

INTERNATIONAL ANALYSIS OF WILDLIFE FARM MANAGEMENT WITH RECOMMENDATIONS TO INFORM POLICIES IN VIET NAM



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Director: Mr Vu Thanh Liem, Deputy Director, International Cooperation Department (ICD)

Chief Technical Advisor: Ms Anja Barth, GIZ Viet Nam

Responsibility

Ms Anja Barth

Authors

Madelon Rusman

Micol Fascendini, MD MPH

English language editor

Harold Browning

Photos

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Abstract

Biodiversity loss, encroachment of wildlife habitats and the increased trade in wildlife have reduced the distance between humans and wild animals, increasing the possibility of pathogen spillover events as well as the risk of new emerging infectious diseases with pandemic potentials. The wildlife farming industry, and the value chain of wildlife trade in general, play a significant role in this scenario, greatly contributing to the close interactions between humans and a variety of wildlife species. The industry is particularly relevant in East and South Asia, where it is worth several billion US dollars and employs millions of people. Despite the knowledge that several farmed species carry a high zoonotic risk, international policy and regulations addressing disease spread at the source are still inadequate. In the current scenario, national governments have the responsibility and are urged to improve their national responses to reduce the risk of zoonotic disease spread, especially in collaboration with wildlife farm owners.

The current study reviews and analyses international experiences and practices for the management of zoonotic disease risks in wildlife farms, with the goal of identifying lessons learned and approaches that could be applied to the context of Viet Nam. The study was conducted in the framework of the project 'Reducing health risks in the wild animal trade' in Viet Nam, financed by the German Ministry for Economic Cooperation and Development and implemented by Viet Nam's national One Health Partnership with GIZ technical assistance.

A selection of documents on wildlife conservation and zoonotic risk mitigation informed the study research and helped identifying the most critical themes to regulate the management of wildlife farms with a focus on zoonotic risk mitigation. The themes of animal health, animal welfare, and biosecurity were prioritised for further research and analysis, with the intention of identifying opportunities of immediate actions for enhanced management of wildlife farms in Viet Nam.

International experiences and good practices informed the development of evidence-based short-term recommendations to mitigate the risks of zoonotic pathogen spillover within the wildlife farming industry in Viet Nam.

The current Vietnamese legislative framework is extensive and provides guidance on a high level for the implementation of environmental and veterinary requirements. However, policies and regulations lack practical direction and instructions on how requirements should be enforced, and what standards should be put in place. A five-step framework of actions is proposed in this study to address this gap, providing a roadmap for the development of viable and pragmatic (general and enhanced) standards. Under the stewardship of the One Health Partnership, all relevant stakeholders, including competent authorities, experts, researchers, civil society organisations and representatives from the wildlife farming industry, are called to engage in a collaborative process to the safer management of farms.

Three additional important themes were identified during the literature review but not duly analysed due to time constraints. Traceability, disease surveillance and species listing (i.e., are all considered critical components of a long-term strategy to reduce the risk of pandemics at the source. However, they require a holistic approach that takes the entire wild animal trade value chain into account and need significant time and financial investment. The One Health Partnership should further engage with relevant partners to design a comprehensive plan to mitigate the risk of emergence and spread of zoonotic pathogens at the human-wildlife-environment interface within the entire wild animal trade value chain. Effective and sustainable results can be achieved if stakeholders work collaboratively across disciplines and sectors by adopting the One Health approach and aiming to sustainably optimise and balance the health of humans, animals and the ecosystem.





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Acronyms



BMZ	German Federal Ministry for Economic Cooperation and Development
CITES	Convention on International Trade in Endangered Species
EID	Emerging Infectious Diseases
EU	European Union
FAO	Food and Agriculture Organisation
GHSA	Global Health Security Agenda
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
IUCN	International Union for Conservation of Nature
MARD	Ministry of Agriculture and Rural Development
MOH	Ministry of Health
MONRE	Ministry of Natural Resources and Environment
OH	One Health
OHHLEP	One Health High-Level Expert Panel

OHJEP	One Health Joint European Partnership
OHP	One Health Partnership
OIE	Office International des Épizooties (former name, currently WOAHA)
PPE	Personal Protective Equipment
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TAD	Transboundary Animal Diseases
TFEU	Treaty on the Functioning of the European Union
TWG	Technical Working Group
UNEP	United Nations Environment Programme
WAHIS	World Animal Health Information System
WAZA	World Association of Zoos and Aquariums
WHO	World Health Organisation
WOAH	World Organisation for Animal Health (founded as OIE)

1. INTRODUCTION

1.1 The risk of disease emergence at the wildlife-livestock-Human interface

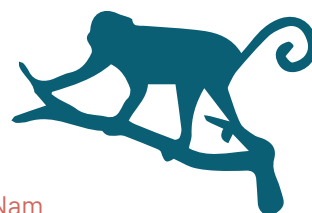
The risk of pathogen spillover from wild animals (henceforth wildlife) to other domesticated species and humans increases when the physical boundaries between them get smaller (Kock and Caceres-Escobar, 2022). Loss of habitat, human and livestock encroachment into (protected) areas with wildlife populations, for example, increase the possibility of spillover events, risking the outbreak of Emerging Infectious Diseases (EID). In order to make informed decisions about mitigation strategies to prevent disease emergence and dissemination, it is important to understand what factors play a role in the transmission of diseases between wildlife and livestock species, and to humans (Ellwanger and Chies, 2021).

The practice of commercial breeding of wildlife species and the value chain of wildlife trade in general contributes to the increased proximity and interactions between humans and a variety of wildlife species. Commercial wildlife trade is a worldwide, complex, multi-billion US dollar issue. For example, estimates indicate that wildlife farming is a USD 20 billion industry that employs 15 million people in China (World Bank and FAO, 2022a). The wildlife farming industry involves thousands of flora and fauna species and plays a fundamental role in regional, national, and international economies (TRAFFIC, n.d.). The spread of a variety of pathogens can be accelerated due to the proximity of animals housed closely together, and housing different species together can cause pathogens to adapt to new hosts. This is particularly true in traditional food markets, where a range of different species may be sold alive and kept closely together with often few to no biosecurity measures (World Bank and FAO, 2022a).

8,000 licensed breeding facilities in Viet Nam

2,5 million wild animals

150 different species are kept in wildlife farms in Viet Nam



At the time of writing, there were more than 8,000 licensed breeding facilities in Viet Nam, which combined house almost 2,5 million wild animals, including protected species (Nguyen and Pham, 2022). Pham et al. (2022) estimate that about 150 different species are kept in wildlife farms in Viet Nam, of which the most common are Siamese crocodile (*Crocodylus siamensis*), Malayan porcupine (*Hystrix brachyura*), sika deer (*Cervus nippon pseudaxis*), Asian palm civet (*Paradoxurus hermaphroditus*), Indian peafowl (*Pavo cristatus*), Sambar deer (*Rusa unicolor*) and Burmese python (*Python bivittatus*). Annual wildlife export and import turnovers of Viet Nam are estimated at over USD 100 million. Several species bred in these facilities are considered to carry high risks of zoonotic transmission (Wikramanayake et al., 2021). According to a study by TRAFFIC in 2008, Vietnamese exports of wildlife to Italy, United Kingdom, Spain, Russia, Japan, China and the United States have an average annual revenue of USD 60 million and employ about 35,000 people (TRAFFIC, 2008).

In April 2021, concerned about the wildlife origin of SARS-CoV-2, the World Organisation for Animal Health (WOAH, founded as OIE), the World Health Organisation (WHO) and the United Nations Environment Programme (UNEP) published an interim guidance on reducing public health risks associated with the sale of live wild animals of mammalian species in traditional food markets (OIE, WHO and UNEP, 2021). It was an urgent call for action by competent national authorities. Among the different recommendations is 'conduct risk assessments to provide the evidence base for developing regulations to control the risks of transmission of zoonotic microorganisms from farmed wild animals and caught wild animals that are intended to be placed on the market for human consumption. Regulations should address traceability of farmed wild animals to ensure that they are distinguished from caught wild animals and should include strict biosecurity measures' (OIE, WHO and UNEP, 2021, p.2).

There is now a call to respond to the COVID-19 outbreak and to prevent the next pandemic by improving current regulatory and policy frameworks by taking a One Health (OH) approach (World Bank and FAO, 2022b). 'One Health explicitly recognizes the interdependence of humans, domestic and wild animals, plants, and the wider environment and 'mobilises multiple sectors, disciplines and communities at varying levels of society to work together to foster well-being and tackle threats to health and ecosystems' (FAO et al., 2022, p.13).

Whilst there have been several urgent calls for action on a global approach to reduce the risk of infectious disease transmission (Wingard et al., 2020; World Bank and FAO, 2022b), recent analyses of international regulatory frameworks reveal weak levels of international policy and regulations on preventing disease spread at the source, focusing especially on the threats posed by wildlife trade and consumption (Wingard et al., 2020). Until a united international regulatory framework has been developed and implemented, national governments have the responsibility and are urged to improve their national responses to reduce the risk of disease spread (Wingard et al., 2020; CITES Secretariat, 2022; CBD, 2022).



1.2 The current OH landscape in Viet Nam

Viet Nam started the first Partnership on Avian and Human Influenza in 2006 with 26 national and international members (Nguyen-Viet et al., 2022). Since then, several partnerships followed, resulting in the establishment of the government-led One Health Partnership (OHP) in 2016, with the overall goal of enhancing Viet Nam's capacity in addressing zoonotic infectious diseases (OHP, n.d.). In March 2021, building onto the first OHP in place from 2016–2020, the Ministry of Agriculture and Rural Development (MARD), the Ministry of Natural Resources and Environment (MONRE) and the Ministry of Health (MOH) signed the Viet Nam OHP Framework for Zoonoses phase 2021–2025, engaging 28 national and international partners (OHP, 2022). The desired objective of all signatories is 'to minimise the risk that zoonotic pathogens and environmental agents will cross species barriers, and to reduce the occurrence of antimicrobial resistance in human and animal pathogens, by improving multi-sectoral OH collaboration in Vietnam' (OHP, 2022, p.32).

A gap analysis was performed based on inputs from stakeholders and findings from the 2016–2020 Strategic Plan of which the results were presented in the One Health Master Plan (2021) as a SWOT analysis. One of the threats that was identified during the analysis process is that Viet Nam is at risk from 'cross-border and cross-continent wildlife trafficking, migratory species, and a poorly regulated wildlife farming industry' (OHP, 2022, p.14). Although Viet Nam has developed an ostensibly comprehensive legal system on the management of wildlife farms, weaknesses exist. For example, there are no effective management systems on the origin of wild animals (e.g., marking and traceability systems), increasing the risk of laundering and illegal trade. Neither are there any technical guidelines on the breeding of high-zoonotic-risk species, or measures to prevent and control infectious diseases on wild animals. Overall, law enforcement remains weak, and more efforts are required to regulate the management of wildlife farming (Nguyen and Pham, 2022).

This research study was conducted in the framework of the project 'Reducing health risks in the wild animal trade in Viet Nam' financed by the German Ministry for Economic Cooperation and Development (BMZ) and implemented by the OHP Secretariat under MARD with technical assistance from the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. As part of a global action to support the 'International Alliance against Health Risks in Wildlife Trade', the project aims to address the human health risks that arise from the trade and consumption of wildlife species, adopting the One Health approach. The project supports the Vietnamese authorities in advancing the work to reduce health risks along the value chain of wild animal products, including the development of policy frameworks and technical standards for commercial

wildlife breeding facilities (i.e., wildlife farms). This research study explored international experience and practices to help develop policy recommendations for the management of commercial wildlife farms in Vietnam.

The document is structured in six chapters. The Introduction provides an overview of the risk of disease emergence at the wildlife-livestock-human interface, a background on wildlife farming in Viet Nam, and the rationale for the study. Objectives and Methods describe the scope of the research study and the approach adopted to conduct it. The findings of the study are reported in the Results chapter that summarises the international experiences and practices for the management of zoonotic disease risks in wildlife farms. The Discussion proposes a framework of action to mitigate the risk of disease emergence and transmission in the context of wildlife farming in Viet Nam. This builds on the evidence gathered from international practices and adopts a One Health perspective. Study limitations and wider recommendations on other important themes to further address the management of wildlife farms are summarised in the Conclusions and Outlook chapter.

2. OBJECTIVES

The study aims to develop a set of policy recommendations for the management of wildlife farms in Viet Nam.

The study has three main objectives:

- Review and analyse international experiences and practices for the management of zoonotic disease risks in wildlife farms.
- Identify lessons learned and approaches that can be applied to the Vietnamese context to reduce health risks from wild animal trade, following the One Health approach.
- Develop recommendations for Viet Nam, including opportunities for immediate action and policy options for defining and/or limiting species that can be farmed.

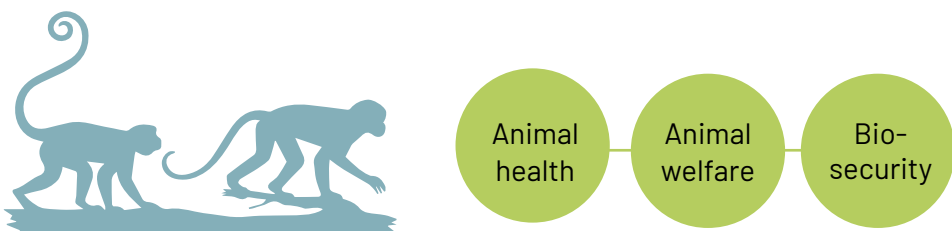


3. METHODS

The study research developed across three consecutive phases.

- 01 Focused on an explorative review of the literature and aimed to describe the risks of disease emergence and transmission in wildlife farms
- 02 Focused on the in-depth analysis of the three identified themes
- 03 The good practices and international experiences were revised taking a One Health lens, with the aim to develop recommendations for Viet Nam

The first phase focused on an explorative review of the literature and aimed to describe the risks of disease emergence and transmission in wildlife farms. This created the opportunity to draft a simple conceptual framework to guide the subsequent phases and the in-depth analysis of thematic areas for the management and mitigation of any infectious threat. Among a few documents and reviews on wildlife conservation and zoonotic risk mitigation, the World Bank series on pandemics prevention (World Bank, 2022; World Bank and FAO, 2022a, 2022b) and the Legal Atlas review on wildlife trade and legislation (Wingard et al., 2020) revealed crucial for the scope. Their careful analysis allowed the identification of three key themes that shaped the research process and following steps: *animal health, animal welfare, and biosecurity*



These are valued among the most important themes to regulate the management of wildlife farms and mitigate the zoonotic risk (World Bank and FAO, 2022a). While acknowledging that the three themes may not cover the wide spectrum of factors that increase the risk of disease emergence and spread in wildlife farming, effective and sustainable interventions that address them may lead

to significant impact on disease control. The research focuses primarily on these three themes with the intention of identifying opportunities of immediate actions to an enhanced management of wildlife farms in Viet Nam. Three additional themes (tracking and traceability, disease surveillance, and animal listing) are briefly discussed in the conclusions. Though essential elements to the mitigation of pandemic risk at the source, they require a long-term holistic approach that goes beyond the focus of the present research.

The second phase focused on the in-depth analysis of the three identified themes. A selective literature review was used to gain solid technical knowledge on each theme. Google Scholar was used as the main search engine. Keywords such as 'legislation', 'laws', 'wildlife' and 'zoonoses' were coupled with more specific keywords to explore the published literature under each theme. For example, the research of the animal health theme included specific words such as 'animal health', 'husbandry', 'veterinary care', and 'vaccination'. Legislations, policies and reports were also searched using Google and browsing the websites of international agencies and national authorities directly involved in the regulation and management of animal health and welfare in farms and captive breeding facilities. Retrieved international policies and practices were carefully analysed under each theme, to provide a global perspective of the topic and guide the identification of good practices for adoption and replication. Policies and standards from individual countries were taken as examples to describe approaches and values of different practices in the management of zoonotic disease risks in farms and draw suitable recommendations to the context of Viet Nam. Since policies and regulations on the specific management of wildlife farms is limited, the review was extended to include publications on legislation and practices in livestock farms, rescue centres and similar settings.



In the third phase of the research, the good practices and international experiences were revised taking a One Health lens, with the aim to develop recommendations for Viet Nam. These were arranged in a framework of actions that builds on the multi-sectoral and trans-disciplinary principles of One Health and proposes an evidence-based multi-scalar approach for the prevention of pandemics at the source. The framework guides the translation of policies into immediate actions for the management of wildlife farms with a focus on reduction of disease emergence at the human-wildlife interface. The framework of actions needs to be analysed and discussed with the One Health Partnership, engaging institutional actors, research and development partners to assess if it is feasible, practical and affordable in the context of Viet Nam and to gather inputs and recommendations for its finalisation and endorsement. A collaborative review of the proposed approach will ensure the alignment of the framework with national plans and priorities and guide the identification of challenges and opportunities for its actual operationalisation.

Within the context of this study, the term 'wildlife farm' refers to any facility that keeps or breeds one or more captive animals that are normally found in the wild (World Bank and FAO, 2022a) with the past, current and/or future intent to utilise animals and/or their offspring for fur, traditional medicine, food, exhibiting animals and pets, or for their use in biomedical experiments (World Bank and FAO, 2022b).



4. RESULTS

This chapter provides an overview of the three themes that were identified through the literature review as crucial for the management and mitigation of zoonotic disease risks in wildlife farms. An introduction to each theme is provided, giving an overview of the topic and underlining the importance of the specific practice to mitigate the risk of disease emergence and transmission. International practices and experiences on the development and application of specific measures under each theme are then presented, highlighting lessons that could be learned and applied in the context of Viet Nam.

4.1 Animal health

Scope and definition of animal health and veterinary services

The animal health and veterinary services theme encompasses the prevention, treatment and management of sick or injured animals and touches upon the areas of animal welfare as well as of economics. Diseases can have a great impact on an animal's physiological functions and can therefore cause it to be less productive in an economic sense. The book *Animal Health Economics* (Dijkhuizen and Morris, 1996) was written from a livestock perspective, but its reasoning of the economic impact of disease can largely be applied to farmed wildlife as well. Premature death is a clear example of how disease can cause economic loss, or loss of projected profit from an animal. Diseases can also cause a change in value of animals and products of slaughtered animals for aesthetic or human safety reasons, as the physiological effects of disease can change the appearance (visible lesions, altered ratio of meat to bone) and consumption safety (presence of a zoonotic disease). From a more humane perspective, prevention and prompt treatment of disease are part of good husbandry and contribute to maximising the welfare of captive animals. This theme revolves around the systems and techniques that should be in place in order to ensure the highest quality veterinary care on wildlife farms. When captive animals are in good health, infectious diseases are less likely to occur, and the risk of emergence and spillover of new pathogens is usually reduced.

Animal health and veterinary care in wildlife farming, however, is not regulated and adequately monitored, despite the sector being quite important, especially in East Asia and the Pacific where the growing demand for wild meat and products lead to its continuous expansion (World Bank and FAO, 2022a). Regardless of the recent efforts in registering wildlife farms, such as in China and Vietnam, there is limited or no regulation and supervision of their health, hygiene and welfare standards (World Bank and FAO, 2022a). The survey on international and national legislation conducted by Legal Atlas (2021) reveals that wildlife is rarely mentioned in animal health laws. These aim specifically to prevent and control zoonotic diseases and include requirements on disease notification, disease control measures (e.g., treatment, isolation and quarantine), and disposal of infected animals or carcasses. However, national laws primarily focus on protecting domestic animals and not the health of wild animals. Only 6 out of the 38 surveyed countries clearly mention wildlife in their animal definition (Wingard et al., 2020). And, even when regulatory requirements address wildlife animals (such as notification or veterinary inspection), these do not take into consideration the disease risk of different animal species. Certain mammals taxa (bats, non-human primates and rodents) and some birds (such as waterfowl), for example, have a greater risk for the emergence of infections with pandemic potential, whereas reptiles and amphibians have mainly an occupational health risk rarely generating a human-to-human transmission (World Bank and FAO, 2022a). The lack of legal and technical frameworks on wildlife farm management, lead to poor health monitoring programs and an increased vulnerability of farmed species to stress and immunosuppression with a consequent risk of disease (Magouras et al., 2020).

The control and management of zoonotic diseases is one of the primary objectives of the tripartite WHO/FAO/WOAH, which has been transformed into a quadripartite with the addition of UNEP in 2022. The Tripartite Guide to Addressing Zoonotic Diseases in Countries, issued in 2019 and recently complemented by operational tools to support the multi-sectoral coordination, risk assessment, surveillance and information sharing, proposes the adoption of One Health and the active engagement of the wildlife and environmental sectors to ensure an effective and sustainable management of zoonotic disease threats. Wildlife veterinarians and experts are called to take part in the identification and prioritisation of zoonotic diseases, their epidemiological surveillance, and the strategic planning and emergency preparedness activities (FAO, WOAH and WHO, 2019). However, the inclusion of the wildlife sector in the management of animal health is reportedly limited; wildlife is often a responsibility of the environmental sector that may have no or inadequate capacity in animal health and vice versa (WOAH, 2021).

Animal health and control of zoonotic risk

Animal health and veterinary services play an essential role in the control of zoonotic diseases in livestock farms. These include a vast array of preventive and curative services that are performed and adapted depending on the species of animals and the intensity of the production system (Collins and Wall, 2004). Good husbandry practices are the foundations of healthy animals, including appropriate feeding and clean nutrition, control of pests, suitable and adequate space, and proper disposal of farm waste products such as slurry and bedding (Petrovan et al., 2021). Veterinary care includes both preventive and curative treatments, and the proper management of sick and deceased animals. Control of parasites in farmed animals, for example, can prevent animal debilitation and thus protect from disease emergence (Collins and Wall, 2004). Separation of individuals by species and age groups can limit pathogen transmission within the farm (Petrovan et al., 2021). Veterinary care requires a specific health plan that includes routine on-site visits, preventive care and timely management of sick animals by seeking appropriate veterinary care and isolating sick individuals (Petrovan et al., 2021). Health monitoring, especially for notifiable and emerging diseases, enables the early management and control of potential outbreaks, limiting the spread of diseases within and beyond the farms (Petrovan et al., 2021). Epidemiological investigation in farmed animals also plays a key role in the management of disease emergence and transmission, as data on disease can inform research and eventually guide the planning and implementation of preventive measures and specific interventions (Murray et al., 2016; Cossaboom et al., 2022).

Farmers are primarily responsible for the health of their animals, as it is in their (economic and health) interest to avoid the entry of pathogens or the emergence of diseases in their facilities. Appropriate and consistent application of good animal husbandry and veterinary care practices is the most effective way to keep farmed animals healthy (Collins and Wall, 2004). Training animal keepers and farmers is, thus, a key strategy to guarantee that animals are kept in good and healthy conditions and that they are properly managed when diseased (Craig, 2021; Petrovan et al., 2021). Farmers should be trained on the early signs of animal disease, the risks of zoonotic disease transmission, the basic protocols to manage a sick animal and control the disease spread within their farms (Petrovan et al., 2021).

The zoonotic risk of wildlife farms can be reduced adopting the hygiene and health measures used in livestock farms. High-level hygiene and health standards are critical in intensive (wildlife) production farms, where animal density and stressful conditions ease disease transmission among genetically similar and immunocompromised individuals (Murray et al., 2016; Petrovan et al., 2021).

Basic husbandry practices (including, water and food provision, bedding and disposal of farm waste products) could be monitored through the introduction of detailed protocols and veterinary health plans (including, routine veterinary visits, health monitoring, preventive treatments, management and isolation of sick individuals) could support the adoption of standard preventive and curative services. Moreover, wild animals could be tested for specific pathogens and known zoonoses and sick animals isolated to reduce the risk of transmission within the farm (Murray et al., 2016).

Animal health in legislation and policy

National animal health legislation varies from country to country and, as already mentioned above, rarely makes specific mention to wildlife and disease transmission. The Animal Health Law of the European Union provides a good example of legislation on transmissible animal diseases covering virtually all animals (farmed and wild, vertebrate and invertebrate, terrestrial and aquatic) (Verniers, 2022). The Regulation (EU) 2016/429 entered into force in April 2021 and replaced all existing animal health rules, simplifying the law and setting clear priorities to tackle disease transmission (EUR-Lex, 2022). The Regulation supports the livestock and food production sectors and aims to prevent and control the transmission of animal diseases to other animals or humans (Verniers, 2022). Important elements of the law include an enhanced focus on prevention and a common system to detect and control diseases, a risk-based approach that builds on the categorisation of animal diseases and allows for a better use of resources, and simplified tools for surveillance, diagnosis and notification (Vermeersch, 2021; Verniers, 2022).

The regulation gives clear responsibilities to animal keepers, farmers, veterinarians and competent authorities, providing them with transparent rules for early detection to prevent disease transmission and spreading (Vermeersch, 2021). Furthermore, it allows for enough flexibility to accommodate different local circumstances and ensure the application of minimum standards across different size and type of facilities (Verniers, 2022). This reflects on the registration requirements as well as the response expected in case of emerging diseases and outbreaks (Verniers, 2022). In terms of veterinary care, the regulation introduces the site visits by veterinarians as part of the ongoing surveillance and as a possibility to prevent and control diseases in wild animals (Verniers, 2022) and maintain a specific focus on prevention, emphasising the importance of biosecurity, knowledge of animal health and vaccination (Vermeersch, 2021).

Lessons learned and recommendations

The review of international practices and legislations, reveals a few important

issues that should be taken into consideration for planning interventions aimed at mitigating the risk of zoonotic disease transmission in the wildlife farming industry. Across the three themes, this chapter summarises key lessons that seem feasible and practical for application in the context in Viet Nam and that should be integrated in any future planning for the management of wildlife farms.

- *Risk-based approach to animal diseases.* Animal diseases pose different risks to animal and human health and may therefore require different prevention and control measures. The categorisation and prioritisation of diseases and taxonomic groups of wild animals help the identification of appropriate measures that are based on specific disease risks, allowing for focused investments and better use of available resources (Vermeersch, 2021; Nguyen-Viet et al., 2022).
- *Flexible application of regulations based on farm size and production type.* Value and relevance of veterinary measures and protocols depend on the size and production type of the farm. Regulations that accommodate for different local circumstances facilitate their acknowledgement and appropriation at the farm level (Petrovan et al., 2021; EUR-Lex, 2022).
- *Prevention.* Healthy farmed animals are less susceptible to disease. Good husbandry practices, vaccination and preventive measures focused on hygiene and biosecurity, are of primary importance to maintain animals in good health. Disease prevention will reduce the cost of managing and controlling the disease at a later stage (EUR-Lex, 2022; World Bank and FAO, 2022a).
- *Farmers' knowledge on animal health.* The achievement of good animal health requires that farmers and animal keepers are educated on basic husbandry and veterinary care practices. Training on zoonotic disease risks, transmission and prevention will promote the rigorous application of control measures (Collins and Wall, 2004; EUR-Lex, 2022).
- *Routine veterinary visits.* Regular animal health visits by qualified and expert veterinarians allow the timely identification of disease and support on-farm surveillance (Petrovan et al., 2021; EUR-Lex, 2022). Depending on the farm size and production type, veterinary visits could be arranged with external or on-site animal health officers.
- *Shared responsibility.* Animal health is the responsibility of all actors involved in the farming industry, including legislators, veterinary officers, and farmers. Effective communication and collaboration among actors support the early detection and prevention of disease outbreaks, the control of disease transmission within and beyond the farm, and the mitigation of potential subsequent damages (EUR-Lex, 2022).

4.2 Animal welfare

Scope and definition of animal welfare

In animal welfare science, the focus of research mainly lies on three overlapping ethical concerns: 1) whether an animal is feeling well, 2) whether an animal is leading a natural life and 3) whether an animal is functioning well (Fraser et al., 1997). In their natural habitat, wildlife species live in complex environments and continually make decisions about how to use that environment for their individual benefit. From sourcing food, choosing safe nesting and sleeping sites, keeping territories, finding suitable mating partners to raising their offspring, every decision is based on maintaining the individual's fitness levels and optimising reproduction. These decisions depend on species-specific and individual needs. Animal welfare is about meeting those needs in a captive setting, considering the awareness that animals are sentient beings (Bousfield and Brown, 2010) and therefore can experience feelings and emotions. The World Association of Zoos and Aquariums (WAZA) refers to animal welfare as: 'How an animal copes with the conditions in which it lives. A good state of welfare (as indicated by scientific evidence) results in an animal that is healthy, comfortable, well-nourished, safe, able to express innate behaviour and not suffering from unpleasant states, such as pain, fear and distress' (Mellor, Hunt and Gusset, 2015, p.87). A well-known basic concept of animal welfare was initially published in the 'Report of the Technical Committee to Enquire into the Welfare of Animals kept under Intensive Livestock Husbandry Systems', known as The Five Freedoms of Animal Welfare (Brambell, 1965).

- 1 Freedom from hunger and thirst by ready access to fresh water and a diet to maintain full health and vigour.
- 2 Freedom from discomfort by providing an appropriate environment including shelter and a comfortable resting area.
- 3 Freedom from pain, injury or disease by prevention or rapid diagnosis and treatment.
- 4 Freedom to express normal behaviour by providing sufficient space, proper facilities and company of the animal's own kind.
- 5 Freedom from fear and distress by ensuring conditions and treatment which avoid mental suffering.

Even though being abstract, this concept put the welfare of production animals on the public agenda in the 1960s and from then on directed research into the effects of (veterinary) care, housing, nutrition, humane treatment and the opportunity to perform their species-specific natural behaviour on animals' affective states, instead of merely looking at animals' biological functions (Mellor and Webster, 2014).

In a broader societal sense, the WOA defines animal welfare in its Animal Welfare Mandate as 'a complex, multi-faceted public policy issue that includes important scientific, ethical, economic and political dimensions' (WOAH, 2002). The WOAH also states: 'Good animal welfare requires disease prevention and appropriate veterinary care, shelter, management and nutrition, a stimulating and safe environment, humane handling and humane slaughter or killing' (WOAH, 2022b). Good welfare cannot be ensured on its own (Webster, 2001), but is something that needs to be facilitated by ensuring good standards in husbandry, veterinary care, and slaughter practices. In summary, animal welfare is a complex issue that can have different interpretations depending on the dimension it is being viewed from. The humane treatment of animals touches upon the fields of ethics, empathy, economics, science, education, health, societal and cultural morals. Over the years it has been incorporated into legislative frameworks, despite having a range of different stakeholders with often (initial) opposed views and conflicting positions towards animal welfare (David Bayvel, 2006; Dawkins, 2017). As continued research and new measuring techniques increase our understanding of animal welfare, these developments drive the change in minimum welfare standards to inform and shape improved policy and legislation around the world, such as New Zealand (Mellor and Webster, 2014) and the European Union (Regulation 2017/625, Article 7).



Animal welfare and control of zoonotic risk

Even though short-term stress is not necessarily immunocompromising (Martin, 2009), long term continued stress is known to cause suppression of the immune system and the magnitude of immune dysregulation caused by stress can cause health implications in humans as well as animals (Padgett and Glaser, 2003). A well-functioning immune system either 1) eliminates pathogens that have invaded the body by reducing the reproductive ability of the pathogen and reducing the pathogen burden, 2) prevents pathogens from invading in the first place, or 3) creates tolerance for pathogens (Ayres and Schneider, 2012; Rauw, 2012) by limiting damage in the body that is caused by infection without reducing the pathogen's ability to grow and reproduce (Roy and Kirchner, 2000; Rauw, 2012). In other words, animals with a strong immune system may be carrying pathogens without showing any symptoms of disease and can thus spread pathogens unknowingly to the farmer and to other animals, including intermediate hosts. This is especially of concern as, even though specific data is limited, it can be assumed that wildlife farms contain a large number of animals sourced from the wild and that there are high contact rates between farmed wild animals and humans (World Bank and FAO, 2022a). Wild animals kept in a farm environment, especially when managed without much knowledge about their natural history and needs (Nuwer, 2010) and without comprehensive animal welfare legislation and policy frameworks, can be at a high risk of contracting and spreading zoonotic pathogens. Good animal welfare standards protect animals from unnecessary suffering and are a non-negligible element of EID and zoonotic disease mitigation strategies but can also bring direct (financial) advantages to the farmer. These can manifest as increased profits due to reduced mortality rates and thus more surviving offspring, and/or improved health, thus reducing the need to buy medication and improved product quality, allowing higher sales prices (Dawkins, 2017).

Animal welfare in legislation and policy

The general trend in policy has been to move forwards from the mere reactive provisions to reduce or prevent acts of cruelty, to proactive promotion of animal welfare (Mellor and Webster, 2014), although different countries are at different stages of improving legislation (Mellor and Webster, 2014; World Animal Protection, 2020). This journey is influenced by factors like the position of animals in society, the understanding of animal welfare, economical constraints and ethical issues (Bayvel, Rahman and Gavinelli, 2005; Fraser, 2008; Mellor and Webster, 2014). A core element of animal welfare in progressive legislation is the recognition of animals as sentient beings. One of the indicators of the Animal Protection Index, first published in 2014 by World Animal Protection and updated in 2020, is the presence of the recognition of animals as sentient beings in

legislation (World Animal Protection, 2020). The definition of animal sentience is as complex as the definition of animal welfare itself, but can broadly be interpreted as having the capacity for subjective experience (Nagel, 1974; Block, 1995) or more specifically 'a sentient being is one that has some ability

- (i) to evaluate the actions of others in relation to itself and third parties,
- (ii) to remember some of its actions and their consequences,
- (iii) to assess risks and benefits,
- (iv) to have some feelings
- (v) to have some degree of awareness' (Broom, 2014, p.5).

Animals being sentient beings has now been fully recognised in the legislation of several countries in the world, for example: Colombia's law 1774 (2016) states that 'animals as sentient beings are not things' and that they shall receive 'special protection against suffering and pain'; Article 14 of Peru's Animal Protection and Welfare Law (2016) states that 'all species of domestic and wild vertebrate animals kept in captivity' are 'sentient beings' and the European Union's Lisbon Treaty recognises that animals are sentient beings and that the Union and its individual Members shall pay full regard to their welfare requirements when it comes to policy development for agriculture, fisheries, transport, internal markets, research and technological development and space policies. The legislation requires animal owners, animal keepers and competent authorities to respect animals' welfare requirements to ensure their humane treatment and avoid causing them unnecessary pain and suffering (Article 13, Title 2) (World Animal Protection, 2020). The European Union's Animal Welfare legislative and policy framework is based on scientific evidence, regularly scientifically reviewed and amended if necessary. Council Directive 98/58/EC covers general minimum standards for the protection of all farmed animals and other legislation covers minimum standards for separate issues, such as standards for the protection of animals during transport (Council Regulation (EC) 1/2005) and on the protection of animals at the time of killing (Council Regulation (EC) 1099/2009). Under this legislative framework, the European Commission established the Platform on Animal Welfare in 2017 (C/2017/0280), a trans-disciplinary group of experts from competent authorities, civil society, businesses and scientists, to develop and exchange coordinated actions on animal welfare. For example, the platform forms specific thematic sub-groups and voluntary initiatives that work on specific mandates and guidelines, such as the 'EU: Guidelines on Water Quality and Handling for the Welfare of Farmed Vertebrate Fish' (European Commission, no date), practical general standards developed by the Voluntary initiative on the welfare of fish. The Platform for Animal Welfare aims to develop coordinated actions with a focus on 1) better application of EU rules on animal welfare,

through exchanges of information and best practices and the direct involvement of stakeholders, 2) the development and use of voluntary commitments by businesses to further improve animal welfare and 3) the promotion of EU animal welfare standards to valorise the market value of the Union's products at the global level (European Commission, no date).

In recent years, practical guidelines for the livestock industry have also been adopted among ASEAN countries, such as the ASEAN Good Animal Husbandry Practices for Pigs (ASEAN, 2018), aiming to help farmers work in a responsible way in order to produce safe food and to help competent authorities to develop quality assurance systems at farm level.

Lessons learned

- *A shift from cruelty prevention to proactive promotion of animal welfare in politics.* Animal welfare science informs the development of legislation and policy (Mellor and Webster, 2014).
- *Recognition of animals as sentient beings.* Countries are at different stages in improving animal welfare by incorporating the theme into formal legislation (Mellor and Webster, 2014; World Animal Protection, 2020). At the core of progressive legislation lies the recognition of animals as sentient beings (World Animal Protection, 2020).
- *Long-term stress caused by bad welfare standards can cause oppression of the immune system.* This can cause pathogens to reproduce more rapidly, pathogens to be able to invade the animal's body more easily and can make animals more susceptible to get ill from pathogens (Padgett and Glaser, 2003).
- *Good standards are essential.* As animal welfare cannot be ensured on its own (Webster, 2001), good standards in husbandry, nutrition, veterinary care and management as well as humane handling and slaughter and provision of a safe environment are essential to achieving high welfare standards (WOAH, 2022b).
- *Other advantages and incentives.* High welfare standards can protect animals from diseases and can therefore reduce mortality rates and improve health, reducing the need to invest in medication and to gain higher sales prices (Dawkins, 2017).

4.3 Farm biosecurity and biosafety

Scope and definition of biosecurity and biosafety

According to the Food and Agriculture Organisation (FAO), biosecurity is 'a strategic and integrated approach that encompasses the policy and regulatory frameworks (including instruments and activities) for analysing and managing relevant risks to human, animal and plant life and health, and associated risks to the environment' (FAO, 2007). Biosafety on the other hand, are the practices and standards involving the handling of biological materials, such as infectious agents. According to the World Health Organisation (WHO), biosafety involves 'containment principles, technologies and practices that are implemented to prevent the unintentional exposure to pathogens and toxins, or their accidental release. Responsible laboratory practices, including protection, control and accountability for valuable biological materials will help prevent their unauthorised access, loss, theft, misuse, diversion, or intentional release' (WHO, n.d.). Even though biosafety is a very important component in the wider strategy for health security, for the purpose of this study and the relevance to specific policy concerning the management of wildlife farms, this chapter will focus on biosecurity.

The health-security nexus has increasingly been recognised as of great importance in global health, especially after some serious disease outbreaks (e.g., SARS, MERS, Avian Influenza). In 2014 the Global Health Security Agenda (GHSA) was established, bringing countries, international NGOs and private sector companies together to cooperate on global health security. As a member country of the GHSA, Viet Nam has committed to the GHSA 2024 target of taking greater ownership of global health security efforts and to improve health-security-related technical areas within five years (GHSA, 2022).

Biosecurity is not a stand-alone subject and requires involvement of different stakeholders at all levels, from local and national, to international. At the national level, stakeholders such as competent authorities, research institutions and universities, NGOs, industry and public opinion are just some examples of sector interests that are important to an integrated approach to biosecurity (FAO, 2007). The principles of biosecurity (Windsor, 2017) are a useful framework to address biosecurity at the farm level. These were written for livestock farms, but can easily be adapted to appropriately assess and improve biosecurity at wildlife farms:

01

Livestock quarantine and animal movements



Manage the introduction and movement of livestock in a way that minimises the risk of introducing or spreading infectious disease.

02

People, equipment and vehicle hygiene



People, equipment and vehicles entering the village, enterprise or country are controlled to minimise the potential for property contamination.

03

Food and water safety



Quality of stock feed and water is fit for purpose, especially purchased feed that is free from contaminants, untreated swill and/or restricted animal material (i.e., feeds containing ruminant tissue cannot be fed to ruminants).

04

Animal health management, surveillance and reporting



Prevent and control animal disease by using appropriate vaccination programmes, regularly monitoring for diseases, and immediately reporting outbreaks of transboundary animal diseases.

05

Public awareness



All farmers, traders, agency staff and contractors, understand the importance of the biosecurity requirements for the village, enterprise or country in which they work and can implement the agreed practices for which they are responsible.



Biosecurity and control of zoonotic risk

From the perspective of emerging zoonoses and therefore relevant to the practice of wildlife farming, a biosecurity hazard is a biological agent that can be transmitted naturally between wild or domestic animals and humans (WOAH, 2003). Biosecurity measures are the specific protocols and systems in place in order to prevent and minimise the spillover of biological pathogens. Their implementation is especially important, since wildlife farming (and trade) are seen as intensification mechanisms that bring wildlife species and their pathogens into close contact with livestock and humans (World Bank and FAO, 2022a). Especially when there is a risk that wild-caught animals are illegally being brought into the farm environment, the World Bank and FAO (2022b) advise countries to require adequate biosecurity practices, such as prohibiting or minimising mixing of famed and wild-caught animals, as well as contact between different species. Zoonotic pathogens can spread between animals and humans in several ways:

- 1 Direct contact, such as bites, scratches and contact with bodily fluids
- 2 Indirect contact, such as contact with surfaces in animal enclosures, food and water bowls
- 3 Vector-borne, such as mosquito and tick bites that carry pathogens after initially biting an animal
- 4 Food-borne and water-borne, by eating or drinking something that has been contaminated by animal faeces (CDC, 2021)

Biosecurity should be the foundation of any disease control strategy (Murray et al., 2016), as wildlife farming creates an environment where multiple species are brought in close contact when this would not necessarily happen in the wild. This unusual and close contact creates a base for pathogens to evolve and adapt to new host species, especially when large numbers of animals are sourced from the wild (World Bank and FAO, 2022a) this calls for different strategies for risk management (World Bank and FAO, 2022b). Therefore, good disease control strategies should start from the source of potential diseases (e.g., newly obtained animals, hazard control principals at breeding facilities).

Biosecurity in legislation and policy

Biosecurity is incorporated in many legislative frameworks worldwide and is an important preventive strategy to curb the spread of pathogens within sectors such as human health, environmental health and animal health, making it an intrinsic part of One Health (Huber et al., 2022). Despite their importance, the development and implementation of specific measures are complex and challenging (Huber et al., 2022) and compliance in food production systems around the world is generally poor (Racicot et al., 2012). In April 2021, China implemented its new Biosecurity Law of the People's Republic of China with infectious disease and pandemics as one of the actions to address biological securities within the context of the approach to national security (Cao, 2021; Huigang et al., 2021; Wang, 2022). This law is considered the first comprehensive biosecurity law in the world (Huigang et al., 2021), setting both general as well as detailed requirements for the management of biosecurity issues (Huigang et al., 2021).

Whilst there is little available literature on the specifics of biosecurity on wildlife farms, a review of biosecurity in livestock production systems could be used to identify measures at farm level, such as the distinction between external and internal biosecurity and the importance of risk assessments in the development of relevant, achievable and adequate measures (Lewerin et al., 2015). As (Murray et al., 2016) point out, **the risk of disease spillover in wildlife farming could be reduced if biosecurity and health measures similar to the livestock industry are applied.**

A work group under the One Health Joint Partnership (OHJEP) "biosecurity practices for pig farming across Europe" (BIOPIGEE) programme conducted a study to define the term biosecurity measure. Although this was developed by experts and based on scientific literature from the pig sector, the authors emphasise its usability in sectors with other animal species (Huber et al., 2022), highlighting the need for clear definitions in order to develop appropriate, achievable and effective standards and measures. The authors conclude that it is essential to develop a precise and clear definition of what a biosecurity measure is, to achieve necessary standards of biosecurity to improve and protect human and animal health, as well as the wider environment. As Conan et al. (2012) point out in a review study of biosecurity measures for small scale backyard poultry systems, the available recommendations in literature all seem based on measures designed for intensive farming sectors without looking at financial and technical feasibility for smallholder farmers. This further complicates the effective implementation of and adherence to measures, especially when these are designed as short-term measures without evaluation, rather than embedded in long-term national programmes (Conan et al., 2012).

A clear definition of biosecurity and feasible standards are necessary to improve communication of biosecurity measures to and from relevant stakeholders (Huber et al., 2022). One incentive for farmers would be having healthy and therefore more likely productive animals (Lewerin et al., 2015). However, pathogens may not cause visible symptoms in all animals and therefore adhering to biosecurity measures is also part of 'the greater good', without being of direct obvious benefit to the farmer. The problem of low compliance with biosecurity cannot be solved by a single intervention (Racicot et al., 2012), communication should be part of a biosecurity plan and training programmes are an essential part of its implementation (Vaillancourt, 2009; Racicot et al., 2012).





Lessons learned:

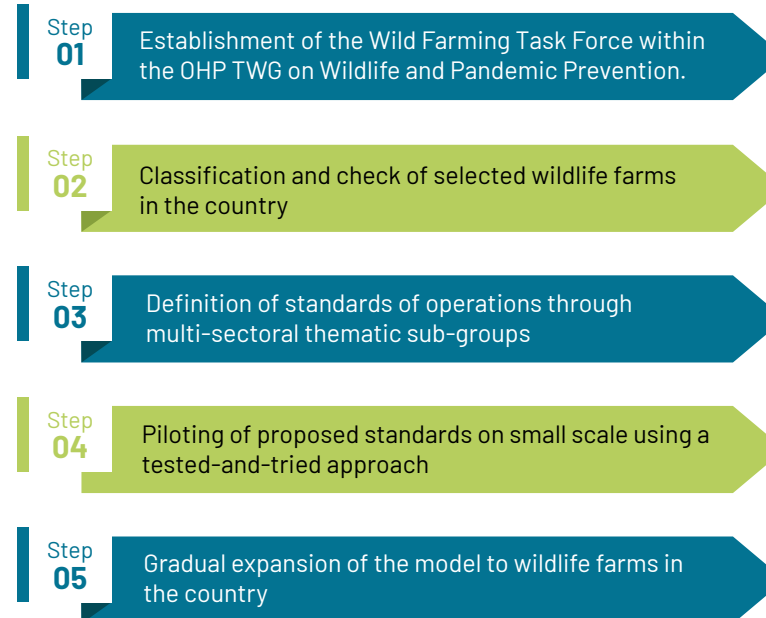
- **Biosecurity involves stakeholders at multiple levels.** Biosecurity is not a stand-alone issue. It requires strong presence in legislation and coordinated actions for an integrated approach at global, national and regional level (FAO, 2007).
- **Biosecurity should be the foundation of disease control strategies.** High intensity production systems farming high-risk species of carrying novel pathogens could result in increased risk of pandemics (Murray et al., 2016).
- **Clear definitions are needed.** A clear definition of what a biosecurity measure is, in the context of the wildlife farm industry in Viet Nam, is important to be able to create feasible measures. Clear definitions are important in the communication to and from stakeholders (Huber et al., 2022).
- **Feasible standards are a necessity.** Standards that were designed for a certain production system, may not automatically be applicable to another. This stresses the importance of developing relevant, achievable and adequate measures (Conan et al., 2012; Lewerin et al., 2015).
- **Communication and education are essential.** Compliance with measures can be a problem, despite clear benefits such as healthier and more productive animals (Lewerin et al., 2015). Communication should be part of a biosecurity plan and training programmes are an essential part of its implementation (Vaillancourt, 2009; Racicot et al., 2012).

5. DISCUSSION

With the One Health Partnership agreement in place between MOH, MONRE and MARD, there is a good foundation to address the mitigation of zoonotic disease spread within the Vietnamese wildlife farming industry. The current legislative framework is extensive and provides guidance on a high level for the implementation of environmental and veterinary requirements. However, policies and regulations lack practical direction and instructions on how requirements should be enforced, and standards put in place (Pham et al., 2022).

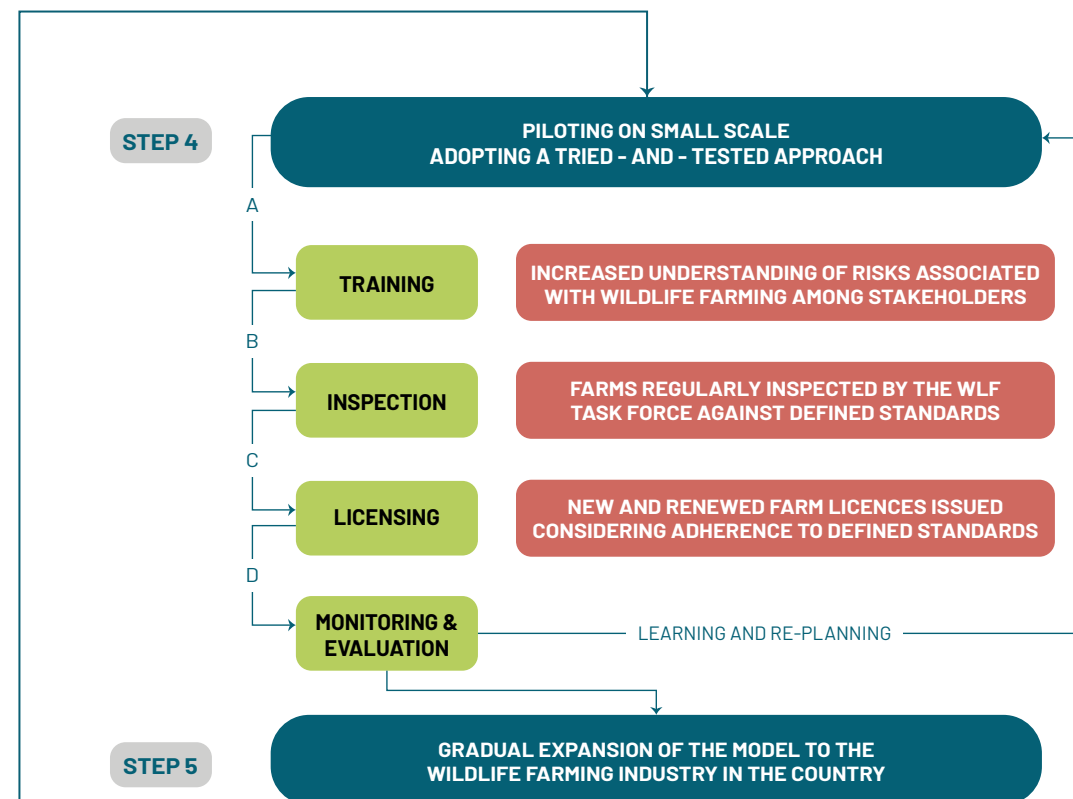
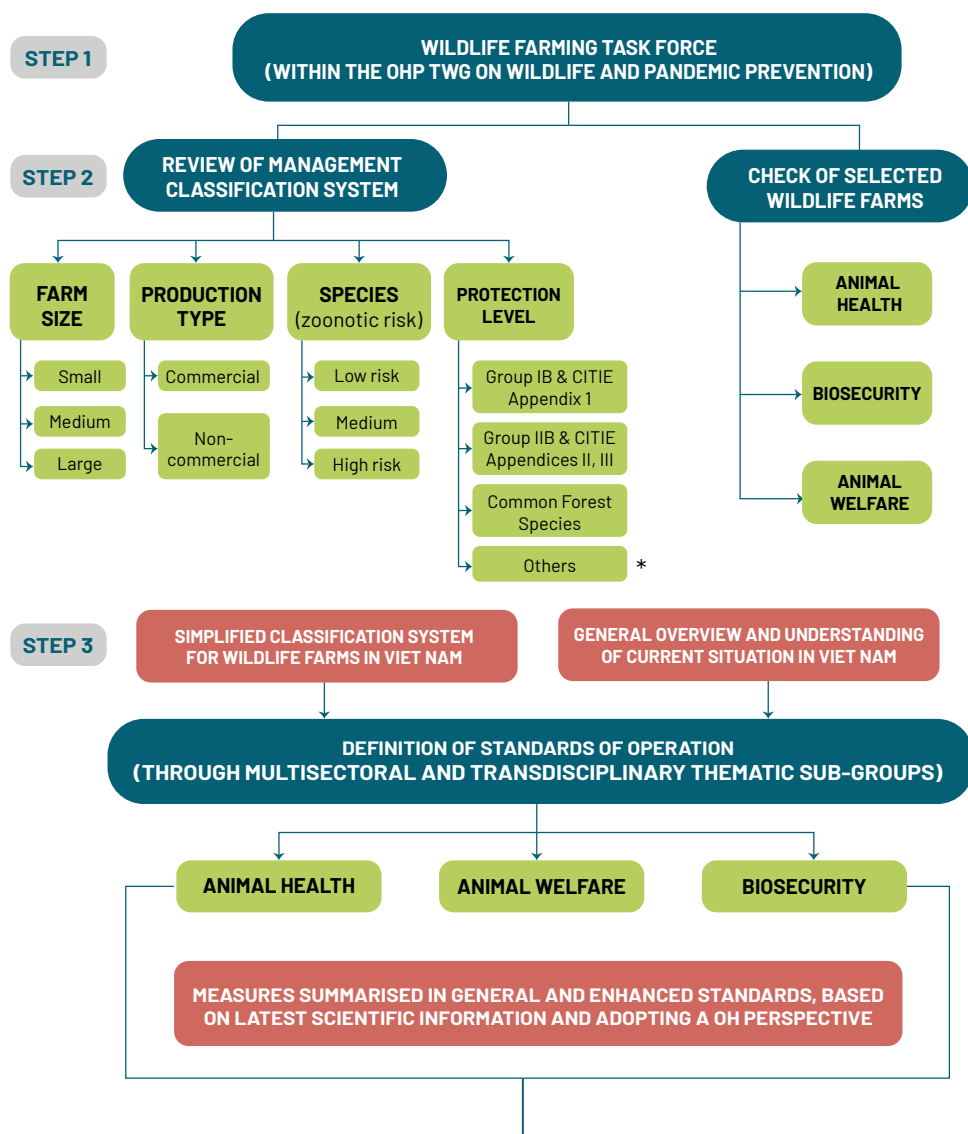
We hereby propose a framework of actions to address this gap by providing a roadmap to the development of viable and pragmatic standards and the engagement of all stakeholders in a safer management of wildlife farms. The framework enables the translation of evidence-based recommendations into their implementation to achieve the long-term goal of mitigating zoonotic risk at the source. The recommendations are based on the need for immediate actions whilst adhering to the relevant laws and legislation. The approach allows to get away from the complexity of law and regulations already set for wildlife farm licencing (Pham et al., 2022), and instead focus on practical short-term goals that can be rapidly implemented, engage all actors in the process, and eventually pave the way to the endorsement and enforcement of a more controlled and reinforced licensing system.

The framework builds on the foundational principles of One Health (WHO and UNEP, 2017; Fascendini and Rusman, 2021; Adisasmito et al., 2022) and advances across a multi-stage process to support the enhancement of the legal framework for wildlife farming in Viet Nam. It consists of five steps, each containing specific actions and aiming at specific outcomes as described below and depicted in Figure 1 below.



The normal flow of actions would allow for the implementation of subsequent steps, moving from the planning phase (Step 1 and 2) to the development of standards (Step 3), their piloting and evaluation (Step 4), and eventually their expansion to a wider scale (Step 5). However, should the process be too complicated or costly, the proposed approach does not prevent the implementation of a certain step independently from the others. For example, should the definition of the management classification system take too long and require resources that are not readily available (Step 2), the development of general standards of operations under each thematic area could proceed with the engagement of experts from different disciplines (Step 3a and 3b).





*Terrestrial animals belonging to the following taxa: bird, mammal, reptile, amphibian, excl. species listed by MARD in collaboration with MoNRE and related agencies (Decree No.84/2021/ND-CP).

Figure 1: Framework of actions for the management of wildlife farms in Viet Nam

The framework builds on a few principles of One Health that were identified and adapted from the Guidance on Integrating Biodiversity Consideration into One Health Approaches (WHO and UNEP, 2017). Under the leadership of the OHP in Viet Nam, the management of zoonotic risk in wildlife farms will ensure the application of the multi-sectoral and trans-disciplinary principles. Collaborative thinking, planning and working will allow the definition of common goals and actions, a more effective distribution and utilisation of (human and financial) resources, and a shared and transparent reporting structure. Challenges and practices in farm management will greatly benefit from experience and expertise of researchers, service providers and farmers themselves, ensuring efficient standards of veterinary care, animal welfare and biosecurity are clearly defined, appreciated, understood and consistently applied. The framework focuses on the principle of prevention and provides guidance to the development and application of evidence-based standards to minimise health risks at the human-wildlife interface. These will be developed based on comprehensive scientific risk assessments of species and pathogens that will support the translation of research findings into policy and concrete actions. Finally, the framework adopts the multi-scalar principle. Small scale interventions will be used to initiate, test and evaluate the defined standards for wildlife farm management and mitigation of zoonotic disease emergence. Data and experience on a few pilot farms will inform the gradual expansion of the model to wildlife farms across the country.

STEP 1: Establishment of the Wild Farming Task Force under the OHP TWG on Wildlife and Pandemic Prevention

Our first recommendation is to establish a Task Force under the OHP TWG on Wildlife and Pandemic Prevention to specifically address the risk of zoonotic spillover in the wildlife farming sector in Viet Nam. Following the One Health approach, the Task Force would consist of a multi-sectoral trans-disciplinary team of members including competent authorities, experts, researchers, civil society organisations and representatives from the wildlife farming industry. Facilitation of the Task Force by the One Health Partnership allows for collaborations between its members in order to coordinate work on issues and risks at the human-animal-environment interface that are associated with the wildlife farming industry. The Task Force would act as a focal point for different stakeholders and ultimately be responsible for the operationalisation and careful monitoring of the proposed framework of actions. The Task Force would meet on a regular basis to assess progress, discuss challenges in implementation and identify suitable corrective measures to the actualisation of the framework and its recommendations. In the short term, the Task Force should provide technical assistance to the development of a new decree replacing Decree No. 06/2019/

ND-CP and Decree No. 84/2021/ND-CP on the management of endangered, precious, and rare forest fauna and flora and CITES implementation.

STEP 2: Classification and audit of wildlife farms in the country

Once established, we recommend the Task Force to take the following actions:

a) Develop a classification system for wildlife farms

We propose the Task Force to conduct a review of the already existing database of registered wildlife farms based on the wildlife farm survey conducted by the CITES Secretariat with support from FAO in 2021. With more than 8,000 wildlife farms in Viet Nam, there are unsurprisingly significant differences between them. Some facilities keep thousands of animals, employ numerous members of staff, and have many available resources. In contrast, other businesses are smallholder or 'backyard' farmers, with often a small number of animals and no staff other than direct family members (Pham et al., 2022). As reported by Pham et al. (2022), the requirements under the current legal system are often difficult to understand and implement by small scale farms. This is not an uncommon situation as shown, for example, in the literature on poultry systems (Msami, 2007; Conan et al., 2012). It is important to take different factors, such as farm size, species and epidemiology of pathogens in the particular region, into account to develop economically feasible, practical and flexible initiatives to reduce zoonotic hazards (Collins and Wall, 2004). Species such as non-human primates, bats, pangolins, civets and rodents for example, pose higher risks to humans as they are known (intermediate) hosts of more harmful pathogens (Wikramanayake et al., 2021) and their farming (and trade) should therefore be tightly regulated.

The development of the classification system for wildlife farms in Viet Nam could resemble the principles of the FAO's classification system (FAO, 2004) for the poultry sector and build on the risk assessment tool proposed by Wikramanayake et al. (2021). Different risk factors (e.g., farm size, production type, taxa and species) could be combined together to create a simple matrix that enables the categorisation of wildlife farms in Viet Nam. Outcomes of a matrix analysis would place farms in one of the predetermined categories, which will help the design and implementation of (economically) effective, relevant and achievable measurements to reduce zoonotic spillover risks at the farm level. For example, a small-size farm holding animals of a high-risk taxon of the IUCN Red List's Endangered category, that is located <100 metres away from a human settlement and from where animals leave the premises and enter the market alive, could be placed in the same category as a large-size farm with high production rate of a low-risk, IUCN Red List Least Concern species, located >500 metres away

from the nearest human settlement and where animals are being slaughtered and processed on site. This will depend on the weighting the Task Force gives to the different elements composing the matrix. In this example it is assumed that the 'number of individual animals' (small vs large size) and the 'risk category of species' (high vs low risk) will combine crosswise to require a higher level of, for example, biosecurity measures. In contrast, a smallholder farm of less than 50 pythons (low risk taxon) bred for the pet trade, operating from the farmer's house, would be placed in a category that requires less stringent measures. In other words, whilst the law allows for the farming of large numbers of animals, or high-risk taxa, this policy would impose stricter requirements and higher standards to these operations in an attempt to reduce the higher spillover and pandemic risk they bring to society.

Ultimately, as long-term-recommendation, it is also important to mention that a well-designed classification system for the Vietnamese context could also help the licensing process of farms, as requirements to obtain a licence could be linked to the particular category a facility would fall under. Strict measures and higher financial investment to comply with requirements imposed on farms with high-risk taxa might be an incentive for people to redirect their focus on farming species of a lower risk and less endangered taxon.

b) Conduct a check on a selection of wildlife farms

We recommend the Task Force to conduct a check on a selection of farms, to understand the reality on the ground and to ultimately be able to develop standards that are based on the local context and that would be able to effectively respond to the local needs. This will allow the Task Force to have good knowledge of opportunities, challenges and the status quo within the wildlife farming industry. Pham et al. (2022) underline that several (conservation) policies are already in place, but they are often based on international standards and do not take into consideration the context of Viet Nam. Observations made by Li et al. (2021) on the importance of gaining better understanding of zoonotic transmission and disease emergence in the wild animal trade value chain in China, are similarly relevant to Viet Nam. Few publications exist about the farming and trading of wild animals that document interactions with humans and domestic animals before reaching the consumption market, making risk-assessments challenging. The check will help the Task Force, and the thematic sub-groups engaged in the definition of the standards of operation (see Step 3 below), to understand and appreciate the reality on the ground and to develop protocols and procedures that effectively respond to the local needs.

STEP 3: Definition of standards of operations through multisectoral thematic sub-groups

As part of a wider mitigation strategy of zoonotic spillover risk from the wild animal value chain, we emphasise the importance of having clear, general standards in place for all wildlife farms that can be developed, communicated and implemented within a timely manner. Whilst acknowledging that there are many differences between farms, we propose that they have many very similar characteristics to which general standards can be applied.

We therefore recommend the Task Force to:

a) Establish three multi-sectoral and trans-disciplinary thematic sub-groups

The sub-groups will work on the three themes identified as key for the regulation of wildlife farms management and the mitigation of zoonotic disease risks, namely animal health, animal welfare, and biosecurity. The main task of each thematic sub-group will be to translate the current legislative framework into practical measures and to write recommendations for the Task Force on the establishment of a set of general standards for the management of wildlife farms, with reference to their specific theme. These recommendations should be seen as a first step towards a holistic mitigation strategy plan and could be implementable in a relatively short term. Each sub-group would be composed of representatives from competent authorities and the scientific community, experts and representatives from the wildlife farming industry, to follow the multi-sectoral and trans-disciplinary principles of the One Health approach (WHO and UNEP, 2017; Fascendini and Rusman, 2021; Adisasmito et al., 2022). Measures and protocols proposed by each sub-group should be based on scientific evidence and aim to reduce the risk of zoonotic spillover, whilst keeping economic and practical feasibility in mind.

We hereafter recommend the Task Force to take into account their understanding of the current situation of wildlife farms in Vietnam, as well as the recommendations from the three sub-groups and to:

b) Develop general standards to be applied across all wildlife farms

These general standards should be considered as a minimum set of measures and actions that will altogether result in a basic mitigation strategy to reduce the risk of zoonotic disease spillover in the wildlife farming sector in Viet Nam. These standards should be written as clear actions or measures to avoid misinterpretation and ensure they are clearly understood and applied across all farms keeping non-domestic species. For example, when COVID-19 started spreading in early 2020, countries responded by implementing and communicating emergency measures to curb its spread, such as physical

distancing, guidance on hand washing, use of hand disinfectants and mask mandates. These measures were a general and non-specific, though effective and powerful, response whilst long-term strategies specifically addressing the SARS-CoV-2 virus (including research into the specifics of the virus, vaccination programmes and treatment guidelines) were under development.

While acknowledging that specific standards are needed for the proper management of different categories, based on farm size, production type, zoonotic risk, and animal species (see section below: § Develop enhanced standards based on farm categorisation), we believe that general standards will quickly support the mitigation of zoonotic risk in wildlife farms. Specific standards based on farm categorisation, in fact, may require significant time and investment to be developed, endorsed and enforced, while there is an urgent need of simple practical guidance on veterinary care, animal welfare and human safety. General standards serve as practical measures for immediate action and mitigation of disease risk. They will need to be applied across all farms, regardless of their classification. The following are preliminary lists of minimum standards, grouped under the thematic areas identified as critical to the safe and healthy management of wildlife farms. The lists are not exhaustive but rather exemplify possible measures based on the international experiences and practices reviewed through the study.

1. General minimum veterinary standards, e.g.

- Having access to a veterinarian (either on-site or external)
- Routine on-site veterinary visits
- Farmers have basic knowledge of simple medical procedures such as wound disinfection
- Well-ventilated housing

2. General minimum welfare standards, e.g.

- Unrestricted access to fresh drinking water
- Available shelter from the elements
- Available comfortable places to sleep (especially for groups housed together)
- Absence of torment or cruelty by staff and visitors

3. General minimum farm biosecurity standards, e.g.

- Basic staff PPE
- Hand washing and disinfecting protocols
- Changing footwear
- Staff vaccination

Once general standards have been developed, and all registered wildlife farms have been assigned to a category, we furthermore recommend the task force to:

c) Develop enhanced standards to be applied to wildlife farms as per their categorisation

Despite having an extensive legislative framework around wildlife farming, there is a lack of clear standards that hinders execution and enforcement (Pham et al., 2022). For example, Decree 06/2019/NĐ-CP currently describes standards for keeping crocodiles, cobras and bears. Having different species listed under different lists of Decree 06/2019/NĐ-CP and Decree 64/2019/NĐ-CP seems to cause problems for enforcement agencies as well as for farm owners (Pham et al., 2022), as standards are unclear or non-existent. With the current knowledge of the risks associated with the practices of wildlife farming, the implementation of and adherence to appropriate standards is paramount in any strategy to prevent a next pandemic at its source. A set of very detailed standards from Australia are the General standards for exhibiting animals in New South Wales (NSW Department of Industry, 2019). Despite the word 'general' in the title, this document can be seen as an excellent example of detailed standards applicable to a category (in this case, facilities that display animals to the public). Acknowledging the differences between these facilities (as there will be in Viet Nam between farms within a single category), a comprehensive set of standards was developed to offer guidance on the practical implementation of measures to comply with the law.

In Viet Nam, a Board of Assessors was appointed for the formulation of Decision 95/2008/QĐ-BNN promulgating the regulation on management of raised bears (World Animal Protection, 2020). However, the standards and conditions mainly focus on human safety of the facility, whilst current scientific knowledge of animal welfare and biosecurity were not thoroughly taken into account in the formulation of the decision. For example, the Sun and sloth bear Care Manual by the American Association of Zoo and Aquariums (AZA Bear Taxon Advisory Group, 2019) reports that the exhibit (enclosure) design should be given careful consideration to ensure the areas of the bear's living environment meet its physical, social, behavioural, and psychological needs. The manual promotes large, natural enclosures and provides ample examples of how enclosures can meet physiological needs, whilst also providing detailed advice on the safety requirements. The minimum size for bear enclosures is 279-465 m², but it is recommended to build enclosures that are 465-929 m². In comparison, Decision 95/2008/QĐ-BNN does not provide any guidance on physiological, or welfare needs of the animals and the minimum required enclosure size is 2.25 m² (1.5m x 1.5m) for an indoor enclosure (cage). Whilst acknowledging that there may be a difference between housing animals for farm purposes and educational display

purposes, the discrepancy in enclosure size requirements illustrates that scientific knowledge of animal welfare and its impact on animal health and risk of pathogen spread was most likely not taken into account in the development of these minimum standards.

The development of enhanced standards provides a valuable opportunity to engage multiple actors in achieving improvement of the wildlife farming industry in many ways, taking the latest scientific knowledge of animal health, welfare and biosecurity into account. Under the stewardship of the One Health Partnership, the thematic sub-groups can ensure that enhanced standards for the wildlife farming industry are developed, adopting the One Health approach and aiming to protect the health of people and animals, reduce the risk of economic loss, and prevent the next pandemic from starting. The sub-groups will need to engage specialists and experts in individual species and production systems, to ensure that comprehensive enhanced standards are tailored to the needs of the different farm categorisations. The enhanced standards could build on the latest evidence and adopt international practices and measures but would need to align with the Vietnamese context to ensure they can be effectively adopted and consistently applied across the country.

STEP 4: Piloting of proposed standards on small scale using a tried-and-tested approach

The implementation of the proposed framework provides a continued opportunity to follow the One Health approach. In this regard, we recommend the Task Force to align with the multiscale principle and use a tried-and-tested strategy to pilot the implementation of any proposed standards on a small scale before adopting them at country level. A few farms would be selected as pilot sites. The Task Force may decide to adopt a concentrated approach and test the standards only in one province to allow for easier supervision and monitoring of outcomes, or a dispersed approach and select the pilot sites across different provinces to enable the engagement of more provincial authorities straight from the planning phases. Regardless of the chosen approach, the selection process would need to ensure a good representation of the different farm categories to allow for the identification of difficulties and bottlenecks in the operationalisation of the defined standards at different levels and propose adaptations and revisions based on the local realities.

Piloting the defined standards will require a step-wise approach:

- a. Key stakeholders would initially be trained on the defined general (and eventually also the enhanced) standards to promote an immediate application of basic measures on animal health, animal welfare and biosecurity and

reduce disease risk within wildlife farms. Training will address all key actors in the wild farming industry, including competent authorities, veterinary officers, farm managers and animal keepers. The training will increase the understanding of key actors on the risk of zoonotic disease emergence and transmission at the human-wildlife interface and promote their mindful engagement in the application of control and preventive measures.

- b. Routine inspections of the pilot farms would be carried out by multidisciplinary teams appointed by the Task Force under the stewardship of the One Health Partnership. Farm inspections will serve to verify the adoption of the defined standards and provide an opportunity to engage in an open dialogue with farm managers and animal keepers about the challenges of their application. The employment of multidisciplinary teams for the inspections would contribute to further benefits, such as the provision of a diversified and increased range of knowledge and the decentralisation of the inspection process. The results of the inspection will not be limited to the perspective and decision of only one agency in charge, but rather consist of a combination of views and recommendations by different team members on whether the several standards are adhered to. The inspection exercise would become the basis for information sharing and enhance the collaboration between sectors and enforcement agencies. Pham et al. (2022) report that certain forestry offices currently already employ veterinarians to be able to be more effective when it comes to management and inspections of wildlife farms. A study done among Belgian livestock farmers by Laanen et al. (2014) showed that the main source of information about disease prevention and biosecurity are veterinarians, which bolsters this approach.
- c. As a long-term recommendation, outcomes of the multi-disciplinary inspection could eventually lead to the release of new and renewed licences for the assessed farms, based on their adherence to the defined standards.
- d. The pilot phase would generate solid evidence for an accurate validation of the proposed model of farm management, with its strict (general and enhanced) standards on animal health, animal welfare and biosecurity.

An effective Monitoring Evaluation and Learning framework would need to be developed to help evaluate the implementation of the proposed model and its eventual improvement for replication and expansion at a wider scale. The Monitoring Evaluation and Learning framework will ensure that inputs, activities and results of the pilot phase are carefully monitored and analysed, and that the evidence and information generated is reflected in the planning of the expansion phase. Information and evidence collected during the pilot phase, for example, will inform the revision and validation of the proposed standards based on their actual applicability and acceptability at the farm level.

As already mentioned above, the framework proposes a modular approach to implementing changes in the management of wildlife farms in Viet Nam with a focus on disease risk mitigation. The modular approach means that the piloting of general standards could start immediately and does not need to be delayed until the enhanced standards have also been developed. With the current knowledge about the potential risks that commercial breeding of wildlife species can pose to society, the piloting of general standards would allow taking an immediate step towards the mitigation of zoonotic disease risks and the prevention of epidemic and pandemic outbreaks at the source. Moreover, testing the standards as they are developed would also allow for an early engagement of final users in the process and the assessment of the feasibility, affordability and sustainability of the application at farm level.

STEP 5: Gradual expansion of the model to wildlife farms in the country

The adoption of new norms and regulations is always a difficult process. Stakeholders are used to the long-established and traditional ways of doing and reluctant to change, even when (health and economic) benefits are involved. The framework of action proposes a collaborative transformation of the management of wildlife farms in Viet Nam with the final goal of preventing epidemics and pandemics at the source. The development, validation and enforcement of strict measures in animal health, animal welfare and biosecurity will serve to regulate the wildlife farming industry in the country and eventually mitigate the risk of disease emergence and transmission at the human-wildlife interface. The multi-sectoral and trans-disciplinary collaboration guided by the One Health Partnership will require time, effort, and investment to allow building trustful relationships across disciplines and achieving sustainable outcomes. It will necessitate a radical shift in thinking from all stakeholders involved, including competent authorities, experts, researchers, civil society organisations and representatives from the wildlife farming industry. The outcomes, strengths and challenges of the small-scale pilots would need to be carefully revised to inform the strategic expansion of the proposed model to the whole country. The One Health Partnership would lead the process, involving all the relevant stakeholders at both national and provincial level to review success and failures of the pilot phase and identify key requirements and resources for its expansion at a wider scale. Outcomes and achievements of the pilot sites will promote the gradual recognition and appreciation of the defined standards and support their adoption and consistent application in an increasing number of farms. The gradual expansion of the model will require a detailed work-plan with inputs, targets and verification means, to ensure its effective operationalisation in a reasonable time. This should be aligned with the Master Plan for the OHP Framework for Zoonoses 2021-2025 (OHPS, 2021) and the National Action Plan on the Management of Wildlife Farming 2022-2027 (CITES MA, 2022).

6. CONCLUSIONS AND OUTLOOK

This report provides a framework of actions for the OHP TWG on Wildlife and Pandemic Prevention with the aim to mitigate risks of zoonotic pathogen spillover that are present in the wildlife farming industry. The proposed framework guides the translation of evidence-based recommendations into viable and practical actions that can strengthen the management of wildlife farms, improving the health and welfare of animals while protecting the health of humans. Aiming at the mitigation of pandemic risk, the framework focuses on three elements identified as critical in the control of disease emergence and transmission in wildlife farms: animal health, animal welfare and biosecurity. While the framework provides opportunities for immediate action to reduce pathogen spillover at the human-animal interface created by the practice of commercial wildlife farming, many challenges remain.

Time constraints narrowed the focus of the research and hindered the in-depth review of other themes that still play a significant role in the zoonotic risk management in wildlife farms. The three themes of animal health, animal welfare and biosecurity were prioritised for analysis based on the fact that they can be directly applied at farm level. Definition of preventive measures, training of stakeholders, supervision and enforcement of actions by competent authorities are all activities that can be implemented based on the current legislative framework, without the long-time scale and financial burden of changing the legislation itself.

However, it must be acknowledged that the wildlife farming industry in Viet Nam is only one part of the entire wild animal trade value chain. Other themes that were identified through the review of literature are no less important, but rather require a holistic approach that takes the entire wild animal trade value chain into account. In this regard, we believe that tracking and traceability, disease surveillance, and animal listing are crucial themes that need to remain on the agenda of the OHP and its stakeholders, to ensure the achievement of effective and sustainable results in pandemic prevention.

One of the first steps towards understanding where to be able to mitigate disease risk, illegal trade and unsustainable practices is supply chain mapping (Campbell et al., 2022). Efforts to regulate and monitor the wildlife trade cannot take a 'one size fits all' approach but rather require tailored interventions to be

effective (Roberts and Hinsley, 2020). Moreover, they should aim to differentiate legal wildlife products from illegally sourced ones (Xiao et al., 2021). Tracking and tracing can be an important tool in the field of wildlife forensics (to monitor global ivory and rhino horn trade routes, for example), illegal wildlife trade mitigation (to effectively address illegal poaching) as well as in food safety (to assess the origins and contact points that an animal passes along the supply chain). There is currently no straightforward answer to the complex issue of tracking and traceability of animals and products within legal wildlife trade supply chains. In the recent review published by Campbell et al. (2022) Options for managing and tracing wild animal trade chains to reduce zoonotic disease risk, the authors disseminate policy recommendations for improving supply chain traceability within different geographical contexts and welcome opportunities for collaboration with cross-sectoral partners (Campbell et al., 2022). The report highlights three wild meat industries where some degree of disease risk management with specific traceability measures is already in place: Australia's kangaroo meat industry, France's venison industry, and South Africa's ostrich meat industry. These could serve as valuable examples for the development of a similar system in Viet Nam. The recent national level qualitative analysis of six wildlife trade chains by TRAFFIC in Viet Nam (bats, rats, macaques, pangolins, civets, and birds) (Campbell et al., 2022). will provide important initial insights in where safety and sustainability of legal wildlife trade can be improved. As done for the framework of actions, we recommend to adopt the One Health approach and follow a 'one species at the time' strategy to develop, test and implement a strict traceability system and food safety regulations. This would allow assessing the feasibility and efficacy of the developed tracking system, before expanding it to a wider scale and more species. We recommend the OHP to engage with researchers, international organisations and other relevant stakeholders to conduct thorough value chain analyses that can inform the development of an integrated and transparent approach to improve the management of wildlife trade, mitigate potential infection risks along the entire value chain and at the same time limit illegal and unsustainable practices.



The theme of disease surveillance and prevention requires a broad local, national and international focus. Since wild animals are known reservoirs of several EIDs, animal disease surveillance serves public health by early detection, prevention and control of zoonotic diseases (Kumar et al., 2021). There is currently only a formal duty to report the notifiable diseases as listed in chapter 1.3 of the (WOAH, 2022a) to other states and partners and therefore information might be only partially reported and shared within the international community. The shared platform World Animal Health Information System (WAHIS) is used to monitor, quickly analyse and disseminate to other members and non-members, the latest status of any health situation or disease outbreak in livestock. A prerequisite of this system is that member and non-member states need to have proper surveillance programmes in place in order to provide substantial reports on the country's situation. The aim of surveillance programmes is to demonstrate the absence of a disease or infection, determining their occurrence or distribution, and to detect emerging diseases as quickly as possible. The surveillance of animal health is therefore essential to detect diseases, monitor disease trends, control endemic and exotic diseases, and to provide data to support risk analyses and coordinated responses (Wilson, 2005). However, surveillance of animal health is usually limited to domesticated animals and livestock. WOA members are encouraged to report wildlife disease through the wildlife equivalent WAHIS-Wild, but this is on a voluntary basis. Collection of data on wildlife disease occurring in a country can support risk assessments and policy development (World Bank and FAO, 2022a). We recommend further research and coordinated actions, at national, regional and global level, to enhance the current (wild) animal disease surveillance system, including testing capacity, data collection and data sharing. This is a necessary step to support the assessment of disease risks and guide the prioritisation of zoonotic threats for intervention.

Despite the known risks of wildlife farming, calls for a total ban will likely remain unanswered for the time being. A blanket ban on consumption of wildlife will affect many livelihoods and there is not a guaranteed direct link between bans and pandemic prevention; intensification of livestock farming may in fact lead to increased zoonotic spillover risk, such as in the case of Highly Pathogenic Avian Influenza (Karesh et al., 2012). Additionally, it is unknown how consumers will behave following a ban, they might either stop consumption completely or turn to the black market. In case of the latter, regulatory capacity will be non-existent, potentially increasing the risk of disease spread even more through hard to monitor black market trade (Roe and Lee, 2021). Instead of a complete ban, there are calls for better regulation, demand reduction campaigns and enforcement, concerning species of greater concern for emerging diseases of pandemic potential such as primates and bats (Johnson et al., 2020; Roe and Lee, 2021; World Bank and FAO, 2022a). One potential regulatory mechanism is

partial bans, or 'positive lists'. A list of species that are allowed to be farmed, should be based on risk assessment (World Bank and FAO, 2022b). In 2013 for example, The Netherlands adopted the Prohibition of Fur Production Act with a 10-year phase out timeline which would end the practice by December 2023. However, the Dutch government shut the industry down completely in 2020 as a preventive measure after the COVID-19 outbreaks on mink farms throughout the country (Overheid.nl, 2020). In November 2022, the European Parliament adopted a resolution on a positive list of exotic animals allowed to be kept as pets. The resolution aims to provide one list of animals allowed to be kept in any of its member states, removing permits for high-risk species and species that cannot be guaranteed good welfare in captivity (Resolution 2022/2809(RSP)). We agree that a partial ban on keeping high risk species (e.g., a 'negative' or 'black' list) or a list of species allowed to be farmed (e.g., a 'positive' or 'white' list), could contribute to reducing disease spread risk, simply based on the reduction of close physical contact between humans and animals in the farm setting. However, development, implementation and enforcement of such a list would take time and resources that are beyond the short-term recommendations that were aimed to be developed in this report. Further research and efforts are needed to promote collaborative thinking and planning around any listing approach and ensure the development of regulations and legislations that are suitable, acceptable and affordable in the context of Viet Nam. As for the proposed framework, the OHP will have a significant role to play in leading the process and coordinating all relevant stakeholders to ensure an appropriate listing system is being developed, whilst more urgent biosecurity, animal health and welfare standards are implemented.

The operationalisation of the framework of actions for an improved management of the wild farming industry in Viet Nam requires that some basic conditions are met. The OHP would have to lead the process, ensuring a continuous and effective engagement of all relevant stakeholders including competent authorities at national and provincial level, experts and research institutions, civil society organisations and representatives from the wildlife farming industry itself. Collaborative infrastructures and mechanisms would need to be put in place to enable and guarantee the open and continuous sharing of data and information among partners and stakeholders. The Partnership should coordinate with existing initiatives that are already engaged in the study of the complex drivers of viral spillover to address disease threats, such as the 'STOP Spillover' USAID-funded project (Nguyen-Viet et al., 2022), the EU-funded UNODC-FAO SAFE project and other initiatives by members of the Pandemic Prevention Task Force. A good coordination would ensure a strengthened collaboration and communication while working towards common goals. Moreover, engagement and collaboration with research institutions, development and conservation partners would help

enhance the Task Force's work on development, implementation, education and communication of measures, for example by providing technical knowledge in the form of species-specific care guidelines, provision of training workshops and media campaigns to communicate information to stakeholders and the public. The participation of final users would need to be ensured throughout the decision-making processes to increase the understanding and application of recommendations at the community level. This could be done, for example, through regular consultations with local farmers during the revision of the management classification system or the development of standards. Finally, the operationalisation of the framework will require a strong political commitment and a significant investment of (human and financial) resources to create a solid institutional capacity and enable the development and enforcement of the desired standards of operations that can effectively mitigate the risk of pandemics at their source.

Prevention of pandemic risk at the source is a complex issue that goes beyond the management of zoonotic risk in wildlife farming (Petrovan et al., 2021; Wikramanayake et al., 2021; Pham et al., 2022; World Bank and FAO, 2022b). While the study had a specific focus on the latter, we recommend the OHP to engage with relevant partners and stakeholders to design a comprehensive plan to mitigate the risk of emergence and spread of zoonotic pathogens at the human-wildlife-environment interface within the entire wild animal trade value chain. This may include interventions to reduce the demand for wild animal trade and consumption, ban or regulate the sale of live animals in traditional markets, enhance biosecurity and hygiene measures along the supply chain, and minimise land exploitation and encroachment activities that affect biodiversity loss and increased human contact and proximity with wildlife. We acknowledge the complexity and magnitude of this task, but effective and sustainable results can be achieved if stakeholders work collaboratively across disciplines and sectors by adopting the OH approach and aiming to sustainably optimise and balance the health of humans, animals and the ecosystem.



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Project "Reducing Health Risks in the Wild Animal Trade in Viet Nam "

Unit 021, 2nd Floor, Coco Building
14 Thuy Khue Str., Tay Ho District, Hanoi, Viet Nam

T: +84 24 39 32 95 72

I: <https://alliance-health-wildlife.org/>

