, e.g. Australia, are considering bans.

If transport of live animals is banned or limited, how will this affect global trade? Is it a positive or negative for animal health? Will transport of animal carcasses become the only viable and ethical way to transport meat?

CARD #33

Food, Inc.

Economic

©Peter Bond/Unsplash

Corresponding article: 'Who's Tipping the Scales?' (ipes-food.org) [25]

As transnational food and farming companies grow ever bigger, their political influence and reach are increasing. They have convinced governments they must be central in any discussion on the future of food.

How might the increasing clout of food and agrobusinesses enhance or constrain WOAH's efforts to assure animal health and welfare?

CARD #35

Reinvention of the feed sector

Economic

©Arisa Chattasa/Unsplash

Corresponding article: 'Animal feed trends in the changing world' (medfiles.eu) [26]

Cereals, mainly barley and maize but also soya and grass (silage), are important protein and energy sources in farm animal nutrition. Cultivation is becoming more challenging and expensive, and feed companies are searching for alternatives. Alternative protein sources for livestock feed include insect proteins, microalgae biomass proteins, seaweed (macroalgae) and yeast biomass. Their use might vastly increase in the future to complement current feed crop production and feed materials.

What might the expansion of feed sources mean for animal health and welfare?

CARD #37

Harvest failures

Environmental

©Md. Hasanuzzaman Himel/Unsplash

Corresponding articles: 'Risks of synchronized low yields are underestimated in climate and crop model projections' (*Nature Communications*) [27]

'Why Australia banning live sheep exports may be a net loss for animal welfare' (theconversation.com) [24]

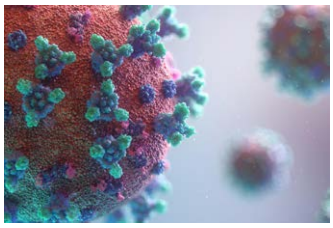
Simultaneous harvest failures across major crop-producing regions threaten global food security. Concurrent weather extremes driven by an unstable jet stream could trigger such events. Extreme weather, including increasing heat stress, affects leaf production and, more worryingly, can kill pollen and interfere with the fertilisation of crops.

How might such failures damage our capacity to increase edible plant production, both for humans and livestock?

CARD #38

Agro-bioterrorism

Legal



©Fusion Medical Animation/Unsplash

Corresponding article: 'Animal Agrocrime: An Overlooked Biological Threat' (liebertpub.com) [28]

Crime and terrorism targeting animal health are often overlooked threats, but can substantially impact animal health and welfare, public health, food security and authenticity, and national security. Easier access to bioengineering tools could mean increased risks of terrorist acts, affecting the global food system and related ecosystems.

How can WOAH help lower these risks?

The aforementioned polycrisis presents farmers with interrelated challenges – increasing floods, droughts, wildfires, and heat stress for humans and livestock – which makes their work more difficult and emotionally stressful. This is exacerbated by market shifts in demand for their products, especially livestock, as consumer demand evolves in favour of sustainably produced foods. In an age of advancing bioengineering capabilities, the potential for terrorists to unleash attacks on the food chain represents a new risk for the industry.

Sense-making workshop participants flagged psychological pressures on farmers from polycrisis and 'permacrisis' impacts and events. They also underlined that younger generations typically do not wish to work long hours, which directly affects the potential labour pool for agriculture as baby boomers retire. This only exacerbates rising stress and mental health problems in the profession. In terms of agricultural markets, shifting values, especially among younger people, are increasing vegetarianism, veganism and 'flexitarianism'. Younger generations are also more interested in animal welfare, while awareness around traditional and Indigenous perspectives on farming might contribute to truly regenerative practices.

Evolutions in animal rights and welfare

Societal values regarding wildlife, livestock and pets are shifting. Emerging scientific evidence of animal cognition and emotion is supporting growing advocacy for animal rights. In addition, and perhaps surprisingly, political forces shaped by diverse values find common ground in protecting animals. This intricate interplay between ethical considerations, scientific evidence and political dynamics defines the evolving discourse on animal rights: one that could change how people view and approach animal welfare issues.

CARD #18

Animal rights enshrined in law

Legal

©Jorge Mayal/Unsplash

Corresponding articles: 'They can think, feel pain, love. Isn't it time animals had rights?' (*Harvard Gazette*) [29]

'Animal Law: Human Duties or Animal Rights?' (SSRN) [30]

Coinciding with a rise in veganism and vegetarianism is the idea that animals deserve their own legal rights. Science is revealing that animals can think, feel, and even love, providing fuel for this argument. A recent initiative for octopus farming faced backlash, owing to the animal's proven intelligence.

What sorts of rights will animals have in the future? How will this affect global farming practices, as well as cultural norms and consumers? How might our relationship with food animals evolve and transform?

CARD #30

Increasing political polarisation increases tensions over animal rights

Social/Values

©Artem Beliaikin/ Flickr

Corresponding article: 'Animal advocacy and the radical right: the case of Sweden' (tandfonline.com) [31]

Political forces that are polarised in terms of values such as multiculturalism, ecologism, and gender equality nonetheless can share a common interest in animal protection. Conversely, animal rights are also used to fuel political controversy, e.g. overprotection of ecosystems vs. exploitation of natural resources.

How can this tension be held productively?

The louder the call for animal rights – supported by evidence – the more contentious politics become, especially when animal rights compete with economic interests. This set of interconnected changes is also linked to a growing acknowledgement of traditional and Indigenous perspectives on animals and their place in natural systems.

Workshop participants underlined that local religious contexts, including beliefs about animals that constrain how people interact with them, supports some animal rights and regulations in some cases and conflicts with them in others. They also identified the emergence of animal pet therapy in some countries and rising concern for the physical and mental health of animals.

Next wave for antimicrobials

The escalating threats of air and microplastic pollution worldwide are intricately linked to rising antimicrobial resistance (AMR) in both humans and food animals. As AMR increases among food animals, those working closely with them face heightened health risks. The intersection of environmental issues and health concerns generates serious challenges.

Technological advancements in gene editing (CRISPR) and artificial intelligence (AI) offer potential solutions to these challenges. Scientists are exploring innovative approaches to combat AMR, including inhibitors preventing bacteria from expelling antibiotics and using peptoids to dismantle viral threats. This convergence of environmental issues, health risks and groundbreaking technologies marks a pivotal moment in the pursuit of global health resilience.

CARD #25

The impact of rising pollution on agriculture

Environmental

©Johannes Plenio /Unsplash

Air pollution and microplastic pollution increasingly threaten human health worldwide and are linked to antimicrobial resistance.

This convergence of two already complex issues underlines the pertinence of One Health approaches in addressing health issues.

Corresponding articles: 'Microplastics May Sprout Antimicrobial Resistance' (USDA) [32]

'Air pollution linked to rise in antibiotic resistance that imperils human health' (*The Guardian*) [33]

CARD #26

Increasing antimicrobial resistance and possible responses

Environmental

©Sangga R. Roman Selia/Unsplash

Antimicrobial resistance is on the rise in humans and animals.

What will happen when antimicrobial resistance in food animals greatly increases health risks for people who work with them?

New technological advancements in both gene editing (CRISPR) and AI could be used to prevent antimicrobial resistance and create new antibiotics, respectively.

Is there reason to hope that antimicrobial resistance can be managed?

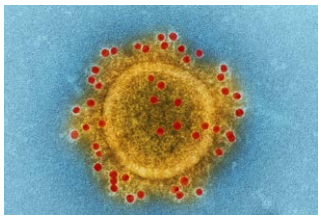
Corresponding article: 'CRISPR-Cas used against antimicrobial resistance' (*Inside Precision Medicine*) [34]

'AI Reveals New Antibiotic' (*Inside Precision Medicine*) [35]

CARD #44

Beating back microbial defences

Technological



©CDC/Unsplash

Corresponding articles: '"Molecular wedge" renders superbugs vulnerable to antibiotics again' (newatlas.com) [36]

'Peptoids pop some viruses like the disease-causing balloons they are' (newatlas.com) [37]

Scientists are exploring new approaches to undermining bacterial defences. These include inhibitors that prevent bacteria from flushing out antibiotics, allowing them to work. Administered alongside existing antibiotics, they could restore the drugs' efficacy. Researchers are also using specific peptoids to pop viral membranes, effectively disabling them.

How to support research towards the race against growing microbial resistance? How might WOAH act as a research and data network to support innovations?

This cluster of changes addresses systems unseen by the naked eye and is a stark reminder that critical changes occur at all scales. Pervasive pollution – to which microplastics contribute – affects the health of both humans and animals, in turn affecting immune responses. Recent observations of widespread microplastic contamination of human placentas underscore just how much unseen damage plastics are doing to living systems. Decreasing health means decreased resistance to diseases, which would make antimicrobial resistance even more disastrous. Breaking the feedback loop of increased antibiotic use and microbial resistance requires innovative approaches.

Workshop participants noted that addressing such challenges might mean both applying innovations in new ways and taking new approaches. Applying innovations like increasingly sophisticated microsensors to detecting, tracking and modelling disease occurrence could aid early diagnostics and prevention, reducing the need for antibiotics. Applying different perspectives, such as traditional and Indigenous approaches to animal welfare, could contribute to developing new treatments for diseases and pests that might enable veterinarians to limit use of antibiotics.

Innovation unleashed

Technological innovation is a prime driver of emerging changes, and one that generates widespread impacts, both positive and negative. This cluster explores how the sequencing of extinct animals' DNA can be harnessed to enhance the resilience of modern livestock. This underlines how enhanced understanding of the animals and ecosystems of the past could help combat animal diseases and climate change moving forward.

Such genetic exploration extends to the potential creation of entirely new species, combining ancient and modern animals. In addition, technological advancements such as lab-grown meat and gene editing could revolutionise agriculture and animal welfare. Smart sensing technology introduces the concept of digital twins for animals, while synthetic biology's impact on biodiversity conservation remains uncertain, with potentially positive and negative outcomes. As boundaries blur between biology and digital systems, the future holds promise and challenges in reshaping our relationship with animals and the environment.

CARD #24

De-extinction and re-invention

Technological

©Chris Nguyen /Unsplash

Corresponding articles: 'Ancient chickens, cows and pigs may hold secrets to modern animal diseases' (europa.eu) [38]

'Resurrecting Australia's Extinct Tasmanian Tiger' (*Al Jazeera*) [39]

Scientists are currently trying to understand extinction better by sequencing extinct animals' ancient DNA, in a bid to make modern livestock more resilient.

Can promoting ancient DNA in modern livestock be the answer to animal diseases and climate change?

Scientists and research centres are experimenting with the revival of extinct species, e.g. the Tasmanian tiger.

Should funding instead prioritise protecting existing endangered species? How will this trend affect local ecosystems? What are the risks and potentialities of creating entirely new species? What might the health and welfare implications be for these animals?

What is the potential of meat grown from cells of currently extinct animals, offered on the luxury foods market? Is lab-grown meat a concern for WOAH in the domain of animal health and welfare?

CARD #20

Breeding applied to climate extremes

Technological

©Annie Spratt/Unsplash

Corresponding article: 'Beef producers breeding for heat tolerance' (farmprogress.com) [40]

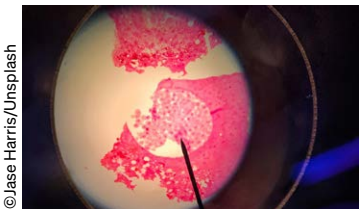
Throughout the history of farming, breeding has yielded bigger, more docile livestock fit for mass human consumption. In the era of climate change, breeding and even genetic engineering may now be used to make livestock more resilient to extreme temperatures.

How could genetic engineering be used in farming to protect against different climate extremes? What infectious pathogens and diseases might arise in new breeds?

CARD #19

Gene editing to reduce methane

Technological



©Jase Harris/Unsplash

Corresponding article: 'The climate-friendly cows bred to belch less methane' (*Reuters*) [41]

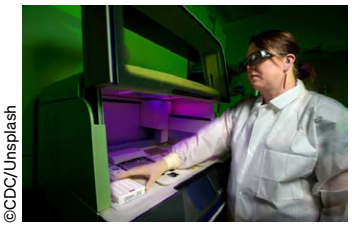
Gene editing technology is rapidly advancing and will soon be applicable in commercial settings. The applications of gene editing are broad and exciting. For instance, when Canadian dairy farmer Ben Loewith's calves are born next spring, they will be among the first in the world to be bred with a specific environmental goal: burping less methane.

Could this technology be used worldwide to reduce methane emissions from farming? What does this mean for Veterinary Services' roles in adapting to and mitigating climate change impacts?

CARD #41

Synthetic biology to the rescue?

Technological



©CDC/Unsplash

Corresponding article: 'Direct and indirect impacts of synthetic biology on biodiversity conservation' (*ScienceDirect*) [42]

Synthetic biology has the potential to directly and indirectly transform biodiversity conservation, to positive and negative effect. However, applying these biotechnology tools to environmental questions risks harming cultures, rights, livelihoods and the natural world. Decisions about whether to use synthetic biology in conservation should be weighed alongside the risks of ongoing biodiversity loss.

What risks to animal health and welfare might arise from the introduction of synthetic organisms into local ecosystems?

CARD #28

Cross-species organ transplants

Technological

©Robina Weermeijer/Unsplash

Corresponding article: 'Xenotransplantation: could a pig's heart save your life?' (*Science Focus*) [43]

Every year, millions of people die due to lack of supply for organ transplants. A potential solution may lie within animals. Researchers in the US have genetically engineered a pig's heart and successfully transplanted it into a baboon.

Could a similar procedure be successful in humans? Could the animals of the future be bred specifically for human organ transplants? Might WOAH be called on to develop health standards for this purpose?

CARD #7

In vitro laboratory animals

Technological

©Ricardo Raggione/Unsplash

Corresponding article: 'Spain's first farm animal organoid biobank will be set up at the IRTA to allow research into infectious diseases without the use of live animals' (IRTA) [44]

Laboratory animals might soon be a thing of the past. Scientists have been exploring the use of 'organoids', miniature organs made from stem cells, for *in vitro* study of the effects of pathogen infections. This method will hopefully eradicate the need for live animal experimentation.

How might these innovations affect pathogen research costs? Would the use of organoids, along with various microsensor 'lab on a chip' innovations, make in-field and locally specific research less expensive and more practical? What would WOAH's role be in disseminating this information, and in supporting standards development?

CARD #22

Bridging biological and digital systems

Technological

©Warren Umoh/Unsplash

Corresponding article: 'Capturing the immense potential of microscopic DNA for data storage' (nus.edu.sg) [45]

As we push the boundaries of DNA data storage, there is an increasing interest in bridging the interface between biological and digital systems.

What might this mean for animals? Could this bring new meaning to 'data farms' where animals may be used in the recording and storage of information on infectious diseases?

CARD #43

Digital twins for animals too?

Technological

©Jørgen Håland/Unsplash

Corresponding article: 'Star Trek-style scanner creates "digital twin" to track your health' (*BBC Science Focus Magazine*) [46]

Smart sensing technology raises the possibility of creating digital twins for animals. A US company has built a scanner capable of measuring hundreds of biomarkers in around an hour, from hormone levels to inflammation markers to cancers. The data could produce a 3D digital avatar of a patient's body – known as a digital twin – that would be tracked over time and updated with each new scan. While initially developed for humans, the same technology could be applied to livestock health and welfare.

What opportunities might this present for disease modelling, and would results from digital twin studies be accepted as evidence to enhance WOAH's animal health and welfare standards?

CARD #5

Farm apps of the future

Technological

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Corresponding article: 'From Weekend Project to $250 Billion Arena: Neetu & Kriti's Animall Journey' (yourstory.com) [47]

New technology could revolutionise farming by improving sales efficiency and interconnecting otherwise-isolated farmers. In India, an app called Animall has registered over 180,000 cattle for sale on its platform, establishing over a million buyer–seller interactions. The user-friendly app has transformed the previously mocked concept of online cattle trading into a commonplace activity.

How might such innovations enhance animal health and welfare during sales and transport? Could WOAH support the dissemination of such applications and the standardisation of commercial data regarding the health of animals available for sale?

CARD #6

Walk and talk with the animals

Technological

©Marwan Ahmed/Unsplash

Corresponding article: 'Could AI interpret and decode animal communication?' (openaccessgovernment.org) [48]

Animal welfare and disease detection could be radically transformed by technologies helping humans understand animal communication. AI models are being trained on animal noise recordings whose identified patterns could help humans understand species' behaviour.

Could analysing animal noises and sounds assist in continuous monitoring of their health and welfare? Might WOAH usefully serve as a base for animal translation sound databases?

Three interlinking clusters emerge from this set of changes. The first three changes are interconnected by genetic analysis and editing. The more we understand historical patterns of evolution through species' DNA changes, the more we can ensure living species are more resilient to changing climatic conditions – and less likely to contribute to climate and environmental crises. A growing ability to genetically re-design entire species raises significant ethical issues and issues of unintended ecological impacts; this is an area where scientific discoveries could disastrously outpace ethical considerations.

The second cluster of three changes highlights our growing capabilities in genetic engineering. The more these advance, the greater the challenges we can potentially address using bioengineering and synthetic biology. Examples of innovations that might help address ethical challenges in the use of live animals for medical research and treatment include the potential for replacing live laboratory animals with *in vitro* animals and increasing the use of cross-species organ transplants where donor organs are in limited supply. However, applying novel technologies always necessitates adequate assessment of impacts, dangers and potential unanticipated consequences.

The third cluster describes four changes arising where biotech meets digital tech, and sophisticated bioengineering capacities spur potential innovations for animal health and welfare. At the smallest scale, engineers and biologists are examining the information storage potential of DNA. More everyday applications include creating digital twins for livestock as part of integrated herd management software. Potential farming apps that interpret animal noise patterns, 'translate' sounds and even gait patterns could transform how farmers and veterinarians monitor the welfare and health of livestock.

Sense-making workshop participants highlighted opportunities arising from technological innovation. They also identified the potential of digital tags and 'rapid remote microsensors' linked to AI systems for herd health monitoring, as well as portable diagnostics. Digital tagging and digital twinning data could be stored on the blockchain for enhanced traceability of specific herd animals. The increased use of sensors, robotics and AI for herd monitoring could reduce direct human contact with animals, increasing biosafety. Participants highlighted potential dangers of this strategy: the more digital technologies are deployed, the greater the risk of cyber-attacks on food production facilities and farms, and the potential for cyber-extortion of veterinary records.

These advances in monitoring and diagnostics could inform mRNA vaccine development for rapid epidemiological response. Workshop participants also observed the increasing use of biotech and genetically-modified animals for producing drugs, organs and other non-food materials. They also noted that greater use of technological innovations by farmers and veterinarians would place higher demands on education and training in these areas.

Not avian influenza or artificial insemination, but 'that other AI'

In 2024, rapidly developing artificial intelligence (AI) is still generating social and economic buzz. AI technologies will certainly continue to evolve and shape our lives – but exactly how is less clear. Its profound ability to disrupt and transform is why AI is addressed separately from 'innovations unleashed' in this document.

AI and machine learning, already employed in tracking viral pandemics, could assist in emergency responses to animal diseases. Telemedicine and 'virtual vets' are emerging as possible solutions to the global veterinarian shortage, with debates about the future role of AI in Veterinary Services – will it mean replacement of human expertise, an augmentation of human skill, or something else? Using AI to address animal health challenges could produce a transformative shift in disease surveillance and veterinary practices.

CARD #16

Can AI do everything?

Technological

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Corresponding articles:
'Partnerships to access data under new Animal Health Surveillance Strategy' (agriland.ie) [49]

Transport & surveillance drones for environmental monitoring (DeltaQuad VTOL UAV) [50]

Developments in AI will shape the future of animal health and the pastoral farming industry. A new Animal Health Surveillance Strategy aims to develop public/private partnerships to access surveillance data from private veterinary laboratories, practitioners and farmers to monitor disease spread.

What other technological advances could be used to control the spread of disease in animals? Could drone surveillance technology be employed to detect and track animal diseases? As a 'data-driven' organisation, what sort of future role might WOAH have amid these developments?

CARD #29

AI and virtual vets

Technological

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Corresponding articles: 'Scientists develop AI-based tracking and early-warning system for viral pandemics: Machine-learning system effectively predicts emergence of prominent variants' (*ScienceDaily*) [51]

Will veterinarians be replaced by AI & robots? (willrobotstakemyjob.com) [52]

AI and machine learning are increasingly applied across all human activities, including animal health (e.g. improving warning systems for viral pandemics through AI tracking). How will this affect emergency responses to animal diseases? The global shortage of vets is being addressed by some via telemedicine and 'virtual vets'. Some now suggest that veterinarians may soon be replaced by AI technology.

Is that feasible? How does the veterinary human network work with AI to operate as an early warning system? What is the role of WOAH in this?

The use of AI could potentially augment veterinary medicine capabilities and capacity in significant ways, creating both opportunities and challenges for the veterinary profession worldwide, as well as how it educates and trains the next generation. Perhaps AI will augment veterinary work, functioning as assistants to human practitioners, or even potentially replacing them. However, it also has the potential to widen global inequalities in veterinary practice and education.

Workshop participants saw AI as potentially useful in coordinating input from digital tags and distributed sensors tracking herds and food animals, including fish. AI interpretations of resulting herd welfare databases could provide more efficient disease-spread modelling for diagnostics and prevention. AI translation use in veterinary science could, meanwhile, reduce language barriers between nations to help them share data, insights and new approaches.

An economist and a politician walk into a barn

Policies, laws and regulations concerning animal health and welfare interact with investments and profit margins in the food industry. This cluster of changes thus raises critical questions regarding investments in veterinary medicines and products, and addresses issues around the equitable distribution of resources and profits. It also considers potential impacts on trade arising from contamination of global waters and the advantages to protecting biodiversity through Indigenous-managed lands. Finally, it highlights the potential ripple effects of evolving economic and political dynamics on multilateral organisations working in agriculture and food systems.

CARD #13

North–South medical divides

Economic

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Corresponding articles: 'Veterinary Medicine Market would grow to USD 42.59 billion by 2030 (PharmiWeb.com) [53]

'As pandemic raged, low and middle income countries lacked vaccines. Never again, researchers vow.' (*The Washington Post*) [54]

Veterinary medicines and product market growth are attracting more investments, forecast to increase.

How do such investments affect veterinary professionals? How will investments be distributed globally?

For potential animal pandemics, will a coalition of countries develop labs and relationships with drug companies to ensure a fair allocation of locally produced veterinary medicines? What might this mean for private–public partnerships in animal health?

CARD #40

Marine impact uncertainties at hemispheric scales

Political

©Naja Bertolt Jensen/Unsplash

Corresponding article: 'Fukushima fish with 180 times legal limit of radioactive cesium fuels water release fears' (*The Guardian*) [55]

Ocean warming, ocean acidification, pervasive plastic pollution, and more recently the potential for unknown radioactive contamination effects underlines uncertainties about human impacts on marine biospheres.

Will monitoring of aquatic animals and environments be required on a global scale? What are the impacts on trade? Should WOAH maintain its infectious diseases mandate as this trend continues?

CARD #34

New powers in the world

Political

©Mathias Reding/Unsplash

Corresponding article: 'A new world order? BRICS nations offer alternative to West' (*DW*) [56]

In 2014, with USD 50 billion (around € 46 billion) in seed money, the BRICS (Brazil, Russia, India, China, South Africa) nations launched the New Development Bank as an alternative to the World Bank and the International Monetary Fund. They also created a liquidity mechanism called the Contingent Reserve Arrangement to support members struggling with payments. These offers were not only attractive to BRICS nations, but also to many other developing and emerging economies.

If the BRICS start setting political agendas, how will their different worldviews and values shift regulations around animal health, transport and trade? What are the implications for current intergovernmental and international organisations?

CARD #45

Increasing Indigenous management of biodiversity

Political

©Yohan Marion/Unsplash

Corresponding articles: 'New dawn for Arctic's first people: the Inuit plan to reclaim their sea' (*The Guardian*) [57]

'No basis for claim that 80% of biodiversity is found in Indigenous territories' (*Nature*) [58]

Recent studies contest the view that biodiversity is highest on Indigenous-managed lands, and wildfire risk lowest – but do confirm that 'Indigenous Peoples managed or held tenure rights over more than one-quarter of Earth's terrestrial surface – land that intersected with at least 37% of the remaining natural lands worldwide' [58] and show little sign of habitat fragmentation or alien species incursion.

How can WOAH support de-colonisation of ecological and biodiversity management in local contexts, supporting animal health and welfare and One Health?

The political and economic seas of the 21st century are increasingly turbulent. This makes creating a collaborative approach to the polycrisis more difficult. As natural resources come under increasing pressure from competing human activities and actors, conflicts increase and collaboration becomes more fraught. Economic and resource inequities between the Global North and South worsen these tensions and make accessing much-needed veterinary resources difficult for many communities. Joint stewardship of global resources like fish stocks and waterway quality becomes more problematic.

The increasingly multi-polar nature of international politics further complicates this picture, as new international alliances form and share resources. The upside is more choice for partners and greater leverage within international systems for many nations, as well as an influx of new perspectives into global dialogue.

Diversity of perspectives helps generate creative responses to challenges. Increasing attention to context-sensitive approaches for managing ecosystems and animals arising from traditional local and Indigenous practices also offers potentially new solutions to climate and environmental crises.

Workshop participants identified existing political impediments affecting the livestock industry (such as trade barriers), but also flagged instances of health and food safety scares invented for geopolitical reasons. They observed a dysfunctional disconnect between political messages of support for farming industries and sustainability and resulting policies. They highlighted the rise of ideological movements and individuals that transcend national identification, such as animal rights, green and faith-based movements, that have affected animal health and welfare issues. Non-state actors are impacting national Veterinary Services, e.g. ISIS, terror groups and trans-national organised crime. In some failing states, federal Veterinary Services have been specifically targeted to cause social, political and economic disruption.

Societal shapeshifting

Values people hold shape trends and drive change; changes can in turn shape societal values. This cluster tracks the swinging pendulum of shifting consumer preferences from meat to plant-based alternatives, cultured meat and back again. It also traces developments in the exploration of other sustainable protein sources such as insects and algae-based products. Perhaps most importantly, it highlights the burden of filtering the noise of 'infodemics' and combating misinformation, addressing how emerging information and communications technologies fuel increasing mistrust of science.

CARD #14

Back to meat

Social/Values

©Nick Karvounis/Unsplash

Corresponding article: 'Cost of living: Beyond Meat hit as inflation squeezes shoppers' (*BBC*) [59]

In recent years, consumers have been shifting away from meat and towards plant-based meat alternatives, which can be more expensive. Recent economic downturns are prompting people to return to meat. One day, cultured meat may even be more economically viable and sustainable than pastoral farming. However, public perceptions of lab-grown meat are generally negative, stunting the industry's growth.

Can cultured meat become the primary protein source for people if it's less expensive than meat?

CARD #21

The future of surf and turf

Social/Values

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Corresponding articles: 'Looking at edible insects from a food safety perspective. Challenges and opportunities for the sector' (fao.org) [60]

'Creating consumer demand for algae-based products (europa.eu) [61]

Insects are a viable sustainable food source for protein. Consumer acceptance remains an issue, but that may change.

The food industry is also exploring creating consumer demand for algae-based products, which could become a healthy dietary staple for more people. With the right messaging and products, consumers may show interest in incorporating specific types of seaweed and microalgae into their meals.

What regulations will be needed to develop around these products? What might this mean for WOAH?

CARD #31

Handling infodemics and mythbusting

Social/Values

©Ayla Verschueren/Unsplash

Corresponding article: Infodemic Management Approaches Leading up to, During, and Following the COVID-19 Pandemic (Center for Health Security) [62]

When SARS-CoV-2 first began to sweep the globe, so too did information about the virus, including accurate, false, and misleading information. This deluge of information was recognised as a significant threat to public health: what became known as an 'infodemic'. Similar issues have recently arisen relating to African swine fever. Government agencies are attempting to counter misinformation, e.g. with regulations concerning transparency in labelling.

How will disinformation undermine the response to disease outbreaks?

There is commentary that suggests a shift to plant-based, if not vegan, diet would contribute significantly to addressing global carbon footprints and slowing ecosystem degradation. However, that switch depends upon how consumers view and value meat-based foods. If people increasingly value sustainability, consumer demand for traditionally produced meat may drop, especially if the market offers meat-like options, either lab-grown from animal cells, or mimicked via clever processing of plant proteins. Another option is making use of widely available insect protein – but that might require a more significant value shift, not to mention clever marketing. The increasing use of insects as protein sources raises the question of what insect husbandry might look like, and what Veterinary Services it might require. Value shifts of this significance will cause tension and create conflict – which could be exacerbated by the ease with which convincing misinformation can now be created and disseminated.

Workshop participants were particularly concerned with managing misinformation and public perception. They underlined the need for comprehensive governmental responses to ensure the public receives correct information. They specifically pointed to misinformation about veterinarian public health as cause for concern.

Surprising developments

> Any useful statement about the future should at first seem ridiculous.
>
> Jim Dator

The final cluster of change cards represents developments that may seem to exceed WOAH's and Veterinary Services' current concerns and mandates. Yet it is useful to explore the potential ethical questions raised when researchers use deceased animals in radical technological innovations. A different set of moral and ethical challenges arise when we consider bioengineering improvements to animal cognition and intelligence. These experiments blur the boundaries between the living and the artificial, the natural and the engineered. The ethical critiques that arise could uncover issues related to animal health and welfare that are yet unaddressed.

CARD #23

Spinning new uses for dead creatures

Technological

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Corresponding article: 'Rice engineers get a grip with "necrobotic" spiders' (Rice University) [63]

Necro-robotic (robots created from preserved animal carcasses) spiders have been developed.

If the world starts finding uses for dead animals beyond consumption, how will attitudes change?

CARD #36

Becoming a post-dog

Social/Values

©Ryan Stone/Unsplash

Corresponding article: 'How to Become a Post-Dog. Animals in Transhumanism' (calpoly.edu) [64]

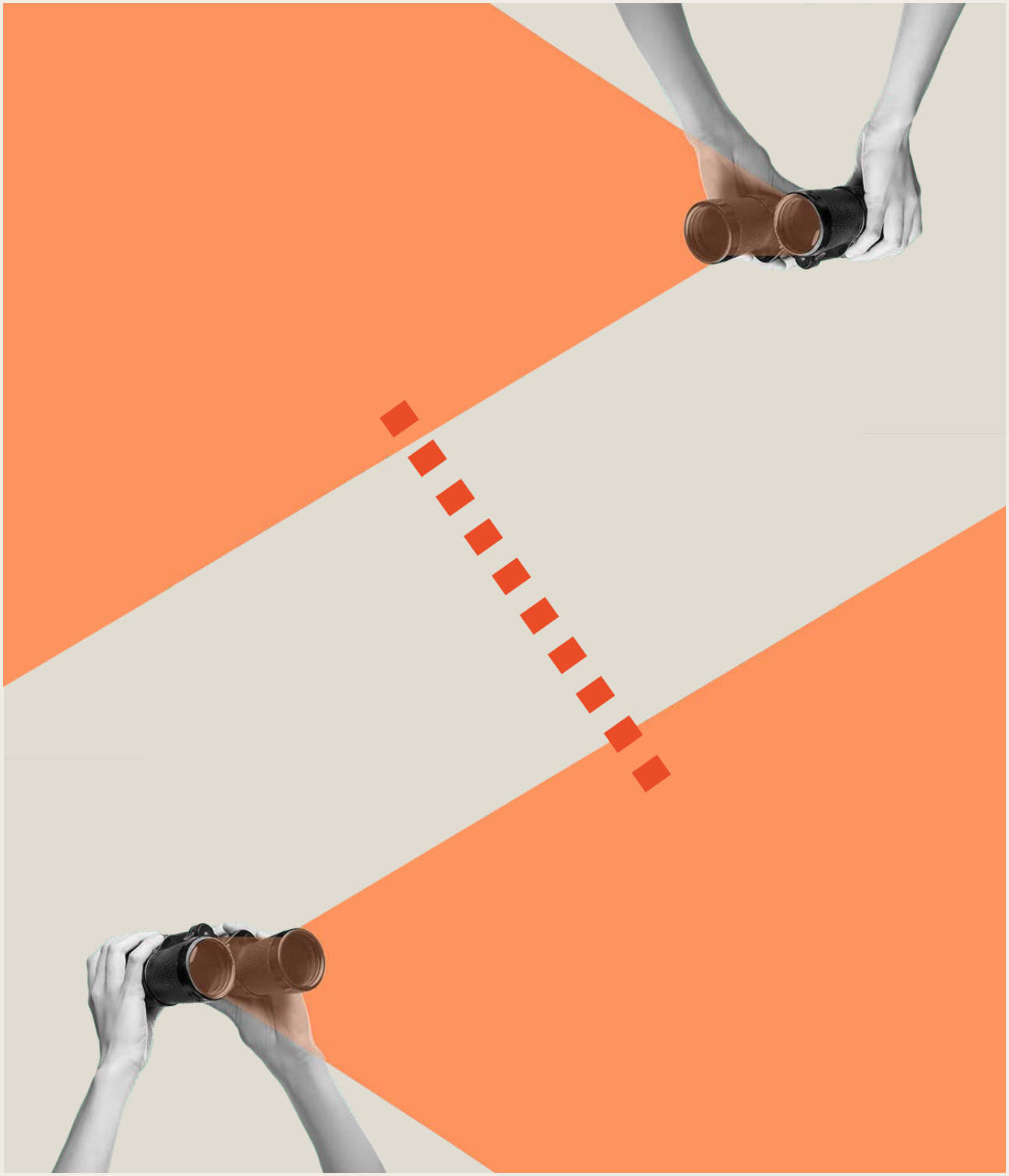
Transhumanists have argued that a commitment to animal welfare includes a moral imperative to help non-human animals overcome their biological limitations by enhancing their cognitive abilities, and generally 'uplifting' them to a more human-like existence.

Does such a transhumanist approach to animal welfare ultimately aim at the destruction of the animal as we currently conceive it?

Throughout history, human creativity has led to transformative and disruptive innovations, enabled more efficient production of goods and services, and improved health and well-being for humans and animals in their care. It has also created the unintended consequences accumulating in the current polycrisis. These two examples of more extreme changes are meant to challenge your thinking.

As the reader of this trend and driver book, what are the most startling changes you see around you? What are the most transformative, disruptive changes you can imagine arising? How might those imagined changes interconnect? What impacts might they create for animals, ecosystems, agriculture and the human food chain? What might the implications be for animal health and well-being? What might the implications be for your own work, and your local community? Whatever else happens, we know the future has surprises waiting for us. It's time to exercise 'what if' questions.

4 Links, interconnections, emergent possibilities



4 Links, interconnections, emergent possibilities

With horizon scanning results in hand, it is also useful to assess the potential impacts and interconnections of trends, drivers and uncertain emerging changes on an organisation's interests and responsibilities. Using systems thinking and mapping in this way deepens change assessment and sense-making efforts. For example, in surveying the core components of the domain of interest systems map of WOAH responsibilities (**Figure 2**, page 6), consider how any of these changes affect those core components, and which changes would cause the greatest disruption.

Changes do not arise in a vacuum. They emerge to affect numerous life systems, interacting with these – whether social, cultural, political, economic, technological, legal or deeply held values – to create cascades of impacts and additional changes. In addition, changes do not emerge neatly and singly; they emerge simultaneously, often in clusters. Emerging changes can collide, interconnect, and in some cases cancel each other out, while in others amplify each other. When considering emerging changes identified with horizon scanning, it is crucial to ask which changes are supporting and amplifying each other's impacts, and which are balancing each other.

Examining the 45 changes described in the preceding pages, potential interconnections can be detected among them. The systems map below (**Figure 5a** and **5b**) demonstrates how interconnected changes can form cascades, and eventually, ecologies of change: clusters that support and reinforce each other, potentially amplifying overall impacts in areas of concern. This systems map, drawn from the changes identified in the horizon scan, highlights interconnections between climate crisis impacts, more generally, and animals in the food chain more specifically.

As the planet warms, glaciers melt and fresh water changes the density of ocean salt water, disturbing patterns of ocean currents – which affects not only marine life, but global weather patterns at hemispheric scales. The effects on marine life create challenges for marine aquaculture, potentially disrupting one source of protein in the food chain. The intersection of global warming and environmental pollution – another dimension of the polycrisis – threaten agricultural harvests around the world. Simultaneously, more numerous and severe heat waves challenge animal transport and cooling capacities. These challenges heighten interest in and support for innovative solutions, such as breeding animals for resilience amid climatic extremes. Re-engineering livestock is increasingly possible as biotechnological capabilities advance, as is countering extinction and completely re-inventing domesticated animals.

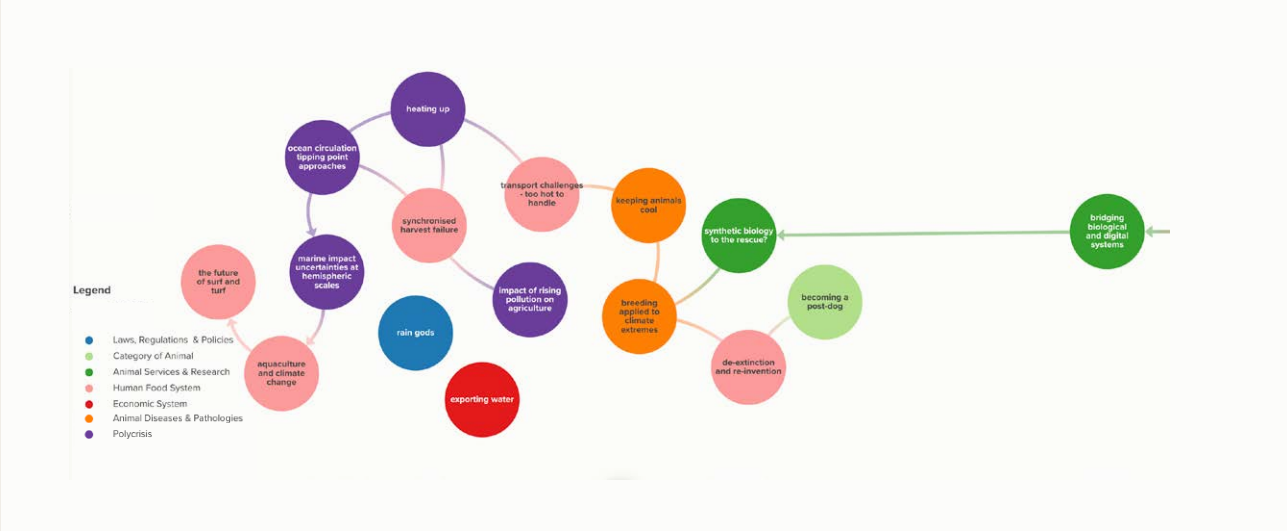


Figure 5a. Cascading interconnected changes

Technological innovations and scientific discoveries are potentially powerful enablers and disruptors to human and natural systems. Notice the green arrow entering the systems map from the right and connecting to synthetic biology. The other end connects to a cluster of AI-related emerging changes, at the node where emerging changes bridge biological and digital systems. AI is increasingly used to monitor, analyse and model living systems, from entire ecologies to single cells and DNA strands. The explosion of AI applications suggests the potential for interconnected capabilities: if 'digital twins' are built for various species of domesticated animals, how might that accelerate the evolution of farm applications assisting animal husbandry and livestock production? Will veterinary science-informed AIs, coupled with extensive environmental and livestock sensors, lead to the emergence of 'virtual veterinarians'? Will continuous tracking of animal behaviour enable farmers and vets to communicate with their livestock and improve their health and care?

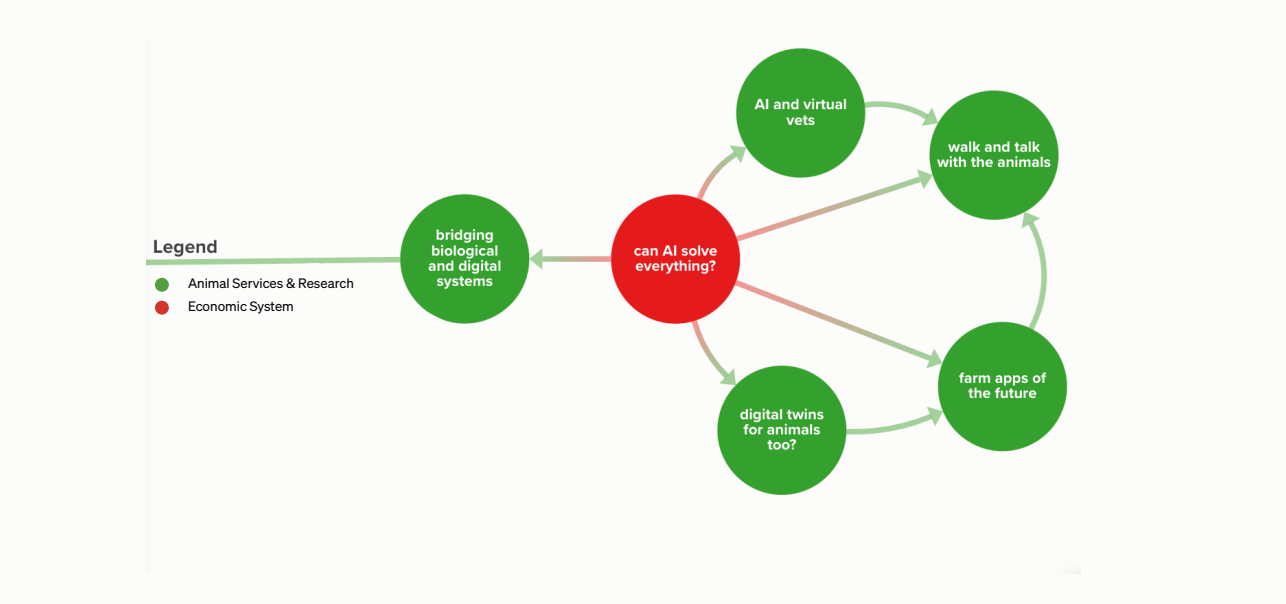


Figure 5b. Cascading interconnected changes.

In essence, foresight helps WOAH decision-makers and Members think systematically about both the Organisation's mandate and areas of work, and the external changes it must confront. Facing present and possible futures with foresight methods like horizon scanning helps eliminate blind spots in operating assumptions and in planning, and increases organisational resilience in the face of change.

5 Next steps

5 Next steps

This publication has presented an initial sampling of changes that are shaping the animal health and welfare landscape. A critical next step is considering how to incorporate the monitoring of change and assessing its impacts as a continuous strategic priority. WOAH wishes to anticipate the challenges that the Organisation and its Members might face in the years to come – and the opportunities that may be seized to render the animal health and welfare domain more effective and resilient.

Here are some interconnected considerations for making this happen:

1. **Identify missing elements:** reflect on this publication with colleagues and collaborators to assess whether other crucial or emerging changes should be added and addressed.

2. **Anticipate and interconnect**: conduct thought experiments on how identified changes might play out over time and possibly interconnect with each other. Identify possible synergies or conflicts that might amplify potential consequences or be disruptive to the *status quo*. As part of these thought experiments, regularly review how these interconnections could affect WOAH operations and strategies, as well as Members' work.

3. **Prepare for unexpected resource demands:** this relates to anticipating how change may play out on operations; therefore, be prepared to acknowledge that changes in the external environment may create unexpected demands on resources. In that case, what sort of contingency plans might enhance organisational resilience and flexibility to respond effectively to challenges?

4. **Regularly scan the horizon and reassess:** continuous horizon scanning along with revisiting and reassessing the insights drawn from horizon scanning is a good practice to remain dynamic and responsive to evolving and new changes.

Adopting these strategies will empower any organisation to navigate the challenges of a dynamic landscape of change, thus fostering a culture of proactivity and resilience. Even individual values can shift with surprising speed: consider the recent European court decision that actually weighted animal welfare higher than religious freedoms. Remember that change itself changes. In looking ahead to the uncertainties of the next 100 years of WOAH's work, the Organisation should use foresight methods, like horizon scanning, to navigate uncertainty, learn from it, be curious about it and be ready to be surprised and challenged.

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