Eating wild animals:
Rewards, risks and recommendations

Better Management of Wild Meat Value Chains through One Health

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ILRI thanks all donors and organizations that globally support its work through their contributions to the CGIAR Trust Fund.

Editing, design and layout—ILRI Editorial and Publishing Services, Addis Ababa, Ethiopia.

Cover photo: Left: Barbecued rat for sale, Ayutthaya, Thailand. Photo Dave Stamboulis/Alamy Stock Photo. Right: Roasted mice, Malawi. Photo Steve Evans.

ISBN: 92–9146–684–6

Citation: Grace, D., Bett, B., Cook, E., Lam, S., MacMillan, S., Masudi, P., Mispiratceguy, M., Nguyen, H.T.T., Nguyen-Viet, H., Patel, E., Slater, A., Staal, S., and Thomas, L. 2024. *Eating wild animals: rewards, risks, and recommendations*. Nairobi, Kenya: ILRI

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Foreword

This new report led by researchers at the International Livestock Research Institute (ILRI) addresses one of the most pressing issues of our time—balancing the benefits and risks of wild meat consumption in a way that protects human health, wildlife welfare, and our environment.

Wild meat plays a crucial role in the livelihoods and diets of many communities, particularly in regions of Africa and Asia, where it often serves as both a critical food source and a vital part of the local economy. However, the complex relationship between wild meat consumption and broader health, environmental, and animal welfare concerns requires careful consideration.

This report provides a comprehensive analysis of the benefits and risks associated with the wild meat value chain. At its core is the One Health approach, which highlights the interconnectedness of human, animal, and environmental health. The findings underscore the need for sustainable practices that protect not only human health but also the welfare of wild animals and the ecosystems they inhabit. The report highlights the importance of integrated conservation strategies and preserving critical habitats through the establishment of protected areas to combat habitat fragmentation and enhance biodiversity.

Key recommendations from this report include the importance of regulating wild meat markets, raising awareness of zoonotic disease risks, and fostering community engagement in wildlife management. It also calls for innovative approaches to ensure that wild animal welfare is protected, while promoting alternative protein sources to alleviate pressure on wildlife populations.

I am glad to see this consolidation of the work of ILRI and our partners on wild meat and the timely launch at the 8th World One Health Congress. The important topic of One Health and wildlife will be further strengthened in the CGIAR science portfolio 2025–2030 which will contribute to improved understanding of the role of wildlife in food systems and how to better manage the benefits and risks.

It is my sincere hope that this report will prove useful to policymakers, researchers, and development practitioners, as we collectively work to ensure a healthier, more sustainable future for people, animals, and the planet.

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Acknowledgements

The authors would like to acknowledge the important feedback from the reviewers, Doreen Robinson, Julia E. Fa, Martin Nielsen, Vu Hoai Nam Dang, Shashi Ramrajh, James Compton, Wiseman Ndlovu, Katie Beckmann and Trinh Le Nguyen and also acknowledge the detailed review, proofing, copy editing final edits, and reference checking and organization by Deborah K. Kirby, Tezira Lore, Susan MacMillan and George Shouha and infographics by Annabel Slater.

The authors would like to thank the Federal Ministry for Economic Cooperation and Development of Germany (BMZ), who provided financing for this report through One Health Education and Research Center in Africa (OHRECA) as well as the CGIAR Initiative on One Health – 'Protecting human health through a One Health approach'. The authors would like to thank all funders who supported this research through their contributions to the CGIAR Trust Fund: https://www.cgiar.org/funders.

This report depends heavily on several strategic review reports and studies on practices of the wild meat industry and communities, their zoonotic implications, and potential policies and strategies for mitigating harmful practices. The two major sources were an earlier ILRI report on wildmeat value chains and zoonotic risks in Africa (Staal et al., 2021) and an ongoing systematic literature review of zoonotic risks from wildlife in Southeastern Asia (Nguyen et al., in review). These reports provided many of the sources and some text used in developing this report (where original documents were not obtained, the citing reports are indicated). Other key reports used are Bowen-Jones et al. (2003), Brown et al. (2007), Cawthorn and Hoffman (2015), Coad et al. (2019), Jones et al. (2008), Kurpiers et al. (2016), Nasi et al. (2008), Nielsen et al. (2017), Taylor et al. (2015), Wilkie and Carpenter (1999) and Wolfe et al. (2005a).

Disclaimer: The views expressed in this document are those of the authors and do not necessarily represent views or recommendations of Germany's Federal Ministry for Economic Cooperation and Development (BMZ).

Abbreviations and acronyms

BMZ	German Federal Ministry for Economic Cooperation and Development
CBSWM	Community-Based Sustainable Wildlife Management
DNA	Deoxyribonucleic Acid
DRC	Democratic Republic of the Congo
FAO	Food and Agriculture Organization of the United Nations
FBD	Foodborne Disease
HIV-AIDS	Human Immunodeficiency Virus-Acquired Immunodeficiency Syndrome
HPAI	Highly Pathogenic Avian Influenza
H5N1	Influenza A virus subtype H5N1
MERS	Middle East Respiratory Syndrome
MT	Metric Tonnes ('tonnes' refers to metric tonnes throughout)
RFID	Radio-Frequency Identification tagging
RNA	Ribonucleic Acid
SARS	Severe Acute Respiratory Syndrome
SARS-CoV-1	Severe Acute Respiratory Syndrome coronavirus 1
SARS-CoV-2	Severe Acute Respiratory Syndrome coronavirus 2
SWMP	Sustainable Wildlife Management Programme
USAID	United States Agency for International Development
USD	United States Dollars
WHO	World Health Organization

Key definitions

Bush meat: (*viande de brousse* in Francophone countries) is the term used in Africa for meat from wild terrestrial animal species for consumption or sale. However, following the International Union for Conservation of Nature/World Conservation Union General Assembly Resolution 2.64 (Wiseman and Hopkins 2001), we use the term 'wild meat' to refer to animal wildlife used for food and non-food purposes, including medicinal uses.

East Asia: This report focuses largely on uses of wild meat in the developing countries of East Asia—China and Mongolia—as well as those of Southeast Asia and sub-Saharan Africa.

Food neophobia: The tendency to avoid unfamiliar food. 'Neophobia' is the fear of new things. In the context of children, the term is generally used to indicate a tendency to reject unknown or novel foods.

Foodborne disease: A disease commonly transmitted through ingested food. Foodborne diseases (FBDs) comprise a broad group of illnesses and may be caused by microbial pathogens, parasites, chemical contaminants and biotoxins (WHO 2015).

Global North: broadly comprises countries of North America, Europe, Israel, Japan, South Korea, Australia and New Zealand.

Global South: broadly comprises countries of Africa, Latin America and the Caribbean, Asia (excluding Israel, Japan and South Korea) and Oceania (excluding Australia and New Zealand).

Informal food markets: Markets that are part of the informal economy and refer to all food-related economic activities by workers and economic units that are—in law or in practice—not covered or insufficiently covered by formal arrangements. While informal food markets are neither taxed nor effectively monitored by governments, actors in these markets may pay fees to authorities. Informal markets include open, public markets; small shops, kiosks and dukas; street, door-to-door or itinerant vendors; small eateries, restaurants and public houses. The terms 'traditional market', 'wet market' and 'territorial market' are synonymous or overlapping.

One Health: A framework that aims to foster the health of humans, animals and their shared environments through transdisciplinary collaboration (Gruetzmacher et al. 2021). One Health is an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems (OHHLEP 2023).

Pathogen of zoonotic origin: A pathogen that, following a spillover event, becomes naturally maintained in the new human host. Human infection is therefore sustained directly by humans (with no or little zoonotic contribution). These pathogens may be endemic in the human population or may have newly emerged.

Southeast Asia: This report focuses largely on uses of wild meat in the developing countries of Southeast Asia—Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Thailand and Vietnam—as well as those of East Asia and sub-Saharan Africa.

Spillover: The transmission of a pathogen maintained in a 'natural' or 'traditional' host species to a novel host species. Often referring to the first transmission event from a non-human vertebrate host to a human host.

Sub-Saharan Africa: This report focuses largely on uses of wild meat in the developing countries of sub-Saharan Africa—those in Central, East, Southern and West Africa and in the Horn of Africa—as well as in the developing countries of East Asia and Southeast Asia. The term 'Africa' in this report refers to sub-Saharan Africa.

Wet markets: See 'informal food markets' above.

Wild meat: The term this report uses to refer to wild harvested terrestrial animal species used for food and non-food purposes, including medicinal uses (see 'bush meat' above).

Zoonoses: Diseases caused by a pathogen maintained in a non-human vertebrate host that is naturally transmissible to humans and where the reservoir non-human host is a continuous source of human infection. Most zoonoses have limited human-to-human spread after their transmission from the non-human host (Haider et al. 2020).

- *Zooanthroponosis or reverse zoonoses:* A pathogen maintained in human hosts capable of being transmitted to non-human vertebrates.
- *Panzootics:* an (epizootic) outbreak of an infectious disease of animals that spreads across a large region (such as a continent) or even worldwide. The equivalent in human populations is called a pandemic.

Zootherapy: The use of therapeutic drugs derived from animals.

Executive summary

During the COVID-19 pandemic, prominent calls were made in the Global North to end the hunting, selling and eating of meat from wild animals. This report is a partial response to such calls, arguing that such a ban would be both impossible and arguably immoral to enforce due to the benefits wild meat provides for many millions of mostly poor communities. It also acknowledges the risks inherent in eating wild meat and recommends reshaping the wild meat trade in ways that 1) ensure it is sustainable and fair to poor and under-nourished populations of the Global South; 2) do not harm biodiversity or put endangered species at increased risk; 3) are safer for human, animal and environment health; and 4) are more humane.

The importance of meat from wild animals to human diets has long been studied as has the human health risks from consuming it. Based on literature reviews, this report seeks to understand wild meat consumption by people and the value chains that supply it—including hunting, harvesting, marketing and consumption—and the implications of consuming wild meat for both human nutrition and zoonotic risks in Africa and East and Southeast Asia regions where wildlife is an abundant especially abundant renewable resource and widely consumed and where ILRI has been researching use of wild meat for many decades. The report synthesises the available evidence on wild meat and recommends practices and research priorities to mitigate the biodiversity conservation and zoonotic risks related to its consumption, particularly for use by organisations working in the health, veterinary, environment and wildlife sectors.

Value, scale and trends of the wild meat market

Value extracted: The value of wild meat in Africa and East and Southeast Asia includes domestic consumption in rural communities, rural-to-urban marketing and a considerable high-value, and largely illicit, export trade, such as trade from Africa to diasporic African communities and to East Asia and largely into the European Markets from South Africa In Africa, wild meat is most important for its high protein content and human sustenance: estimates of its value for countries range from 5 million United States dollars (USD) per year in Gabon to over USD 200 million per year in Ghana, and these may not even include the value of rural consumption. Overall, the value of the wild meat trade alone is likely to exceed USD 1 billion per year in Africa and possibly several times that amount. In Southeast Asia, wild meat is also important for conferring high status and as a health food, and medicine. The annual value of traded wild meat has been estimated at USD 1 billion for Indonesia and USD 66.5 million for Vietnam. The annual value of the illegal trade in wildlife in Southeast Asia has been estimated at USD 8–11 billion and likely exceeds that. The annual wildlife farming industry in China was valued at USD 74 billion. This trade in wild meat from the African continent can only make Africa as being seen as an equal trading partner on the global platform rather than a continent as one of handouts .It has wild animals, a renewable resource, a population of young educated women, versatile in technological skills to take this market of wild meat to another level with appropriate resource allocation.

Volume extracted: Across Africa, the volume of wild meat extracted is also very large, estimated at between 1 and 5 million metric tonnes (mt) per year. That compares to the volume of Africa's livestock production of about 14 million mt per year and so represents a significant share of meat availability on the continent. In some African countries, the amount of wild meat harvested is of the same scale as the supply of livestock meat. There is less information on extraction rates in Southeast Asia, but in countries with some data (Indonesia, Japan, Vietnam), thousands of tonnes are extracted each year, which is much less than the amounts of meat that livestock or fish supply in those countries.

Challenges in measuring wild meat use: Accurate estimates of the volume and scale of wild meat extraction are hindered by the clandestine or subsistence nature of the trade and its absence from official relevant statistical databases such as Food and Agriculture Organisation Statistics (FAOSTAT), maintained by the Food and Agriculture Organization of the United Nations (FAO). Most statistical methods are likely to under-estimate true amounts. Bats, pangolins and other animals consumed locally are especially likely to be under-estimated. Airport and border control seizures, criminal records and

deoxyribonucleic acid (DNA) tests offer new insights into the wild meat global trade.

Growth trends: Although some authors suggest that the overall wild meat industry is growing in volume, the available data are unable to clearly support that view, or even to confirm with any accuracy the scale of the industry, other than to indicate that it is significant and widespread. There is, however, some evidence of declining rather than increasing extraction rates as the result of over-hunting (resulting in 'empty forests'). Unsurprisingly, lifting restrictions on hunting and consuming wild meat increases demand for it. More surprisingly, zoonotic pandemics appear to have had mixed effects on wild meat consumption, with countries reporting an increase, a decrease or no change in wild meat consumption. There is some evidence that climate change may increase extraction rates by reducing the available sources of alternative protein for people.

Consumption of wild meat for nutrition and health

Prevalence and frequency: Surveys suggest that in West and Central Africa around half the population eat wild meat: in rural areas this is two-thirds or more of the population but in urban areas it is often less than half. A smaller proportion (a quarter or less) eat wild meat regularly. The links between wild meat consumption and household income and wealth are weak, so increased disposable income may or may not increase wild meat consumption. There is a tendency for women to eat less wild meat than men and younger people to eat less than older people. There are fewer studies in East and Southeast Asia, and these suggest around half of the general population consume wild meat, while in rural areas and those with greater access, three-quarters of people or more consume wild meat. Again, there is a tendency for men and older people to eat more wild meat than women and younger people. Across sub-Saharan Africa and East and Southeast Asia, around 80 million rural households (nearly 400 million people) depend on hunting–46% of rural households in sub-Saharan Africa and 6% of rural households in East and Southeast Asia.

Quantity consumed: In Africa, the quantities of wild meat consumed are significant, often much higher than livestock meat consumption. Overall, foragers consume on average 38 kg a year and farmers 16 kg of wild meat compared to 19 kg of meat from domestic animals. There is some evidence that extreme poverty is protective of wild animals, as the poorest people cannot afford to buy wild meat or the equipment needed to hunt. In Southeast Asia, where quantitative studies are mainly from rural areas with access to hunting, consumption is around 20 kg per year.

Rural versus urban consumption: In Africa, wild meat consumption is still predominantly associated with rural areas, with no strong overall preference for wild meat in urban areas. In East and Southeast Asia, wild meat is often considered a luxury item and a status symbol by urban dwellers as well as a healthy food and one eaten during special occasions. In urban areas where demand from higher income consumers for traditional meats is high, wild meat may often cost more per unit of weight than livestock meat alternatives. The situation is often reversed, however, in rural areas, particularly in countries where livestock keeping is not a traditional practice.

Contribution to nutrition and food security: Wild meat is often rich in protein and micronutrients and some species have high energy density. In at least 62 countries, wildlife and wild-caught fish contribute at least 20% of the animal protein in rural household diets, providing calories, essential proteins, fats and micronutrients. In some African countries, wild meat provides up to 90% of animal protein consumption. In East and Southeast Asia, relative contributions are smaller but absolute contributions can be significant: for example, 1,711 tonnes of protein are obtained from wild meat each year in China. At least 15 countries, mostly in Africa, would risk food insecurity if wild meat were excluded from diets. In Central Africa, the low availability of wild meat has been linked to childhood stunting.

Consumption for medicinal use: More than 2,000 zootherapeutic practices—the use of therapeutic drugs derived from animals—have been documented in Africa, with around 521 mammalian species being used to treat 371 ailments. Zootherapy often but not always involves consuming wild animals. This practice is also widespread in East and Southeast Asia, with, for example, around 30% of urban households and 70% of rural households in China consuming wild meat for medicinal purposes.

Zoonotic risks of wild meat handling and consumption

Species: Ungulates (hooved animals) tend to be the most frequently hunted animals and are sometimes the most important in terms of overall biomass extracted. These tend to be followed in importance by large rodents and primates but in varying order. Near human settlements, where hunting pressure is greater, larger bodied animals

have over time tended to be 'hunted out' and replaced by smaller species (such as duikers and large rodents), which reproduce at faster rates and thus are more sustainably hunted. The species extraction data available, however, rely heavily on market surveys, which may not closely reflect actual hunting levels or species composition, as much of wild meat is consumed locally and never appears in markets. Much of the data available comes from Central and West Africa, East and Southeast Asia, with less from Southern and East Africa and Central Asia. Primates, rodents, bats and carnivores are the wildlife reservoirs with the highest proportion of zoonotic pathogens.

Pathogens of most concern: Historically, most spillover events have been attributed to bacterial pathogens in ungulates or armadillos, to parasitic pathogens in ungulates, to viral pathogens in rodents and non-human primates, and to undetermined sources. Microbes of most concern for their high risk are those with proven ability to a) cause human pandemics, b) lead to panzootics—large outbreaks of infectious diseases of animals—and c) mutate at high rates and recombine with other similar or dissimilar microbes. Ribonucleic (RNA) viruses are of special concern, with key viruses including Ebola and Marburg filoviruses, hepatitis viruses, herpes viruses, human T-cell lymphotropic virus, monkeypox virus, paramyxoviruses, simian foamy virus and simian immunodeficiency virus.

Transmission pathways: Between 1940 and 2021, a total of 91 spillover events from wild meat consumption have been documented, leading to 25 zoonotic diseases from 10 viral pathogens, 10 bacterial pathogens and 5 parasites. Spillover from consumption was notably higher in Africa than other regions. However, consumption of wild meat may be less of a pathway for disease spillover than exposure to animal body fluids and faeces during the handling and butchering of wild animals.

Drivers and risks: The direct or proximate risks identified by this review include selective hunting of high-value species; the presence of domestic animal 'bridges' or 'amplifier hosts' and insect vectors and contact zones; wildlife transport and sales; the age and sex of the wild animals hunted and consumed; and human characteristics and behaviours. Some of the distal or underlying drivers include globalisation, high human population density, increasing transport infrastructure, market demand, human managed landscapes, corruption and climate change.

Awareness of zoonotic risks: Most studies in Africa find a relatively low awareness among people of the zoonotic risks of hunting and consuming wild meat, except during outbreaks of dreaded diseases such as Ebola. In the Democratic Republic of the Congo (DRC), for example, hunters considered wild animals as 'pure' and disease more likely to result from contact with domestic animals. There is also significant misunderstanding both of which diseases present risks (e.g. misperception of malaria risk from animals) and of which species of wildlife are most risky to handle and eat. Even when awareness of risk is high, very few take measures to mitigate the risk. In Asia, differences have been found between rural areas (low awareness) and urban (higher awareness).

Policies and strategies for managing wild meat hunting

Regulation and enforcement: Control and command (or detect, inspect and punish) penalise was the traditional way of limiting the hunting and marketing of wild meat. Most regulation focuses on establishing reserves and banning hunting and sales of wild meat from some or all species. Protective areas cover 15% of global land and the Global Biodiversity Framework (2022) has the ambitious target of '30 × 30'—protecting 30% of land and water in a representative way by 2030. However, most African and Asian protected areas lack adequate budgets and staff, and while protected areas slow human incursion they do not halt it. Anti-poaching patrols can be effective, and, in some countries, protected species are hunted less than non-protected species. In many countries, there is lack of both awareness and enforcement of wildlife trade regulations. In others, corruption limits implementation of wildlife regulations. And in any case, many communities living close to wildlife do not accept the legitimacy of these regulations.

Market incentives: Natural experiments show the importance of incentives in shaping the wild meat sector. When African swine fever led to mass culling of pigs and shortages of pork, there was increased demand for wild meat. In Tanzania's Serengeti region, arrested wildlife poachers were mainly poor and those with livelihood alternatives were less likely to hunt. Increasing the price of wild meat, or reducing the price of livestock meat, is likely to be effective in reducing poor communities used of wild meat for subsistence, but there are few examples of interventions that rely on market incentives. Commercial wildlife ranches are common in Southern Africa (e.g. they comprise 17% of the land area in South Africa) and have been economically and socially sustainable while also increasing wildlife populations, but they require large and abundant land areas with low human population density as well as high levels of management and legal change to give landowners rights over wildlife.

Community involvement in hunting bans: Bans on wildlife hunting have been promoted since the 1970s with

some successes, but widespread adoption is limited to a few countries in Africa, notably Kenya and Namibia. In Kenya, local community-run conservancies protect 11% of the country's land area compared to the government's State Protected Areas, which cover 10% of the land. Conservancies can be successful where marginal land is abundant, tourism revenue high, community management supported, and legal frameworks exist. Outside these contexts, community involvement has had limited success as it is constrained by high transaction costs of engagement and limited awareness and enforcement. Nonetheless, there is widespread agreement that communities need to be central rather than peripheral to conservation efforts, given their proximity to wildlife populations, knowledge of local wildlife, and wildlife use practices.

Education and awareness raising: There is some evidence that raising awareness of the risks of wild meat trade and consumption is difficult to achieve, especially among the most relevant actors, such as hard-to-reach wildlife hunters and butchers in rural areas. During health crises associated with wild meat, such as Ebola outbreaks, consumption of wild meat typically declines sharply, although whether this is due to public campaigns or other communication channels is difficult to determine. Disgust and 'neophobia'—the fear of anything new—are easily triggered by meat products and developing ways of creating these are promising channels for changing consumption behaviour.

Livestock as an alternative food source: In Africa, domesticated livestock and farmed fish are two of the fastest growing sectors in agriculture. Africa's livestock population between 2010 and 2020 grew by 27%, from approximately 331 to 434 billion livestock units, with pigs and poultry being the fastest growing subsectors. However, demand is growing more rapidly than supply, with the shortfall increasingly met by imports. It is likely that domestic and imported livestock will be increasingly price competitive with wild meat, removing a major incentive for hunting. But in East and Southeast Asia, where wild meat consumption is not driven by protein or meat scarcity outside of some poor remote areas, such pricing is unlikely to be an important consideration.

Farmed wild animal species as an alternative to hunting: With shrinking wildlife habitats and increasing human populations, it seems inevitable that in Africa wildlife will provide an increasingly smaller proportion of human diets, even for rural families living close to wildlife. Despite decades of promotion, most farmed wildlife (e.g. cane rats and giant African snails) are still caught in the wild. In East and Southeast Asia, in contrast, wildlife farming has seen continuous growth driven by the high value of the products, high demand, and local skills in farming wild animals. However, this growth has given rise to several concerns: a) wildlife farming allows the laundering of wild-caught animals, b) farming wildlife products rather than domesticated stock may stimulate demand for wild-sourced products, and c) farmed wildlife may be especially risky sources of zoonotic pathogens.

Appendix 1 summary: Characteristics of the wild meat value chain

People and practices: The participatory risk analysis (Grace et al;2008) allowed for the inclusion of opinions of interdisciplinary personnel, whereby unskilled individuals in the Pongola area of South Africa were included in the estimation of risks of consuming wild meat. However, there were no experts to consult, so risk is based on observations and opinions of role players. To date there have been no reported fatalities from foodborne diseases from the consumption of wild meat either from the formal or informal markets in South Africa. Wild meat value chains have low entry barriers and many diverse participants operating in complex and shifting networks. In Africa, participants often operate in the informal economy, have multiple livelihood strategies, and their occupation is considered of low status. In East and Southeast Asia, wildlife farming was formerly encouraged but, following the COVID-19 pandemic, is often now discouraged. The main actors are:

- **Hunters:** Wild meat hunting is common and widespread in the tropics, especially in Africa, where participation varied from a low of 3% in Ethiopia to 97% in Cameroon. Wild animals are typically killed if encountered, even if they are rare or protected by law. Snaring is most common, but other types of capture are found (e.g. shooting, netting, hunting with dogs). In South Africa, most private game reserves and nature conservation areas enlist professional registered game hunters for the seasonal off take of wild game to maintain the ecological balance. The local community is employed on these game farms, and they too are trained as hunters and enlisted as part of the harvesting team. In the informal sector when hunting rifles are unavailable greyhounds canines are used to hunt down wild animals in the rural areas.
- **Farmers:** Wildlife farming remains niche or rare in Africa but has been adopted at scale in East and Southeast Asia driven by the high demand for wildlife products, including meat, skins, medicinal products and exotic pets. However, the COVID-19 pandemic as well as efforts by national governments to discourage wildlife farming led to declines in demand in some places.

- **Traders:** Traders buy wild meat from hunters and farmers often at relatively low prices and sell it to urban consumers or export it, often at significant markups.
- **Butchers and retailers:** Butchers often operate within close-knit communities where hunting and wildlife consumption are part of traditional livelihoods. In urban areas, they may cater to a broader market, including supermarkets,restaurants, traditional medicine shops, urban farmers open markets and exotic pet markets. As well as butchering, practices may include smoking, drying, or other preservation methods to extend the shelf life of the products.
- **Consumers:** In some countries, much or most of the wild meat is sold locally to rural consumers who are mainly attracted by the availability of the meat and its relatively low prices. Urban consumers of wild meat, especially in Asia, typically are from middle- to high-income classes. Wild meat is often thought to have medicinal properties and frequently seen as healthier than farmed meat.

Economic relevance: The prevalence of hunting among rural households varies enormously from near zero to almost universal, but across Africa,nearly half of households participate in some way. The returns to hunting vary greatly depending on the local setting, markets, species and type of hunting equipment available. The broadest analysis of the economics of hunting indicates mostly low returns generating a small proportion of income (less than 2%) for most hunting households. Exceptions occur where there are commercial hunters, high levels of trade and large species, and where wild meat consumption carries unique cultural importance.

Economic drivers:

- **Remoteness:** Hunting is most prevalent in more remote and rural areas, where alternative proteins are few and hunting is largely for household or community consumption. Non-forest lands, such as agricultural land and savannahs, are often as important as forests for wild meat supply. There is some evidence that the presence of livestock keeping, and the availability of low-cost livestock meat is associated with less hunting.
- **Ecosystem:** On average in Africa, 51% of wild meat was derived from forests compared to agricultural and fallow land, grassland and swamps. However, the proportion of household wild meat income in cash was higher from forest than non-forest areas, which suggests that forest hunting is more commercialized and may be associated with larger bodied and more marketable animals.
- **Livelihood strategies:** A 24-country study found statistically strong evidence that reliance on livestock meat was associated with less reliance on wild meat.
- **Household wealth:** Larger and wealthier households often hunt more frequently and successfully due to their easier access to labour and equipment. Meat consumption needs appear to be the main driver of wild meat hunting by most rural households, and even those that sell wild meat retain a significant share for subsistence or community consumption.
- **International trade:** Thousands of tonnes of wild meat are estimated to be smuggled into Europe each year by diasporic African populations, both for personal use and for commercial trade. Asia is both a major supplier and a major consumer of wild meat, with extensive networks facilitating the trade across borders. Export of wild meat from South Africa into Europe increased over several years and this was due to the high quality and demand of wild meat. In 2000 almost 18 tonnes of wild meat was exported from South Africa and in 2010 it increased to almost 43 tonnes (FAOSTAT,2012) These figures have dwindled in the recent past due to the outbreak of Foot and Mouth Disease.

Appendix 2 summary: Mini livestock alternatives

In settings where wild meat hunting is prevalent, such as forest margins in Africa and Asia, alternative protein sources can reduce the demand for wild meat. Cane rats, found in West and Central Africa, are robust rodents whose farming is well established. They offer economic benefits due to their high reproductive rates and low-cost maintenance, with meat preferred by those accustomed to wild meat. Despite challenges in management practices and health, selective breeding efforts continue to improve the productivity of cane rats. Bamboo rats in Southeast Asia are valued for their lean meat and ease of farming, but poor sustainability and animal welfare are concerns. Civet cats, although farmed for meat in some regions, raise significant ethical and biosecurity issues due to their poor living conditions and zoonotic disease risks. Cavies, or guinea pigs, are a notable mini livestock species in parts of Africa, providing protein and income, especially for vulnerable households, despite constraints like high mortality rates and limited local expertise in managing improved breeds. Aquaculture, particularly with Nile tilapia and African catfish, is a viable alternative protein source, supported by cultural traditions and suitable environmental conditions in Central Africa. Other potential farmed species include capybara and giant African snails, with capybara offering high productivity and snails being a low-capital, space-efficient option. Crocodile meat is fast becoming a replacement for wild meat, as a source of protein, due to its availability in parts of rural South Africa. Overall, these alternative species can help mitigate wild meat hunting by providing sustainable and culturally accepted protein sources.

Recommended strategies

Given the interdependencies of people's livelihoods, food security, markets and zoonotic risks, an integrated strategy is needed that recognizes several objectives at once: a) conserving wildlife populations and biodiversity, with attention to valuable and vulnerable species; b) sustaining livelihoods ,animal welfare and environmental impact, associated with wild meat value chains, at least in a transitional manner; c) maintaining food safety and security for people's access to animal protein and micronutrients, specifically in rural hunting communities; and d) identifying zoonotic risks, species and practices that affect those risks and that pose the greatest health hazards. Implementing such an integrated approach is urgent now given the changing climate, the shifting demands for use of wildlife products, the encroachment on wildlife habitats, and the fact that the wildlife meat sector is unlikely to disappear. Elements of such an integrated approach could include the following.

- *Take a community-based approach*. Although a community-based approach to wildlife hunting and wild meat marketing and consumption faces resource constraints among other barriers, because these practices are primarily locally driven, local communities need to be part of decision-making and given authority and responsibility for managing wildlife practices. A further reason for local authority is that most zoonotic risks are likely to occur at the community level, where most hunting and butchering of wild animals happens. The specific type of community-based authority that is feasible and effective will depend in part on the legislative framework available.A very workable strategy was developed (in Northern KwaZulu-Natal in an area called Pongola,and Nkandla, which is a part of South Africa) whereby established livestock associations are given awareness talks and demonstrations of hygienic handling and safe procedures and processes to be adopted during hunting of wildlife be it for either own consumption or trade in the rural areas for informal trade. In one area known as Jozini,(which is on the south side of the Mozambique border) there is a trained animal health technician well versed and trained in Veterinary Public Health, who is notified prior to hunting so that he does the meat inspection of the wild meat before it is sold by the informal traders. This in addition to traceability not only ensures the safety of the wild meat for public health but direct contact with the community in the case of any foodborne or zoonotic disease outbreak as early warning systems are in place via the correct channels of communication. The tribal chief is in control of all community-based activities including the hunting of wild animals in the rural areas. His instructions are adhered to rigidly by the livestock association.
- *Differentiate local from commercial hunting*. The evidence is relatively clear that the hunting of small robust species (e.g. rodents, duikers) can be sustainable, even in partly degraded forests, and that what Kurpiers et al. (2016) refer to as the 'farmbush' can provide a significant supply of protein, the demand for which has been shown clearly to be the main driver of hunting. With support from local communities, attention and monitoring should be on controlling commercial-scale hunting and the hunting of vulnerable (slow-reproducing) species, both at source and in markets. This would allow continuation of both the supply of needed meat to rural communities and some degree of local livelihoods in wild meat value chains.
- *Raise awareness*. Engagement with local hunting communities should take the same integrated approach, highlighting the importance of limiting hunting to certain robust species, to obtaining alternative or supplementary sources of protein wherever possible and, importantly, to understanding the zoonotic hazards of wildlife handling and how to mitigate the risks. This would include information on which species pose the greatest risk and the best practices for butchering, handling and cooking wild animals (Friant et al. 2015). Following formative research to understand local practices, this could take the form of social marketing (Drury 2009), with specific attention paid to women, who are mainly responsible for food preparation and whose role in wildlife hunting is often neglected -(Lowassa et al. 2012). Information campaigns in urban areas could similarly highlight conservation, the importance of transitioning to livestock meat, and the zoonotic risks of wild meat handling and consumption.
- *Better enforce wildlife laws*. Adequate resources should be provided to protected areas and investments made in new technologies such as drone surveillance while improving the saliency and governance of wildlife crime.
- *Support successful wildlife management strategies*. The evidence from multiple sources is clear that game ranching in Southern Africa and community-based conservancies in Kenya and Namibia have been successful in reducing poaching, increasing wildlife numbers, and generating benefits for communities (although their contribution to food production on a national scale is minimal and even on marginal land they produce less meat than livestock farming). Where conditions for game ranching and conservancies are enabling, these should be supported by national governments, NGOs and donor agencies.
- *Support alternative protein sources in Africa and Asia*. Support livestock and fish farming and facilitate livestock and fish trade within and between countries to reduce both their costs and the demand for wild meat.

- *Improve wild meat monitoring and surveillance*. Better monitoring starts with better definitions. Wild meat as a category distinct from game meat (which includes ranching), and meat from farmed wild animals should be integrated into national and international data collections and statistics (including FAOSTAT). Data collection systems focused on conservation should include zoonotic disease monitoring, rural poverty and human nutrition, and changes in land use and livestock keeping and should incorporate participatory/community-based methods and use risk-based approaches. Trade monitoring can benefit from new technologies such as radio-frequency identification (RFID) tagging, blockchain and DNA analysis.
- *Commit to the Global Biodiversity Framework (2022) target of '30×30'*. Provide the considerable additional investments needed to protect 30% of land and water in a representative way by 2030.
- *Better control global travel*. Require all global travellers to declare any food, animal materials or plant products they may be carrying under penalty of a heavy fine, directly enforceable by border control authorities, similar to what is implemented in high-income countries.
- *Adopt the One Health approach*. Take a multi-sectoral One Health approach involving wildlife and conservation sectors to collaborate with e.g. domestic animal health, human and farming sectors and collectively come up with solutions to wildlife meat management.
- Specifically, adopt a new Eco-Epi-Well-Wel which integrates Ecological betterment, reducing Epidemiological risk for people and animals, improving Wellbeing of people, and Welfare of wild and domestic animals.

Recommended research

The following are some research ideas emerging from the review.

- Past studies of zoonotic spillover events have given most attention to viruses. In future, aim more research at the less-studied spillovers caused by bacterial and other non-viral pathogens.
- Much of the research on wild meat hunting and value chains has focused on West and Central Africa. In future, develop broader understanding of wild meat practices, species and zoonotic disease threats across all parts of Africa and East and Southeast Asia to better target interventions and to generate cross-site learning.
- Further target research to ensure better information is available, particularly around consumer demand, risk drivers, practices and trade routes.
- Continue research on the impacts of agri-food system drivers on wildlife and wild meat (demographic, socio-cultural, environment, geo-political).
- Given the dramatic lack of awareness in many hunting communities of the actual zoonotic hazards associated with wild meat and also of best practices for mitigating risks, conduct formative research to understand the sources of zoonotic risk knowledge and the drivers of behaviour, followed by piloting and evaluating the effectiveness of targeted social marketing campaigns.
- Explore the potential to reduce demand for wild meat by creating or triggering disgust and neophobia.
- Consider digital and technological innovations as well as participatory/community-based approaches to improve monitoring, surveillance and wildlife crime detection (e.g. via drones, AI, blockchain, tagging, DNA).
- Since evidence of the success of community-based approaches to managing wild meat hunting is mixed and still emerging, conduct cross-site and -country comparisons to allow development of best practices and to highlight the resource, legislative and regulatory environments needed for success.
- Recent years have seen many research, development and policy initiatives to improve food safety in traditional, informal food systems. Learnings from these (especially training value chain actors, simple technologies, and introduction of incentives to improve hygiene) are relevant to de-risking of wild meat chains (Lâm et al., (accepted).
- Conduct further research into the links between livestock keeping and reduced wild meat hunting and how these patterns differ across production systems and settings. For example, do livestock constitute a direct consumption effect on wild meat or a wealth effect? A spatial econometric approach could be employed where data are available.
- Elicit accurate information on wild meat activities and consumption that respondents may consider illegal and also on associated zoonotic risk-related activity. Assess and improve the specialized survey and monitoring tools needed to do this, particularly where integrated information is gathered and forms part of community-based management.

Introduction

Zoonotic pathogens, originating in animals and transmitted to people, cause most of an estimated 70–75% of emerging and re-emerging infectious diseases in humans (these are diseases newly appearing in a population or rapidly expanding in terms of their incidence, host or geographic range). Of these emerging zoonotic diseases, approximately 70% have a non-domesticated (wild) animal origin, although many disease 'spillovers' and the vast majority of recurring as opposed to emerging, zoonoses originate from domestic animals (Taylor et al. 2001; Wolfe et al. 2005b; Falk et al. 2013; Paige 2014). A comprehensive review of human pathogens by Taylor et al. (2001) found that over 60% of all human pathogens were zoonotic. Jones et al. (2008) conducted an analysis of 335 emerging infectious disease events between 1940 and 2004. Although they found a peak of incidence in the 1980s related to the HIV-AIDS (human immunodeficiency virus-acquired immunodeficiency syndrome) pandemic, they found that these events are increasing significantly over time. Their review showed that emerging infectious disease events arose largely by zoonoses (60.3% of emerging infectious diseases) and, of those, 71.8% had a wildlife origin.

The recent emergence of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and the resulting COVID-19 pandemic, apparently from an animal source (Holmes et al. 2021) and possibly from wild animals, has dramatically demonstrated the enormous potential threat of emerging infectious diseases. In a recent review by Moloney et al. (2023), out of 114 genera of zoonotic pathogens associated with wild meat, 14 viral, 4 bacterial and 1 parasite genus were reported in humans, indicating possible spillover events.

It has also been widely recognized that the form of contact between people and wild animals most likely to give rise to new emerging infectious diseases is use of their meat and other products (Wolfe et al. 2007; Coad et al. 2019; Tumelty et al. 2023). Although humans have long relied on wild meat for an important share of their nutritional needs, as agricultural systems have evolved, those needs have largely been supplied by domesticated livestock. In many communities and developing economies of Asia, Africa and Latin America, however, the hunting of wild animals remains an important source of food, ethnomedicine and income. This largely unregulated activity comprises 'wild meat value chains', which include all the systems for sourcing and delivering meat and parts derived from wild animals for human consumption and other uses. As will be described in detail, wild meat can be sourced from a wide range of hunted or gathered animals, such as invertebrates, amphibians, insects, fish, reptiles, birds and, most importantly, mammals, including as many as 500 species in sub-Saharan Africa (Kurpiers et al. 2016). The wild meat industry has myriad livelihood and economic aspects, with implications not just for local communities but also for nations and the whole world, all aspects of which underlie the incentives for its continued activity.

This report does not attempt to conduct a thorough systematic review of wild meat and associated zoonotic risks. Rather, given a limited timeframe and resources, this report aims to inventory and synthesise the key evidence needed to provide guidance on research priorities. It also makes no attempt to explore to any extent the epidemiological aspects of zoonotic diseases in wild animals. The focus is on the actors and communities involved in the wild meat trade, their behaviours, and the factors driving wild meat practices. Other studies cover the epidemiology of wild meat more comprehensively.

Overview of wild meat consumption

Historical context

The earliest hominins, like their close relatives the chimpanzees, were probably omnivores, but around three million years ago some hominins living around the Rift Valley in East Africa underwent a remarkable change and began incorporating much more meat and bone marrow in their diets (Domínguez-Rodrigo et al. 2005). This shift to meat consumption likely made it possible for humans to evolve larger brains and to develop more complex societies (Leroy and Praet 2015). A second dietary transition took place with the domestication of livestock starting in southwest Asia in the Neolithic period. Goats and then sheep were domesticated in the Zagros mountains beginning around 9,000 BC, followed by cattle and pigs from around 7,000 BC (Groen et al. 2023). Pigs (and probably dogs) were domesticated independently in Asia and cattle domesticated a second time in the Indus Valley (Peters et al. 2022). Horses, camels, buffaloes and donkeys were domesticated around the fourth to second millennium BC, with birds still later (turkey and Barbary duck in America, hen in Southeast Asia). Guinea fowl are the only food animal domesticated in Africa (Shen et al. 2020).

Box 1: Changing consumption of wildlife in England from the Neolithic to modern times

In pre-Neolithic England, where dogs were the only domesticated animals, wild animals were necessarily the main source of animal protein. Many species of wild animals were eaten, from deer to badgers to shellfish (although there is some evidence of avoidance of some abundant animals, possibly for cultural reasons). However, during the Neolithic period, there is strong evidence of a cultural taboo against eating wild animals, including mammals, birds and fish. This taboo persisted until the Roman Empire, where the elite culture included the exploitation of wild animals. In the medieval period, starting around the 9th century AD, the consumption of wild animals resumed, peaking between the 12th and 16th centuries. Venison in particular became central to building social relations through horizontal gifting. Elite efforts to encourage and essentially farm game led to greater availability of game meat among the rural and urban poor. This led to a decline in the status of game meat among elites, a change in preference that spread to lower classes through cultural diffusion, and a trend that has continued to the present. Modern English attitudes reflect a return to viewing wild animals as sacred 'icons of the wilderness' and not for consumption, similar to Neolithic and Iron Age perspectives (Sykes 2017).

In Neolithic Europe, livestock domestication was accompanied by dramatic declines in consumption of wild animals (Box 1) and their replacement with domesticated animals (except dogs, consumed only rarely, perhaps in periods of famine). In early Neolithic China, meat was mainly sourced from wildlife, shifting to pigs and dogs, and then to herbivores (sheep, goats, cattle, horses), but wildlife and dogs remained a common food source into the Bronze Age (Zhang et al. 2023). Domestic herbivores spread into eastern Africa by 3,000 BC, reaching Southern Africa around 2,000 years ago. Wild meat consumption was less common or even taboo among pastoralist people in Africa (Fernández-Llamazares et al. 2020). However, while the Bantu peoples, who expanded from West Africa to populate much of sub-Saharan Africa, adopted livestock from the pastoralists they encountered, they continued to rely on agriculture and wild meat for most of their diet (Bleasdale et al. 2020). In most local languages of West Africa, the etymological origin of 'wildlife' is 'bushmeat' (Soewu 2020).

The arrival of Europeans in Africa in the 17th century, along with their guns and transport, brought about the slaughter of wild animals on an unprecedented scale. European hunters were mainly motivated by recreation, ivory, trophies and scientific collections, but it was the hunters

and local communities that consumed some or all of the meat of hunted animals (Bollig and Olwage 2016). From the start of the 20th century, African hunting safaris also became popular, with many of these safaris centred in Kenya through the 1930s (Herne 1999). In addition to this, millions of trade guns were sold to Africans, which were used primarily for hunting as well as crop protection, with subsequent increases in African consumption of wild meat (White 1971).

The decline in wildlife due to this slaughter intensified interest in establishing formal protection for African biodiversity starting in the 19th century in South Africa, a policy that was continued by many African countries after achieving their independence. This wildlife conservation movement led to the establishment of game reserves and an increasing prohibition of hunting by indigenous Africans, which reduced the legality if not the practice of consuming wild meat. As Africa's population grew, so did pressure on game reserves, with increasing depletion of their wildlife populations. In the later 20th century, it became widely accepted that poor communities around protected areas should receive economic benefits from the wildlife, both to meet their needs and to incentivize their support for wildlife conservation (Sachadina and Nelson 2010). In Southern Africa, legislative changes during the 1960s to 1970s gave user rights over wildlife to landlords, leading to a large expansion in wildlife ranching for ecotourism, meat, hides and trophy hunting (Lindsey et al. 2013), although the latter remains controversial (Sas-Rolfes 2017). Currently in Africa, while birds and smaller species remain common, and some (often pest) species are increasing, larger mammals are increasingly restricted to Public and Private Protection Areas (national parks, wildlife ranches and conservancies) in response to unlicensed hunting and expansion of human use of land driven by population growth.

East Asian cultures have a long history of consumptive wild animal use, reflecting an instrumentalist and anthropocentric approach to wildlife (Swan and Conrad 2014; Zhu and Zhu 2020). For some rural communities, wild meat serves as a vital source of protein, particularly in areas with limited access to alternative food sources (Mulhern 2020). Additionally, some cultures have incorporated wild meat into traditional medical practices (Lee et al. 2014; Hall et al. 2019; Tierra et al. 2020). There is often no clear distinction between medicine and food; everything ingested is believed to impact one's health. As such, the consumption of exotic, wild species is primarily driven by health and wellness practices, rather than for sustenance.

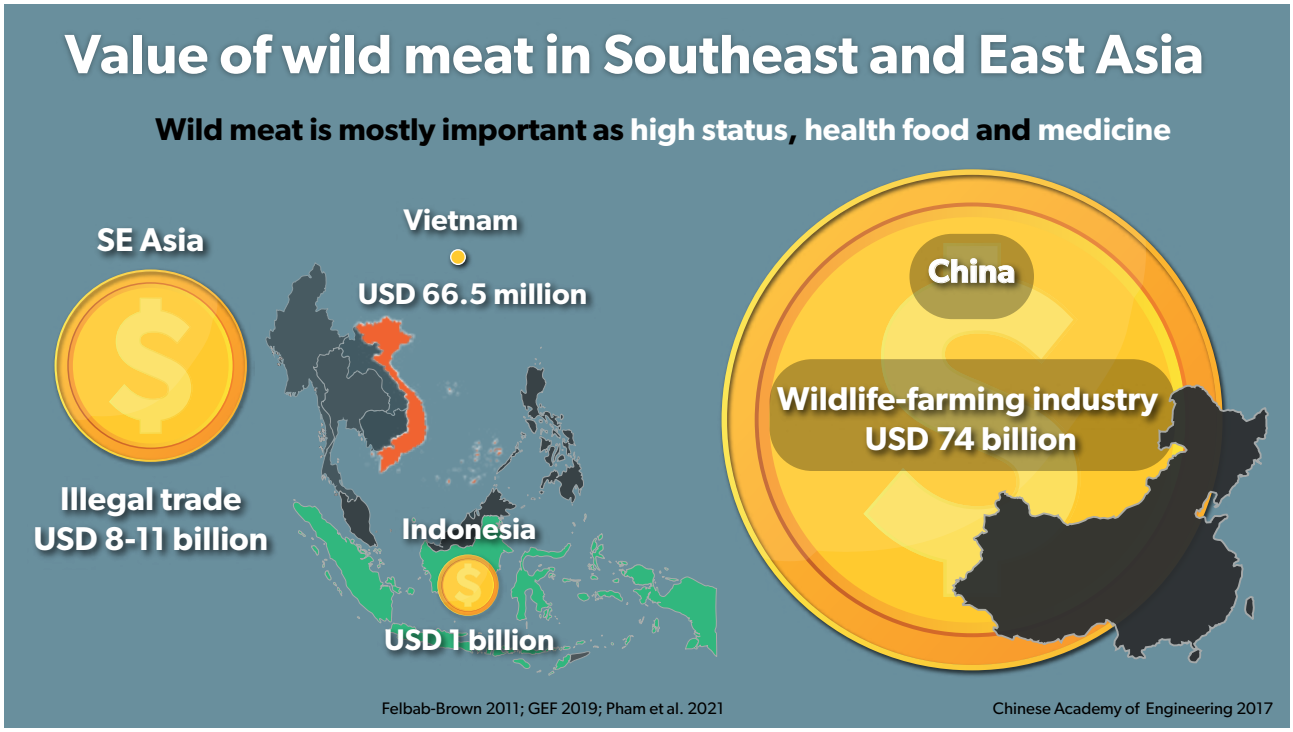
In China, there are historical accounts of hunting being limited to certain parts of the year and government officials being appointed to oversee this, but conservation was not actively pursued (Jing 1989). The first half of the 20th century saw rapid industrialization, modernization and civil wars leading to the dramatic destruction of ecosystems and unsustainable exploitation of wildlife. Modern nature conservation in China, beginning in 1956 with the establishment of the Dinghu Mountain National Nature Reserve, has established laws and regulations that have reduced the threat of extinction for more than one hundred mammalian species (Huang et al. 2021). In other parts of Southeast Asia, such as Indonesia, Malaysia and Singapore, conservationist thinking among the colonial rulers developed in the late 19th century in response to observed depletion of wildlife and natural resources. As in Africa, reserves (often with licensed hunting permits for elites) were seen as ways to protect hydrological reserves on which cities depended for water as well as to prevent unsustainable hunting (Boomgaard 1999).

As East and Southeast Asian economies develop and people's incomes rise, there is a greater demand for luxury medicines and foods derived from animal products, thereby creating a significant demand for wildlife (Drury 2011). In China, for instance, wildlife consumption has shifted from fulfilling food needs to fulfilling food preferences, with wild meat being a delicacy favoured by middle-class consumers (Roe and Lee 2021). Rising incomes had a strong positive effect on wildlife purchasing in Vietnam and future wildlife consumption in Hong Kong (Special Administrative Region of China) (Naidoo et al. 2021). Consumption of wildlife has increased with the opening of international trade, with several countries in this region becoming key players in the global wildlife trade due to their strategic geographical locations. Vietnam, for instance, has been involved in international wildlife trading since 1986; its extensive land borders and numerous deep water ports facilitate the circulation of both international and regional goods, gradually making it one of the largest markets in this trade (Nguyen et al. 2021). Because traditional medicines in Africa and Asia are often consumed, this aspect is covered in this review. Wild animals and wild animal parts also have spiritual or metaphysical significance, being used both to bring good fortune on the possessor and to bring bad fortune on others. Wild animal derivatives have many other, non-consumptive, uses (tools, clothing, musical instruments etc.) that are not considered in this review.

Value extracted

Although all the evidence available indicates that the scale of the wild meat industry is very large, it is nevertheless not easily measured, in part because some of its activities are illegal. Even though livestock production has grown and is largely industrialised across the world, approximately 150 million people across Asia, Africa and Latin America

Infographic 1.



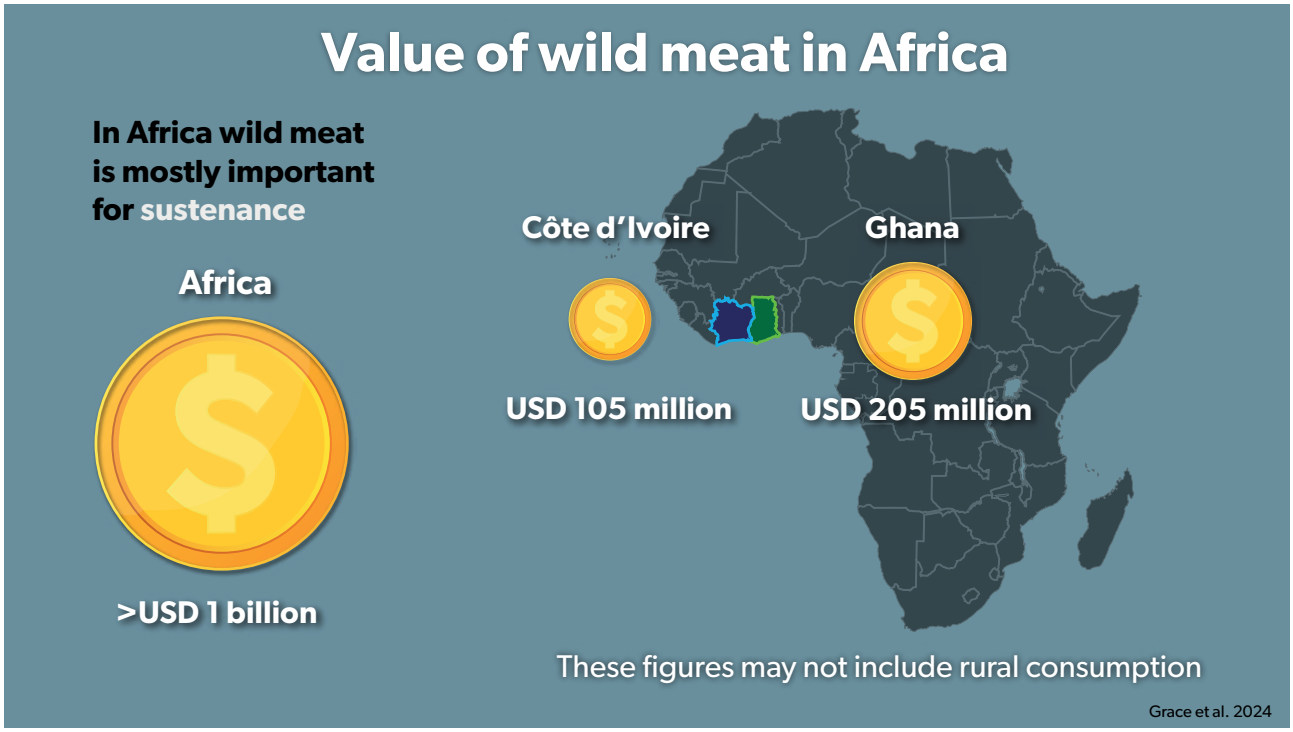
still rely on meat from wild animals for protein, energy and micronutrients as well as for the many forms of livelihoods associated with the hunting and marketing of wild animal products (Nielsen et al. 2018). The industry supplies consumers both within and out of the countries where animals are hunted. The globalisation of trade and migration of people from the Global South has led to a trade in wild meat estimated to be worth USD 50–150 billion per year (UNEP 2014). All illegal trade in species considered under threat of extinction by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which includes exotic pets, is estimated at USD 20 billion per year (Challender and Macmillan 2014), with the value from the illegal trade estimated to be 25% of the legal trade (World Bank 2019). For comparison, the value of total livestock meat exports in 2018 from across Africa (East, Central, Southern and West) was only USD 718 million (FAOSTAT). Some studies at European airports found as much as 5 tonnes per week of wild meat in the luggage of arriving passengers (Chaber et al. 2010), with annual estimates of up to 80 tonnes of wild meat confiscated in Swiss airports (Wood et al. 2014). Morrison-Lanjouw et al. (2023) recently reported an average of 4 kg of wild meat seized in each confiscation in Brussels, and it is estimated that about 3.9 tonnes of wild meat is smuggled through Brussels each month (Chaber et al. 2023).

In African countries where wild meat plays an important role, the annual value of the wild meat trade has been estimated from USD 5 million per year in Gabon (Antsy 1991), or USD 21 million per year when rural consumption is included (Colchester 1994), to USD 205 million per year in Ghana in 2002 (Davies and Brown 2008), although more recent estimates are not readily available (Table 1). Individual wild meat traders have reported profits of more than 50%, with an estimated benefit-cost ratio of 1.95 and a 0.95 return on investment (Soaga et al. 2014; Adebowale et al. 2021). In Cameroon, it is estimated that income from sales of wild meat average Euros 32.2 million per year, while consumers draw benefits of more than Euros 42 million per year from wild meat (Lescuyer et al. 2015).

These numbers of the value of wild meat are impressive when compared to the value of livestock production. In 2018, livestock production was estimated to be worth USD 112 million in Gabon and USD 826 million in Ghana. Across East, Central, Southern and West Africa, total livestock meat production was about 14 million mt in 2018 (FAOSTAT), suggesting that the wild meat harvest comprised at least 10% of livestock production. In Central Africa alone, where most livestock production is not highly developed, total livestock production in 2018 was 2 million mt, about the same scale as the wild meat offtake according to some estimates, such as that by Fa et al. (2003).

The wild meat trade in Southeast Asia is estimated to be worth many billions of dollars each year, making up

Infographic 2.



roughly a quarter of the global trade (Lin 2005), though precise estimates are challenging due to its largely illegal and unregulated nature (OECD 2019). This trade involves the hunting, captive farming, sale and consumption of wild animals and is primarily driven by cultural practices, subsistence needs, market demands, and medicinal beliefs, although these driving factors vary among countries.

According to geospatial models on wild meat activities and drivers (Jagadesh et al. 2023), Central Africa emerged as the largest region with wild meat activities, covering an area of 216,863 km^2, followed by Southeast Asia, particularly Laos and Vietnam, with an area of 205,367 km^2. In Southeast Asia illegal wildlife trade has been estimated to account for up to 25% of the global illicit market in wildlife products, acting as both a source and a transit hub for international wildlife trading (OECD 2019).

Table 1. Value of the wild meat industry in parts of Africa and Asia

	Wild meat trade value per year	Source	Comment
Global			
Global Illegal trade in CITES-listed species (used not just for meat)	USD 20 billion	Challender 2014	Includes exotic pets and poaching for medicinal products
Côte d'Ivoire	USD 105 million	Davies and Brown 2008	
Côte d'Ivoire	USD 22.5 million	Gonedelé-Bi et al. 2022	
Ghana	USD 205 million	Davies and Brown 2008	
Gabon	USD 5 million	Colchester 1994	From Nasi et al. 2008
Gabon	USD 21 million	Antsey 1991	
Uganda (legally traded species)	USD 3 million	Ndizihiwe 2022	Mainly birds, reptiles and amphibians—legally traded

	Wild meat trade value per year	Source	Comment
Global			
Cameroon	Euro 4.35 million	Lescuyer et al. 2015	Rural areas net benefit from the wild meat trade per year
Cameroon	Euro 42 million	Lescuyer et al. 2015	Rural areas net economic benefit from wild meat consumption per year
Cameroon	Euro 10.2 million	Lescuyer et al. 2015	Urban areas net benefit from the wild meat trade per year
Tanzania	USD 210,000	Nilesen et al. 2016	
Tanzania	USD 1–5 million	Ceppi et al. 2014	Only covers the Serengeti ecosystem
DRC	USD 750,000	Batumike et al. 2021	
China	USD 74 billion	Chinese Academy of Engineering, 2017	The wildlife farming industry was valued at 520 billion yuan (USD 74 billion)
Vietnam	USD 66.5 million revenue USD 21.5 million profit	Pham et al. 2021	Illegal wildlife trade
Indonesia	USD 1 billion	GEF 2019	Illegal wildlife trade
Southeast Asia	USD 8–10 billion	Felbab-Brown 2011	Illegal wildlife trade

Volume extracted

Several studies have estimated the levels of both mammalian biomass and hunting extraction across Africa (Table 2), although again largely from West and Central Africa, comprising many different landscapes. Martins and Shackleton (2019) point out that studies of hunting have not adequately addressed Southern Africa, even though there is evidence that the practice is important in the region. Recent figures are hard to obtain, but most estimates range from 1 million to 5 million mt per year of wild meat extraction. Fa et al. (2002) estimated hunting extraction at 2,645 kg per km2 per year (4.9 million mt per year) for the Congo Basin, comprising 479 million animals, but recognized that these figures were four times higher than those calculated for the region by some other researchers. The mt figure contrasts with Wilkie and Carpenter's (1999) estimation of only 1 million mt per year from the Congo Basin. The slightly more recent estimate of 400,000 mt per year in West Africa by Brashares et al. (2004) suggests that a level of 1–2 million mt per year across West and Central Africa is likely.

Fa et al. (2005) used published studies from 36 sites in Central and West Africa (Cameroon, Central African Republic, DRC, Equatorial Guinea, Gabon and Ghana) to review and analyse patterns and between-site variations in hunter-kill profiles of mammals in tropical moist forests. Based on surveys of hunters and market agents, the results showed that annual harvest rates per studied site were variable, and per hunter, average extraction was around 100 carcasses/year, close to 1,000 kg/year in weight. The authors suggest that these levels of harvest fall within the range of unsustainable estimates for mammals in African forests. For instance, wild meat extraction has been reported to reduce the relative abundance of target mammals and birds by 83% and 58%, respectively, in the tropical areas where hunting is prevalent (Benitez-Lopez et al. 2017).

Fa et al. (2006) studied wild meat markets in a large area between Nigeria and Cameroon. In Nigeria, the estimated biomass extracted for sale was three times greater (600 kg/km2 per year) than in Cameroon. In Tanzania, annual extraction is estimated at 370,000 kg (Nilesen et al. 2016). In Côte d'Ivoire, annual market supply and sale of wild meat from over 5,500 animals was estimated at 218,937 kg (Gonedelé-Bi et al. 2022). In Guinea, a biomass 21,314 kg was observed in markets within three months in 2017 (Duonamou et al. 2021). A one-year-long observational study in 2021 reported 283 bushbucks and 211 common duikers supplied to retail shops in three rural retail wild meat centres in Enugu-Nigeria (Andong et al. 2023). Also in Nigeria, a study that followed 28 hunters from 2020 to 2023 reported increased wild animal extractions totalling 2,369 animals from 39 species groups, amounting to 13,870 kg from 28 hunters in three years during the SARS-COV-2 pandemic (Emogor et al. 2024). During the same period, wild meat extraction was reported to only increase for rural communities in Cameroon, Colombia, DRC and Guyana but becoming unavailable for urban consumption

Infographic 3.

(Enns et al. 2023). This supports findings from a recent model hypothesizing the implication of pandemics on the patterns and trends of wild meat extraction and use (McNamara et al. 2020). While country-level data are obtained just from factions of the population, extrapolating these data over time and across regions could give estimates of country-level wild meat extraction volumes.

The complete picture of wild meat is unclear as data only exist for a few places in East and Southeast Asia. Nevertheless, we know that over 300 species are caught and traded in Southeast Asia (Nijman 2010). In Vietnam, it was estimated that 3,400 tonnes of wild meat are consumed per year, around half domestically (BBC 2009). In Laos, an average wild meat market could sell over 71 tonnes of wild meat per year and generate close to half a million USD in trade (Pruvot et al. 2019). In Japan, 2,085 tonnes of wild game were processed at 750 facilities in fiscal 2022, a 1.6-fold increase compared to 2016 (Japan Times 2024). A recent extensive study in Sulawesi, the fourth largest island of Indonesia, found that wild meat was routinely available in 73% of markets and supermarkets (Latinne et al. 2020). Flying foxes were among the most popular, ranging from 662,551 to more than one million individuals sold, a rate considered unsustainable.

Table 2. Quantity of wild meat extracted in parts of Africa and Asia

	Volume (mt of trade in wild meat)	Source	Comment
Global Illegal trade in CITES-listed species (used not just for meat)	USD 20 billion	Challender 2014	Includes exotic pets and poaching for medicinal products
Africa	1 million per year	Bennet 2000	Much resulting from new logging roads
Africa	> 1 million per year	Elliott 2002	Considered by some to be an underestimate
Africa (sub-Saharan)	4.9 million per year	Fa, Peres and Meeuwig 2002	Based on anthropological studies; much higher rate than other studies, equivalent to 282 g of wild meat per person per day

	Volume (mt of trade in wild meat)	Source	Comment
Central Africa	> 2 million per year	Fa, Currie and Meeuwig 2003	
Central Africa	1.2 million per year	Wilkie and Carpenter 1999	Review of studies from Cameroon, Central African Republic, DRC,Equatorial Guinea and Gabon
Congo Basin	1–5 million per year	Davies and Brown 2008	
West Africa	400,000 per year	Brashares et al. 2004	
Cameroon (Yaoundé)	70–90 per month	Bahuchet and Ioveva 1999	
Gabon	10,000–11,500 (sold commercially) per year	Abernethy and Obiang 2010	The equivalent of about 30,000 cattle carcasses
Tanzania	370 per year	Nielsen et al. 2016	A study among hunting communities supplying a rural value chain in Tanzania; data from 1855 observations of trade in one year
Tanzania (Serengeti)	800–4,000 per year	Ceppi et al. 2014	Estimation of extraction from the Serengeti ecosystem
Côte d'Ivoire	218.9 in 1 year	Gonedelé-Bi et al. 2022	Over 68% of the total biomass is from bushbuck and cane rats; values presented are from 6 vendors
Guinea	21 in 3 months	Duonamou et al. 2021	Data from four villages
Nigeria	13.8 in 3 years	Emogor et al. 2024	Wild meat extractions increase among rural communities during SARS-COV-2 pandemics; values presented are from 28 hunters
Vietnam	3,400 per year	BBC 2009	Consumed annually
Japan	2,085 per year	Japan *Times* 2024	Of wild game processed in facilities across Japan
Indonesia (Sulawesi (4th largest island)	810 per year	Latinne et al. 2020	Includes only bats, pigs and snakes—and likely underestimates the total volume

Challenges in assessing wild meat extraction

What cannot be measured will not be efficiently managed. But accurate information on the volume and scale of wild meat consumption is difficult to obtain for several reasons: a) much of the trade is clandestine or illegal and hence escapes observation; b) legal hunting is often small in scale, ad hoc and for subsistence rather than an occupation and hence not recorded; c) wild meat is often not included in official reporting; d) definitions of wild meat, bushmeat, and game are inconsistent; e) where wild meat is not legal it may be passed off as domestic livestock meat (Box 2).

Box 2: Wild meat or not?

Sales of wild meat misrepresented as other types of meat is a growing concern. This deceptive practice involves selling wild meat—often from protected or endangered species—under the guise of more commonly accepted meats such as beef and goat. Food fraud in the form of meat substitution is not a risk only in low- and middle-income countries. The 'horse meat scandal' of 2013 in Europe illustrates that food fraud is a global and pervasive issue; this was one of 413 fraud reports in the global beef supply chain in a 20-year period between 1997 and 2017 (Robson et al. 2020). While the (undisclosed) substitution of one meat product for another always has ethical and economic implications, the implications are even more significant when the substitution product is wild meat, which can harm both wildlife conservation efforts and public health.

The clandestine nature of the wild meat trade in much of the world makes it difficult to both regulate and monitor it. We do know, however, that a significant portion of wild meat enters urban markets, where it is often intentionally mislabelled and sold to unsuspecting consumers, who believe they are purchasing legally sanctioned meats (Njaramba et al. 2021; D'Amato et al. 2013).

A major challenge in addressing this issue is lack of robust systems for verifying meat origins. DNA barcoding has been proposed and utilised in some studies to identify the true species origin of meat products. Use of DNA sequencing methods to test the authenticity of meat labelled as 'game meat' in South Africa indicated a high level of substitution, with meat from wild species not commonly regarded as game often sold as meat from more expected species (D'Amato et al. 2013). More economical high-resolution melt techniques have been deployed to support wildlife forensics by scientists in Kenya (Ouso et al. 2020), who found a 10% substitution rate in meat sold to consumers in Nairobi (Njaramba et al. 2021).

The implications of this practice are far-reaching. As well as undermining wildlife conservation efforts and exposing consumers to significant public health risks, this practice has significant public trust implications, severely undermining consumer confidence in food systems, health authorities and regulatory bodies. When consumers discover that they have been misled about the nature of the food they are purchasing, with wild meat sold under the guise of safer, regulated meats like beef or pork, the erosion of consumer confidence can cause consumers to question the integrity of all food products, not just those in meat substitution scandals. And if consumers feel that their health is being jeopardised by inadequate food regulation and inspection, their trust in public health institutions can decline (D'Amato et al. 2013).

Surveys of wild meat value chain actors, including consumers, remain the most common way of assessing the rates in which the wild meat is being extracted, but these surveys typically are conducted only in a few areas and are not nationally representative. Moreover, because of a dearth of census information in many countries, most surveys are not random and hence may not be representative of the population from which they are drawn. In addition, because many actors in the wild meat business operate informally and do not keep records, their responses to surveys may be inaccurate—and where wildlife hunting and trade is illegal, their responses may not be truthful.

Much data on the volume of wild meat come from market studies because collecting market data is easier than collecting data on rural hunting and consumption of wild meats. The species reported in market studies may not reflect the species composition in the forest, or the species or levels actually hunted and consumed within hunting communities, which are likely to be driven in part by non-market objectives. Birds, reptiles and invertebrates are likely to be underrepresented since they may not be marketed much or may be caught by women and youth and inadvertently missed by surveys (Taylor et al. 2015). A wild meat literature review by Mickleburgh et al. (2009) found that 31 comprehensive studies of wild meat hunting and trade did not mention bats. The same study, however, found evidence that consumption of bats was widespread, both of larger fruit bats and of insectivorous species, particularly in West Africa, although the greatest prevalence was found in Madagascar, Asia and the Pacific. Moreover, a study in Ghana estimated that at least 128,000 bats were sold in markets, reaching distances of up to 400 km away from where they were captured (Kamins et al. 2011). These and other small animals often caught by women and youth may not feature in market studies. This bias in species reports from market studies is reflected in a study in Gabon that found that only 19 of the species in the original catch were represented in the animals destined for market, with three species accounting for 90% of the individual animals sold, the rest being consumed locally, which shows that marketed offtake is selective (Coad 2007). In Akwa Ibom State, in Nigeria, only six species of wild meat were observed traded, with the cane rat comprising the largest volume of wild meat on the market (Jacob et al. 2018).

While pangolins are of interest because they may host zoonotic pathogens, their presence in Africa's wild meat markets is not clearly reflected in the above studies. Boakye et al. (2016) indicate that although pangolins are apparently frequently hunted in Ghana, for example, they do not appear in some major wild meat market surveys. A market study Boakye et al. conducted over 15 months (2013–2014) reported only 341 pangolins traded by 153 respondents. Most of the pangolins were observed close to the protected forests where they were caught, suggesting that pangolins fail to enter longer distance supply chains. The authors suggest that market surveys thus underestimate what is anecdotally known to be a species preferred by wild meat consumers for its dark meat. Furthermore, some recent studies point to an increasing trade in the scales of pangolins sourced

in Africa and exported to Asia, where they are used in decorations and traditional medicines. This increase is reflected in confiscations of shipments of pangolin scales in Zimbabwe reported by Shepherd et al. (2017) and reported more generally by Soewu and Sodeinde (2015).

While seizures of wild meat by law enforcement agencies sometimes report large volumes, law enforcement in much of Asia and Africa is not systematically enforced. Airport seizures provide additional insights. A two-year, statistically representative, study of airports in Belgium (2017–2018) estimated that 47 tonnes of wild meat were smuggled into Belgium every year. Nearly all of the passengers smuggling the wild meat originated on flights from West Africa, with those from the DRC most likely to carry it (7% of all passengers were searched). Porcupines, cane rats and pangolins made up nearly half of the seizures (Chaber et al. 2023). Other studies have found similar results (Chaber et al. 2010; Wood et al. 2014).

A systematic analysis was conducted in China of 9,256 convictions for illegal hunting from a nationwide database of trial verdicts in China spanning January 2014 to March 2020 (Liang et al. 2023). Most hunting was for commercial purposes (usually sales for wild meat or medicine) and some of the seizures were very large (up to half a million birds in one case).

Growth trends in the wild meat industry

The quality and type of data presented above underline the fact that accurate information on the scale and scope of the wild meat industry is generally unavailable. As a consequence, it is unclear to what extent the industry is growing. Cawthorn and Hoffman (2015) make the case that Africa's increasing population growth and urbanization are increasing demand for high-value wild meat which, combined with the high demand value of the international wild meat trade, will combine to cause steady growth in the industry. A survey in Gabon found that wealthier households consumed more wild meat along with more livestock meat (Wilkie et al. 2005). The urban population in the DRC consumes wild meat for its taste, perceived health benefits and as a rare luxury but is willing to replace wild meat with non-frozen livestock meat (Chausson et al. 2019). Some recent studies have pointed to lower interest in wild meat consumption among urban African youth (Chausson et al. 2019; Luiselli et al. 2018), and the same urbanization trend may reduce the largest source of demand and consumption, which are populations in rural hunting communities. An opposite driver is increased urbanization coupled with rises in disposable income, leading to demand for wild meat as a status and luxury good (Brashares et al. 2011; Cawthorn and Hoffmann 2015). There is some evidence that consumption of wild meat is declining as a result of unsustainable extraction practices, known as 'empty forests'. One estimate for Gabon found that about 25% of meat came from wild sources (Ritchie et al. 2017), a decline from about 70% in the early 1960s.

In many countries, the COVID-19 pandemic led to a large reduction in urban wild meat consumption while its rural use increased (Kamogne et al. 2022; McNamara et al. 2020). Post-COVID-19 studies in urban China show a significant decline in wild meat consumption due to heightened awareness of its health risks (Si et al. 2021). However, the impact of COVID-19 is mixed, with countries reporting reduced (Sainge et al. 2023; Funk et al. 2022) or increased (Emogor et al. 2024; Enns et al. 2023) consumption of wild meat or no impact at all (Simo et al. 2024; Patel et al. 2023; Morcatty et al. 2021). A study in Cambodia, Laos and Vietnam found that trade in wildlife decreased during the COVID-19 pandemic but hunting wildlife increased as urban workers returned to their villages and, driven by rising food prices, sought food in forests (Davis et al. 2023). Pandemics and wild-meat-related infections thus may have mixed effects on the wild meat industry, as demonstrated by links between the SARS-COV-2 shocks and wild meat trade reported in McNamara et al. (2020).

Wild meat extraction and trade have also been reported to increase in the dry seasons (Sackey et al. 2023; Sonhaye-Ouyé et al. 2022), indicating how prolonged droughts, often due to climate change, impact the dynamics of the wild meat industry. Lifting bans on the trade and consumption of wild meat, as noted in Tanzania, can also lead to the expansion of the industry (Foya et al. 2023) and it's unsustainable use. Many wildlife conservation-oriented studies point out that current rates of extraction of wild meat are unsustainable except for some small and fast-reproducing species such as rodents (Fa et al. 2005). It is thus not clear that the extraction and marketing of wild meat is growing in volume, although changes in hunting and information technology as well as increasing urban wealth may change the nature and value of the demand for wild meat.

Summary: Macro characteristics of the wild meat industry

Value extracted: The value of wild meat in Africa and Southeast Asia includes domestic consumption in rural communities, rural-to-urban marketing and a considerable and high-value, largely illicit, export trade such as to diasporic African communities and to East Asia.

In Africa, wild meat is most important for human sustenance, with estimates of its value for countries range from 5 million United States dollars (USD) per year in Gabon to over USD 200 million per year in Ghana, and these estimations may not even include the value of rural consumption. Overall, the value of the wild meat trade alone is likely to exceed USD 1 billion per year in Africa and possibly several times that amount. In Southeast Asia, wild meat is most important as a high status, health or medicinal food. The annual value of traded wild meat has been estimated at USD 1 billion for Indonesia and USD 66.5 million for Vietnam. Illegal wildlife trade in Southeast Asia has been estimated at USD8–11 billion per year and likely exceeds that. The wildlife farming industry in China was valued at USD 74 billion.

Volume extracted: Across Africa, the volume of wild meat extracted is also very large, estimated at 1–5 million mt per year. That compares to livestock production of about 14 million mt per year, thus representing a significant share of meat availability. In some African countries, the size of the wild meat harvest is comparable to that of the livestock meat supply. There is less information on wild meat extraction rates in Southeast Asia, but for countries with some data (e.g. Indonesia, Japan, Vietnam), thousands of tonnes are extracted each year, which is much less than that of livestock or fish supplies.

Measurement challenges: Accurate estimates of the volume and scale of wild meat extraction are hindered by the clandestine or subsistence nature of the trade and its absence from official statistical databases. Most methods likely under-estimate true amounts, particularly for bats, pangolins and animals consumed locally. Airport seizures, criminal records and DNA testing offer new insights into the volume and nature of the wild meat trade.

Growth trends: Although some authors suggest that the overall wild meat industry is growing in volume, the available data are unable to clearly support that view or even to confirm with any accuracy the scale of the industry other than to indicate that it is significant and widespread, although there is some evidence of declining extraction rates due to over-hunting ('empty forests'). Unsurprisingly, lifting bans on wild meat increases demand. More surprisingly, the occurrence of zoonotic pandemics has mixed effects on the wild meat trade, with some countries reporting an increase, others a decrease, and still others no change in wild meat consumption. On the other hand, there is some evidence that climate change may increase wild meat extraction by reducing the availability of alternative sources of protein.

Consumption: Food and medicine

Prevalence and frequency of wild meat consumption

Some studies have estimated the overall importance of wild meat for consumption in Africa and Asia, focusing particularly on rural households, for which wild meat is often a staple source of protein and a few studies have made urban estimates as well. As has been emphasized, wild meat is an important food source for many rural communities in Africa that have few meat alternatives. Some studies from rural West Africa show that nearly all respondents have consumed wild meat, e.g. 98% of respondents in Delta State, Nigeria (Ebewore et al. 2015) and 97% of rural households in Gabon (Forester et al. 2013). There is, however, considerable variation among African countries and surveys (Table 7). In general, rural inhabitants, men and older people are more likely to consume wild meat frequently than are urban dwellers, women and younger people.

A taste test among consumers in Gabon by Schenck et al. (2006) found only a weak preference for wild meat and only rural consumers consistently preferred wild meat over alternatives. Respondents interviewed in market centres in Ghana by Kuukyi et al. (2014) were a mix of hunters, traders and consumers, 29% of whom indicated a preference for wild meat, 51% expressed no preference and 20% preferred domestic meat. A larger study across seven countries in West Africa found rural location was the most important determinant of wild meat eating: 67% of rural people consumed wild meat but only 42% of urban (Luiselli et al. 2018). In the same study young people and women tended to eat wild meat less.

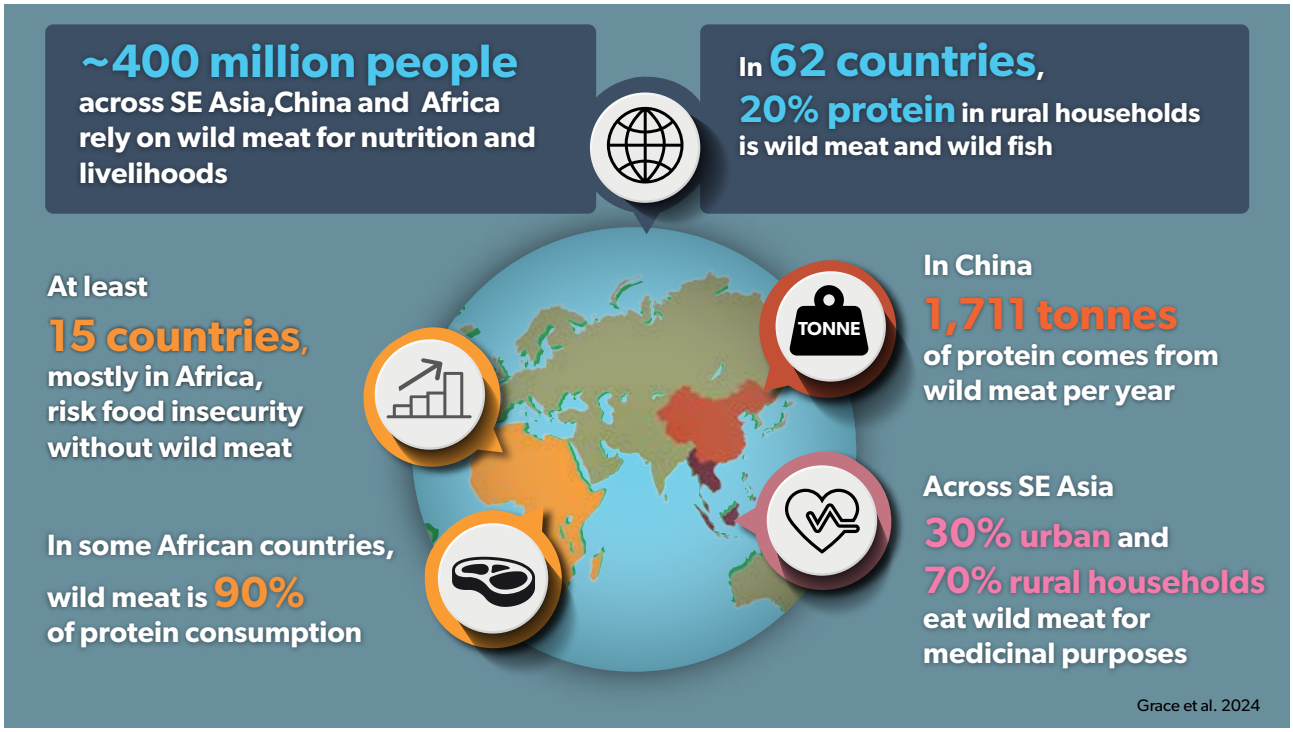
In Equatorial Guinea, Fa, Juste et al. (2002) found that age and sex of the respondents did not affect their wild meat consumption, but different ethnic groups reported statistically different preferences for species. The study concluded that consumption was driven mostly by availability (as did Ebewore et al. 2015) and that the price of the meat did not appear to be a determinant.

In the Manyara-Tangire ecosystem of Tanzania, which is close to wildlife conservation areas, the low price of readily available wild meat compared to livestock meat resulted in no wealth effect on consumption (Kiffner et al. 2015). In rural Gabon, Foerster et al. (2012) found that wild meat consumption per household member was higher in wealthier households and lower in households more removed from the park boundaries. The level of consumption at the village level was lower in villages where wild meat was more valuable on average across species. Again, the indication is that a lack of alternative protein leads to higher wild meat consumption independent of household wealth.

Wild meat consumption varies widely across East and Southeast Asian countries. A study in Vietnam found that 50% of residents surveyed had used wild animal products at some point, and a substantial majority (75%) of that consumption involved wild meat (Shairp et al. 2016). Another study conducted by Drury (2011) in Vietnam found that around 60% of rural households consume wild meat regularly, while urban consumption is lower, around 10–15%. Johnson et al. (2016) estimated that more than 80% of households in rural areas in Laos consume wild meat regularly. A recent study in China published in 2022 indicated that approximately 31% of respondents continued to consume wild animals despite the COVID-19 pandemic (Rizzolo et al. 2023). A study in major urban markets in Cambodia found most of those surveyed consumed wild meat several times a week. Richer and older people were more likely to consume wild meat than poorer and younger people (Nguyen 2023).

In rural areas with access to wildlife, wild meat consumption is more frequent. A survey of households in Cambodia's Eastern Plains revealed that 84% reported consuming wild meat (Ibbett et al. 2021). Bennett and Robinson (2000) found that in Sarawak, wild meat is the main source of protein; 67% of the meals of Kelabits contain wild meat. In Indonesia, Pangau-Adam et al. (2012) found that 51% of respondents reported that their meals contained wild meat. In South Asia, Banerjee (2016) found that about 75% of households in Nagaland, India

Infographic 4.



(a tribal area with a strong tradition of hunting), engage in hunting and consume wild meat regularly. In China's Yunnan Province, approximately 30% of rural households consume wild meat (Zhang et al. 2008).

A global cross-country study estimated 40 million rural households in sub-Saharan (46% of all rural households or 268 million people) and 64 million rural households (11% of all rural households or 123 million people) in Southeast Asia depend in hunting (Nielsen et al., 1918).

Table 3. Share of households consuming wild meat and frequency of consumption

Location	Households consuming wild meat	Comments	Source
Tanzania	46% in the last 12 months (14% had a household member who hunted illegally	Data from 10 ecoregions nationally	Ceppi and Nielsen 2014
Nigeria (Delta State)	98% at some time but 13% still occasionally	98% cane rat, 94% giant snail	Ebewore et al. 2015
Nigeria	71% of respondents had consumed wild meat, with 45% having consumed wild meat in the year of survey	Impact of COVID-19 pandemic on wild meat consumption	WILDAID USA 2021
Madagascar	14%	3-day recall	Jenkins et al. 2011
Burkina Faso, Niger, Nigeria, Togo	25% eat frequently, 28% sometimes and 44% never eat wild meat	Interviews of urban and rural residents; younger respondents more likely not to eat wild meat	Luiselli et al. 2018
South Africa	30–60% of households consume wild caught wild meat	Based on a review of 20 studies, 10 sites in rural areas	Martins and Shackleton 2019

Location	Households consuming wild meat	Comments	Source
Gabon	97% of rural households	Consumed wild meat at least once during the 12-day survey	Foerster et al. 2012
Sierra Leone	57% of men and 25% of women preferred wild meat, with 87% of the men and 55% of the women consuming wild meat frequently	Wild meat consumption during COVID-19	Sainge et al. 2023
Togo	86% of hunters hunted for household meat	185 hunters from 12 villages interviewed	Sonhaye-Ouyé et al. 2022
Cameroon	50% of households	Consumed meat once every week or more	Simo et al. 2024
Ghana	67% of responds were wild meat consumers; men (64.6%) consumed more wild meat than women (35.4%)	Consumers ages ranged 31–60 years	Bannor et al. 2021
Tanzania	79% of respondents had consumed wild meat		Foya et al. 2023
China	31% of respondents consume wild animals	Wild meat consumption after COVID-19	Rizzolo et al. 2023
China	Overall 12% of the population consume wildlife	As high as 60% in some regions (e.g. southwest)	Wang et al. 2020; Zhang et al. 2008
Vietnam	58% of respondents were current wild meat consumers; 279 (85%) of 329 respondents claimed to have consumed wild meat at least once in their lifetimes	Consumer ages ranged 18 to over 65 years, most having completed secondary school	Biller-Sandalj et al. 2016
Vietnam	In Ho Chi Minh, 48% of respondents consume wild meat more than three times a year		Do et al. 2011
Laos	80% of rural households consume wild meat regularly		Johnson et al. 2016
Cambodia	61% consumed wild meat several times a week for special events and 35% several times a week for family meals	Major urban markets	Nguyen 2023
Cambodia	Wild meat was consumed by 84% of households		Ibbett et al. 2021
Malaysia	67% of the meals of Kelabits contain wild meat		Bennett and Robinson 2000
Indonesia	51% of participants reported that their meals contained wild meat		Pangau-Adam et al. 2012

Quantity of wild meat consumed

In terms of quantity consumed, estimates of wild meat consumption, which are not included in the FAOSTAT data as a specific category, compared to livestock meat consumption, are remarkably high (Table 8). (FAOSTAT has a category for 'game meat' but this included both farmed and captured meat and is inadequately reported).

Wilkie and Carpenter (1999) carried out a review of studies in Central Africa that found that rural people consumed about 10 times as much wild meat as urban consumers but across the population the average was some 35 kg/capita per year, much higher than the average level of livestock meat consumption in the same countries and across nearly all of Africa. Other estimates for the DRC and Liberia found consumption as high as 100 kg/capita per year. As reviewed in Booth et al. (2021b), Botswana, Congo and Côte d'Ivoire are Africa's leading wild meat consumers at 9.72 g, 8.08 g and 6.1 g per person, per day,

respectively. It should be noted that some of these studies are based on hunting extraction rates and may reflect body weight rather than butchered meat, so may exaggerate the amounts actually consumed. Nevertheless, the general levels of consumption, which are apparently confirmed by a number of studies, emphasize the enormous importance of wild meat as a source of food for many rural people in Africa.

In Asia, despite extensive searching, due to a lack of available data on wild meat consumption, we were unable to find specific data for most of the countries such as Cambodia, China, Malaysia and Myanmar. A recent review conducted by Pruvot et al. (2019) estimated that Laotians consumed 32 kg/per capita per year, representing 1.5 times the average per capita yearly meat consumption. Other estimates for Indonesia and Vietnam found the quantities of wild meat consumed per capita each year were 14 kg and 14¬–16 kg, respectively.

Table 4. Estimates of per capita wild meat consumption

Location	Per capita consumption estimates	Comments	Source
Sub–Saharan Africa	104 g/day, 38 kg/yr—foragers 43 g/day, 15.7 kg/yr—farmers	Survey of wild meat consumption	Chardonnet et al. 1995
Africa	Ranging from 0.03 g/day, 0.01 kg/yr in Tunisia to 9.72 g/day, 3.5 kg/yr in Botswana	A global review investigating the risks of removing wild meat from global food systems	Booth et al. 2021b
Central African countries	130 g/day, 47.5 kg/yr—rural 13 g/day, 4.5 kg/yr—urban	Review of studies: Cameroon, Democratic Republic of Congo, Gabon, Cameroon, Equatorial Guinea	Wilkie and Carpenter 1999
Cameroon	30 -290 g/day, 11.0-105.9 kg/yr	Range across five studies with farmers consuming least and pygmies the most	Brown et al. 2007
Liberia	280 g/day, 102.2 kg/yr	Rural	Brown et al. 2007
DRC	300 g/day, 109.5 kg/yr	Based on extraction model	Fa et al. 2003
DRC	40 g/day, 14.6 kg/year	Extremely poor households who could not afford equipment to hung	De Merode et al. 2004
Gabon	180 g/day, 65.7 kg/yr	Based on extraction model	Fa et al. 2003
Ghana	<54 g/day, 20 kg/yr	96.3 had consumed less than 10 kg of meat in 6 months while 3.7% had consumed more than 10 kg	Bannor et al. 2021
Tanzania	27.4g/day, 10 kg /yr	Based on a study of 125 hunting households in the Udzungu mountains	Nielsen 2006
Tanzania	30.1- 89.0 g/day, 11–32.5 kg/yr	Western Serengeti; those closer to the national park consumed more	Ndibalema and Songorwa 2008
Laos	87.8 g/day, 32 kg/yr	Consumers in 13 markets identified as hotspots for wildlife trade	Pruvot et al. 2019
Indonesia	38 g/day, 13.9 kg/yr		Alvard 2000
Vietnam	38.4-43.8 g/day, 14–16 kg/yr	Urban inhabitants of tourist hub with abundant biodiversity	Sandalj et al. 2016

Urban versus rural versus diasporic populations

Some studies suggest that wild meat behaves as a 'luxury good' in that demand may increase with a rise in price (particularly for primate meat), reported by Brashares et al. (2011) among diasporic communities in Europe, by Wilkie and Godoy (2001) in Central and South America, and by Drury (2011) in Vietnam, Sainge et al. (2023) in Sierra Leone and Chausson et al. (2019) in the DRC. As in the description of wild meat value chains later in this report, urban African markets provide relatively high-value markets for preferred species of wild meat, often in the context of specialty restaurants.

In Africa, wild meat consumption is still predominantly associated with rural areas. Van Vliet et al. (2015) found in the DRC that poorer urban households consumed wild meat more often than wealthier ones but overall consumed less meat in general. Those poor urban households consumed common wild meat species more frequently, presumably due to price, while wealthier households more often ate larger, threatened species. In contrast, East et al. (2005) found no evidence in Equatorial Guinea of a luxury wild meat market based on rare species. A consumption study in Cameroon showed that wild meat is important in the diets of the poor and is not a luxury product eaten mainly by the rich. The study found that the poorest two quantiles in terms of income spent 16% and 17%, respectively, of their meat budgets on wild meat, versus 7% for the richest quartile and 9% overall (IITA, unpublished data, cited by Wolfe et al. 2005a). Meat budgets of the rich are likely to be significantly larger overall, but these data demonstrate the relative importance of wild meat for the poor. In Delta State, Nigeria, Ebewore et al. (2015) found that increased levels of education and income were associated with somewhat lower wild meat consumption. Across a mix of rural and urban households in Madagascar, Jenkins et al. (2011) found that livestock meat was preferred over wild meat.

In urban Southeast Asia, wild meat is often considered a luxury item and a status symbol. Wild meat is sought after for its exotic appeal and perceived health benefits. A study in Hanoi, Vietnam, found that high-income men were most likely to consume wild meat, often associating it with masculinity and social status (Biller-Sandalj et al. 2015). Zhang et al. (2008) also found similar findings in urban China, where wild meat such as bear paws and pangolin scales are considered luxury items and are consumed by wealthy individuals to showcase their status. Moreover, there is a tendency to consume wild meat during special occasions and festivals, where it is perceived as a delicacy. In Vietnam, wealthier urban populations consume wild meat during (Lunar New Year) and other significant cultural events, reflecting its role as a festive delicacy (Drury 2011). In urban settings, it is theoretically easier to enforce regulations against wild meat, but black markets exist (Nijman and Shepherd 2015). A recent investigation conducted by Luong (2022) in urban markets in Vietnam revealed ongoing illegal sales of wild meat, indicating persistent demand despite strict wildlife trade laws.

Wild meat versus livestock meat

On average, per capita meat consumption globally has increased by approximately 20 kg since 1961, much of it in developing countries. The average person globally consumed around 43 kg of meat in 2021. Consumption trends across Africa and Asia are varied; in some countries, people consume as little as 10 kg of meat per year, around half of the continental average (Ritchie et al. 2017). FAOSTAT data indicate that daily (and annual) per capita livestock meat supply in Africa (in 2013, the most recent available data) was on average 5.2 g/day (19 kg/year), ranging from lows of 3 g/day (11 kg/year) in East Africa, 3.5 g/day (12.8 kg/year) in West Africa, and 6.6 g/day (24 kg/year) in Central Africa to 16.4 g/day (60 kg/year) in Southern Africa, where average incomes tend to be higher than in much of the rest of the continent. In Asia, the average daily (and annual) meat consumption was 7.3 g/day (26.7 kg/year) (in 2016), ranging from 2.2 g/day (8 kg/year) in South Asia, 9.9 g/day (26 kg/year) in Central Asia, 11 g/day (40 kg/year) in Southeast Asia, 12.1 g/day (44 kg/year) in Western Asia, and 14.2 g/day (52 kg/year) in East Asia.

The evidence available suggests that in urban areas where demand from higher income consumers for traditional meats is high, wild meat may often cost more per unit of weight than livestock meat alternatives (Table 5). The situation is often reversed, however, in rural areas, particularly in countries where livestock keeping is not a traditional practice. Alternative proteins may be rare in rural villages with rudimentary livestock production, unless close to coastal regions supplying fish. In Gabon, Abernethy and Obiang (2010) found that in forested areas, livestock meat alternatives were limited and sold at over twice the price of wild meat, whereas in the capitol, Libreville, wild meat was six times the price of the cheapest livestock meat.

Figure 1: Livestock meat consumption in Africa (source: authors' visualization from FAOSTAT 2024)

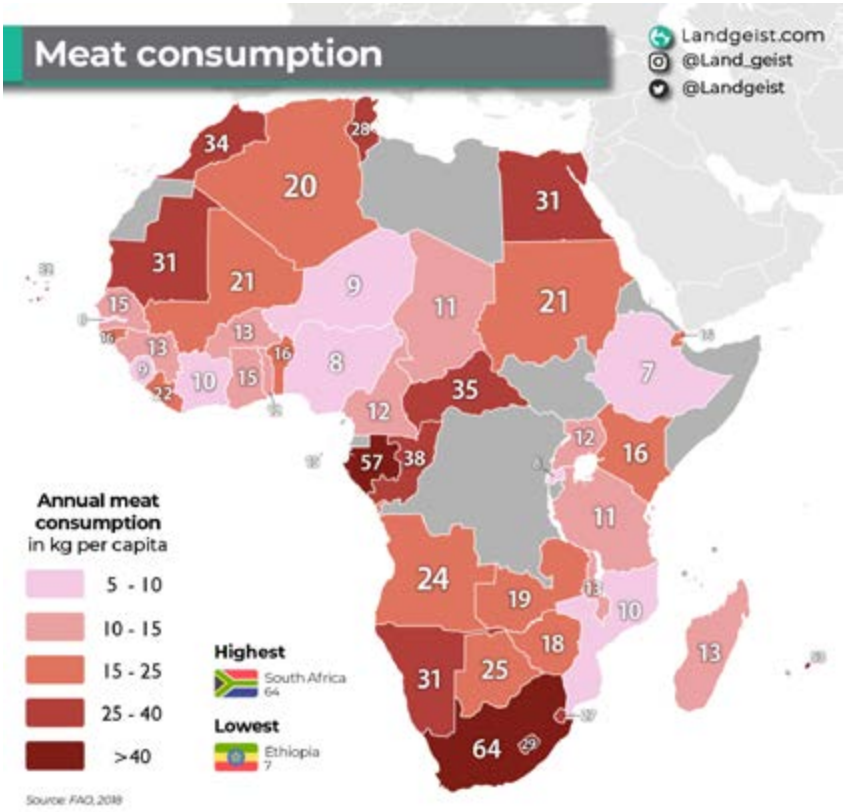


Figure 2: Livestock meat consumption in Asia (source: authors' visualization from FAOSTAT 2024)

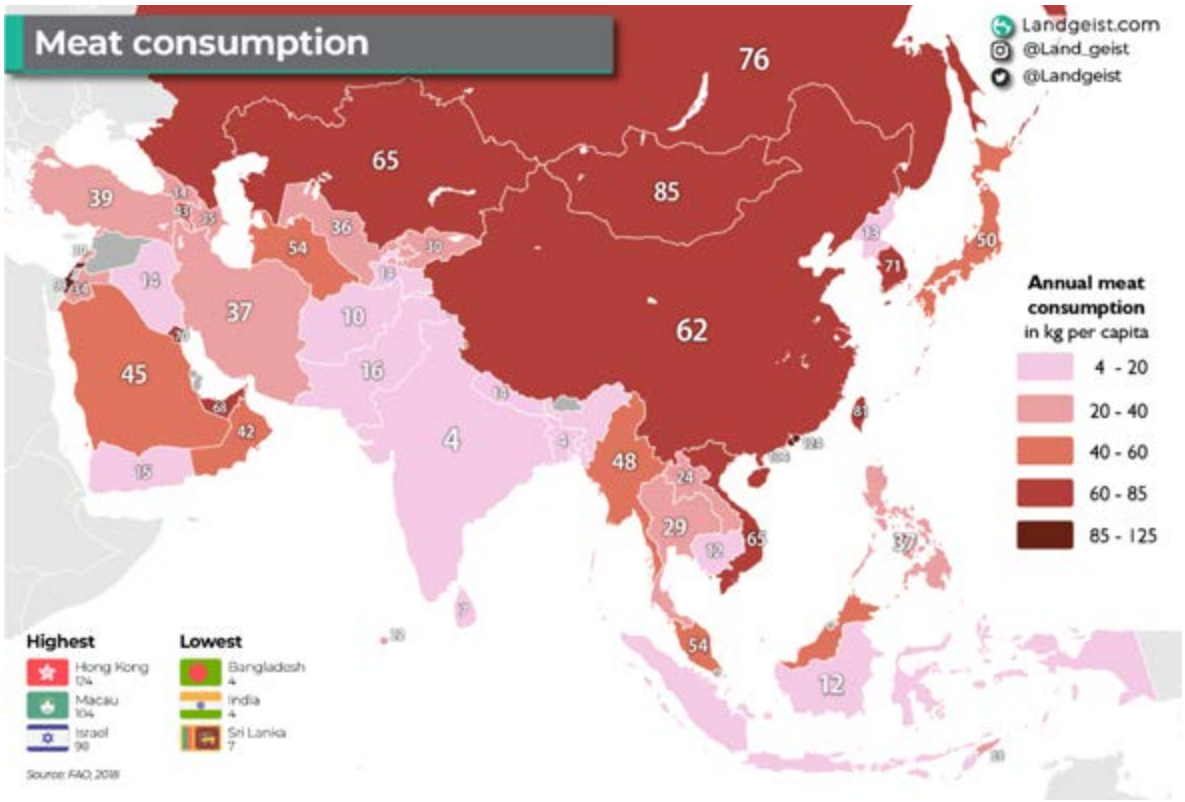


Table 5. Comparison of wild and livestock meat prices in Africa and Asia

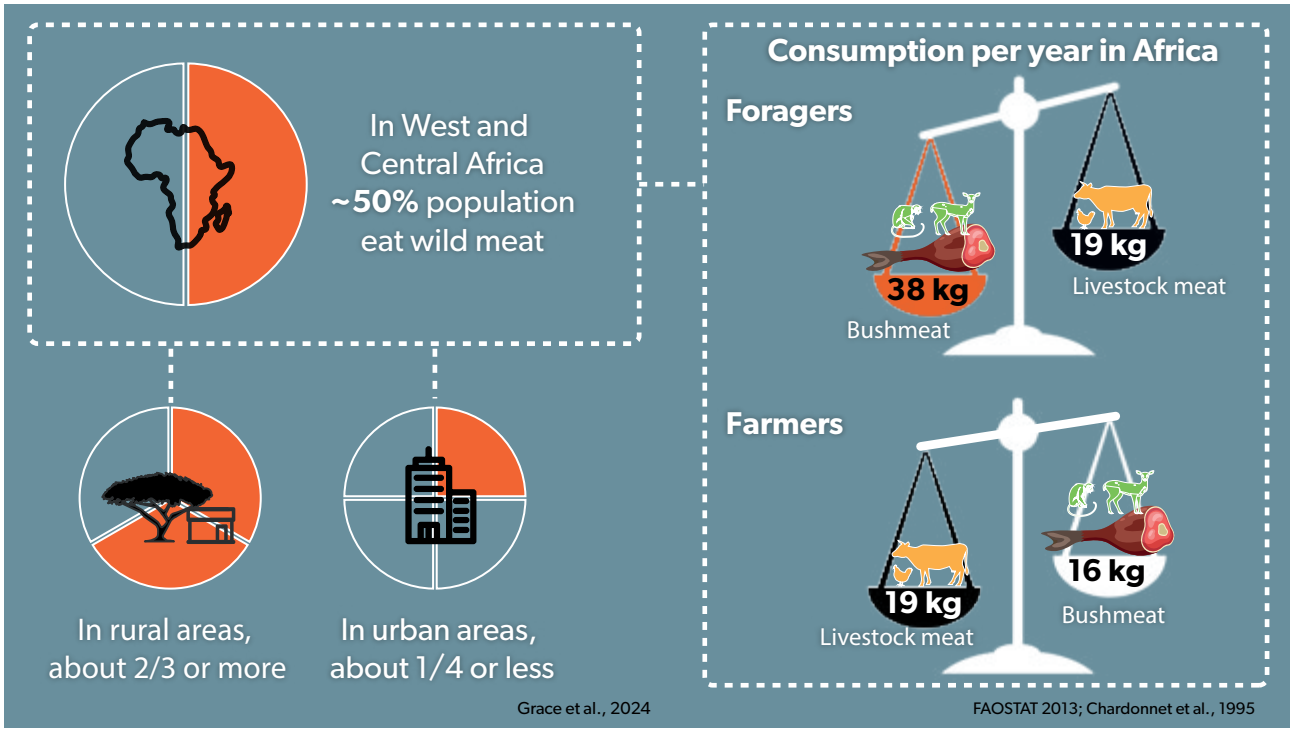
Location	Comparison of wild and livestock meat prices	Sources
Libreville, Gabon	Prices of preferred wild meat are 1.6 times that of preferred beef cuts	Steele 1994
Libreville, Gabon	Wild meat is 6 times the price of the cheapest livestock meat	Abernethy and Obiang 2010
Three markets in Cameroon, Congo and Central African Republic	Wild meat is more expensive than all meats except imported premium steak	Gally and Jeanmart 1996
Urban Nigeria	Wild meat is more expensive than all meats except imported premium steak	Martin 1983
Ngotto, Central African Republic	Wild meat: USD 0.34–0.75/kg Goat meat: USD 1.75/kg Chicken meat: USD 3.25/kg	Delvingt 1997
Manyara ecosystem, Tanzania	Wild meat: USD 2/kg Beef or goat meat: USD 4/kg	Kiffner et al. 2015
Northern Ghana	Wild meat: USD 0.74–7.82/kg Monkey meat: USD 2.07/kg Grasscutter (cane rat) meat: USD 5.51/kg Beef meat: USD 1.89/kg	Sackey et al. 2023
Myanmar	Porcupine meat: USD 10/kg Chicken meat: USD 2–3.5/kg	Evans et al. 2020 and CEIC data 2021
Myanmar	Macaque meat: USD 10/kg Bamboo rat meat: USD 4/kg Pork meat: USD 4–5.5/kg Beef meat: USD 5.5–7/kg	Ibbett et al. 2020 and CEIC data 2021
Cambodia	Wild boar meat: USD 3.75–6.25/ kg Chicken meat: USD 2.5–3.75/kg Pork meat: USD 4.5–6.25/kg Beef meat: USD 6.25–8.75/kg	Ibbett et al. 2020
Indonesia	Bat meat: USD 4.3/kg Macaque meat: USD 2.9/kg Wild pig meat: USD 3/kg Dog meat: USD 2.5/kg Chicken meat: USD 2.5/kg Domestic pig meat: USD 4/kg	Latinne et al. 2020

Contribution of wild meat to nutrition and food security

Wild meat is a nutritious food. One estimate found that the average protein content of wild meat is around 30% (Ntiamoa-Baidu 1997). Cawthorn and Hoffman (2015) assembled nutritional composition data for meat from a range of wild meat species and found protein values of 17–26% among African antelopes and a high of 45% in porcupines. In terms of energy, while some species are low in fat (e.g. monkeys), others, such as rodents, have a high energy density (Cawthorn and Hoffman 2015).

Nasi et al. (2008) reviewed the literature on wild meat contributions to diet and found that in at least 62 countries, wildlife and fish contribute at least 20% of the animal protein in rural household diets, providing calories, essential proteins, fats and micronutrients. De Mérode et al. (2004), however, suggest that wild meat does not make a major contribution to nutrition in forest households suffering from extreme poverty due to remoteness and political instability. Wild meat comprised just 3.1% of household consumption (as a percentage of the total consumption in USD equivalent) but 25% of household sales. The authors suggested that the relatively low consumption was due to the extreme poverty of most people which meant they could not afford the equipment to hunt wild meat or the money to purchase it. While the few who could afford hunting, sold wild meat as it was one of the few ways of earning money. A recent study by

Infographic 5.



Booth et al. (2021b) reported that wild meat provided households with up to 73% of protein in Côte d'Ivoire, 61% of protein in Botswana, and 47% of protein in the Republic of the Congo. Fa et al. (2003) suggest that up to 90% of animal protein consumption comes from wild meat in some West and Central African countries, with smaller but still important shares observed across all countries in the region. Bennet (2000) estimated that in West Africa, 25% of protein consumption was of wild meat, and in Liberia the figure was as high as 75%. One estimate for the Congo Basin found that 30–80% of protein in rural communities was sourced from wild meat (Blaney 2008). Estimates provided by Booth et al. (2021b) give insights on eight sub-Saharan countries at risk of protein deficiencies if wild meat is excluded from their diets: Botswana, Central African Republic, Côte d'Ivoire, Guinea, Madagascar, Republic of the Congo, Rwanda and Zimbabwe. Interestingly, this list excludes some of the West African countries like Nigeria and Ghana where wild meat consumption and trade have been frequently reported. Also, in Gabon, Abernethy and Obiang (2010) estimated that wild meat comprised up to 90% of the protein in the diet of some remote rural households. Specific localities can also be heavily reliant on wild meat, both in rural areas and nearby towns. In rural areas near Cameroon's Dja Faunal Reserve, 98% of meat consumption was wild meat and 80% of meat consumption was wild meat in the nearest town (Muchaal and Ngandjui 1995). In Uganda, 55.3% of hunters hunted to obtain animal protein for their diets (Namusisi et al. 2021).

Box 3: Wild meat, Ebola virus disease and food security in West Africa

Wild meat is a significant source of protein and income for many rural communities in West Africa. This case study explores the role of wild meat in the diets of West African communities, its nutritional contributions, and the associated public health challenges.

West Africa is a region rich in biodiversity, with extensive forests home to a variety of wildlife species. Countries such as Côte d'Ivoire, Liberia, Nigeria and Sierra Leone have vast forested areas where wild meat hunting is prevalent. Wild meat is a traditional food source and vital source of protein and micronutrients in many West African diets. Studies have shown that in rural areas, wild meat can provide a significant portion of daily protein intake (Fa et al. 2015) and that in parts of rural West Africa, wild meat accounts for up to 80% of the animal protein consumed by local communities (Pearce 2005). The most common species consumed in this region include grasscutter rats and duikers (Petrozzi et al. 2016).

It is generally accepted that the outbreak of Ebola virus disease in West Africa from 2013 to 2016 originated from a wildlife source (Spengler et al. 2016). Consequently, governments imposed bans on the hunting and consumption of wild meat (Bonwitt et al. 2018). Wild meat consumption in the region reduced during the outbreak, particularly for species implicated in the outbreak, such as bats and chimpanzees, but consumption of other species such as ungulates and rodents increased following the outbreak (Funk et al. 2021; Onyekuru et al. 2020; Ordaz-Németh et al. 2017; Duonamou et al. 2020). Women were more likely to consume wild meat during the outbreak (Onyekuru et al. 2020).

The reduction in wild meat consumption during the outbreak was likely related to public health messaging (Funk et al. 2021), but the messages did not reflect the experience of people and so caused unintended consequences: distrust of public health actors and their messages and promotion of more under-ground (hidden) value chains for the wild meat trade (Bonwitt et al. 2018).

The long-term impact of the wild meat ban in Côte d'Ivoire was a reduction in wild meat consumption and a shift to alternative sources such as mushrooms and fish. However, it was noted that the limited or inconsistent availability of alternative proteins may have resulted in deficiencies (Dinde et al. 2017). People's reliance on wild meat for protein is greater during the lean agricultural seasons and wildlife depletion is likely to further exacerbate protein deficiencies (Schulte-Herbrüggen et al. 2017).

When determining interventions to manage the conservation and public health impacts of wild meat consumption, authorities need to consider the socioeconomic, gender and food security contexts of the local communities (Duonamou et al. 2020). Efforts to balance wild meat consumption with wildlife conservation and to reduce public health risks should include promoting alternative livelihoods and protein sources, such as agriculture and aquaculture, and implementing wildlife management plans and sustainable hunting practices where appropriate. Importantly, communities should be educated about the health risks associated with wild meat and engaged in work to monitor both disease outbreaks and wildlife populations.

As noted, loss of wild meat from diets could also lead to food insecurity (Booth et al., 2021b). Seasonal food security may also depend on wild meat, with several studies showing that hunting and reliance on wild meat increases during the dry or lean seasons when other food sources are scarce (Lindsey et al. 2011 in Zimbabwe; Alade and Onadeko 2017 in Nigeria; Sackey et al. 2023 in Ghana). Wild meat can provide a general consumption safety net in times of economic hardship and community emergency or shock situations or for migrant workers without the time to plant and grow food crops (Cawthorn and Hoffman 2015; McNamara et al. 2020; Kamogne et al. 2022). In Nigeria's Cross River National Park, wild meat consumption was significantly associated with higher household food security status, with rodents playing a particularly important role (Friant et al. 2020). One study looking closely at stunting among children in rural areas across Central Africa found that households located close to dense and species-diverse forest settings, remote from urban areas, exhibited lower levels of stunting. Households located in less forested and animal-diverse settings exhibited more stunting (Fa et al. 2015), suggesting that the availability of wild meat plays a role in reducing child stunting.

In East and Southeast Asia, although wild meat is less important as a source of protein than it is in Africa, the region's highly dense populations mean that the contributions of wild meat to total quantities of protein consumed can be significant: for example, wild meat supplies 1,711 tonnes of food annually in China (Booth et al. 2021b). More important than the actual contribution is the common perception in this region that wild meat provides more nutritious protein than domestic meat.

Wild meat consumption also plays a significant role in the nutrition and food security of some populations in Asia (often minority, rural and relatively isolated and impoverished). Drury (2011), Shepherd et al. (2010), Clark et al. (2006), Madhusudan et al. (2003) and Alvard et al. (2000) found that wild meat, including that of deer, wild pigs, and various birds, is rich in protein and provides a crucial source of protein and essential micronutrients, particularly in rural areas where access to conventional meat sources may be limited. Wild meat thus helps to ensure food security during times of scarcity and regular hunting practices help to supplement diets with necessary nutrients. A study conducted by Lee et al. (2015) indicated that wild meat consumed in traditional medicines, such as deer antlers and bear bile, not only serves medicinal purposes but also provides high-quality protein and essential amino acids. Evidence from Laos shows that some rural communities in remote areas source a significant portion of their food from wild meat (Pruvot et al. 2019; Davis and Glikman 2020), and wild meat is considered important for the food security of ethnic groups in rural areas (Pathumphone et al. 2016; Singh 2010).

While the preponderance of evidence suggests that rural consumption of wild meat in Asia is less significant than in the Amazon or Congo basin, unequal research efforts between continents hinders meaningful comparisons (Nielsen et al., 2017; Coad et al., 2019). In Asia and particularly in biodiversity-rich areas such as primary forests, the scarcity of site-level hunting data and regional meta-analyses on wild meat consumption constitutes an important research gap (Lee et al. 2014). The level of rural communities' dependence on wild meat, or the extent to which a person's nutritional, economic, or socio-cultural wellbeing would be diminished if access to wild meat declined when a substitute is not available, remains poorly understood in the Asia-Pacific region (Ingram et al. 2021).

Consumption for medicinal use

Wild meat and wild animals more generally are used in many communities for medical purposes (Coals et al. 2024). Van Vliet et al. (2017) conducted a systematic review of evidence on the zootherapeutic uses of wild meat to either treat or prevent illnesses and identified studies conducted in Bangladesh, Brazil, Colombia, India and Nigeria indicating the use of a total of 76 wild meat species. A recent review documented over 2,000 zootherapeutic practices in Africa, with extensive documentation in Ethiopia, Nigeria, South Africa and Tanzania (Fourchault et al. 2024). Around 521 mammalian species (the most common being: 25% ungulates, 23% carnivores, 14% primates, 13% bats and 12% rodents) are used to treat 371 ailments, including infectious and parasitic diseases (38), unclassified symptoms and signs (32) and those without any specific symptoms (64) (Alves et al. 2021). Among the 521 species reported by Alves et al. (2021), 155 are threatened and a further 46 are near threatened. Zootherapy has also been documented as frequent in Brazil, China, India, Nigeria, South Africa, Sudan and Vietnam, with amphibians—e.g. frogs, reptiles such as snakes, lizards, turtles, crocodiles and geckos—used for treatments, even for cancer (Inatimi et al. 2022). In Uganda, wild meat is given to women following childbirth for its perceived benefit in speeding post-partum recovery (Namusisi et al. 2021). In Nigeria, 44 wild animal species (python, tortoise, squirrel, water chevrotain, elephant and potto) were used for 272 zootherapeutic purposes as influenced by gender and age (common for maternal and paediatric care) and seasonal patterns of illness (Friant et al. 2022). Injuries, epilepsy, burns, mental illness and poisoning were among the ailments reported by Friant et al. (2022). In Ethiopia, 20 vertebrates (70% mammals, 20% birds) were used for zootherapy, with hyenas and porcupines being common (Biru et al. 2022). In Ghana's Kumasi market, wild species from 20 families, over 50% considered threatened, were traded for zootherapy with chameleons commonly sold (Dery et al. 2022). In Tanzania, out of 28 animals harvested, 10 were used to treat burns, ear pains and muscle pain and to knead pregnant women during delivery. These studies reported that many different parts of the animals were used: the entire animal, the meat, various organs and inedible parts such as bird bills. Prepared with other ingredients from plants or other animal products, they were used to create medicinal products to treat a range of ailments and diseases. The fat from hippos (harvested in some rural conservation nature reserves in South Africa) is highly sought after for its apparent aphrodisiacial properties, and is sold to the local surrounding communities whilst wild meat is affordable and sold for its protein value in an area were it is a scarce commodity.

In East and Southeast Asia, ingestion of wild meat for medicinal purposes has a long history. Different regions developed their own unique medicinal systems, incorporating a variety of locally available wild animals for various treatments (Ashwell 2008). In Vietnam, certain

animals are believed to have medicinal properties that can treat various ailments. Cobras and other snakes are believed to improve male virility and able to treat ailments such as arthritis and asthma (Drury 2011). Additionally, bear bile is used in traditional medicine for its supposed anti-inflammatory and anti-cancer properties (Shairp et al. 2016). Research by Alvard (2000) indicated that in rural Indonesia, tiger bones and parts are believed to possess strong healing powers and are used in traditional medicines to treat a variety of illnesses, while bat meat is consumed for its supposed ability to treat asthma and respiratory issues. A report by Shepherd (2010) highlighted that in Malaysia, wild animal parts are incorporated into traditional medicine. Sun bear parts are used for their perceived medicinal properties, including treating burns and joint pain, and wild boar meat is consumed to boost energy and treat various internal ailments. According to Lee and Kang (2015), wild meat and animal parts play a crucial role in traditional Chinese medicine, driven by the belief that they have unique properties that can balance the body's energy (Qi) and treat illnesses. Tiger bones are used to make wine believed to strengthen bones and treat arthritis, and pangolin scales are believed to stimulate lactation, reduce swelling, and improve blood circulation (Still 2003). Deer antlers are used in powders and tinctures to boost vitality, improve kidney function, and treat impotence (Lee and Kang 2015), while seahorses are utilized for their supposed ability to treat infertility, asthma and arthritis (Still 2003). In urban China, wild meat used for medicinal purposes is often sold at high prices in traditional medicine shops and specialty restaurants. Despite regulations, illegal trade and consumption of wild meat for medicinal purposes continue, driven by high demand and traditional beliefs. Approximately 30% of urban households in China consume wild meat for medicinal purposes, compared to around 70% in rural areas (Still 2003). In South Asia, a study by Madhusudan and Mishra (2003) found that in rural India, particularly among tribal communities, wild meat is an essential part of traditional medicinal practices. About 65% of tribal households rely on wild meat for treating various ailments. For example, porcupine meat is consumed for its supposed ability to heal wounds and treat kidney stones. In urban areas, the consumption of wild meat for medicinal purposes is much lower, around 5–10%, due to legal restrictions and cultural preferences for domesticated meat. While the use of wild meat for medicinal purposes is not as widespread in Japan as in other parts of Asia, certain traditional practices still exist. According to a report by the Japanese Ministry of Agriculture, Forestry and Fisheries (2018), about 15% of rural households in certain regions consume wild boar meat, which is believed to enhance physical strength and vitality. In urban areas, this practice is rare and largely confined to traditional culinary festivals. In Central Asia, traditional medicine incorporates the use of wild meat, with a significant percentage of rural households relying on it for medicinal purposes. A study by Clark et al. (2006) in Mongolia found that approximately 40% of rural households consume wild meat, such as marmot and deer, believed to treat a range of ailments from respiratory issues to joint pain.

Summary: Consumption of wild meat for nutrition and health

Prevalence and frequency: Surveys suggest that in West and Central Africa around half the population eat wild meat: in rural areas this is two-thirds or more of the population but in urban areas it is often less than half. A smaller proportion (a quarter or less) eat wild meat regularly. The links between wild meat consumption and household income and wealth are tenuous, so increased disposable income may or may not increase wild meat consumption. For many in more remote rural areas, wild meat is the lowest cost form of animal protein, but for some urban consumers it is a relatively expensive luxury item. There is a tendency for women to eat less wild meat than men and younger people to eat less than older. There are fewer studies in Southeast Asia, which suggest that around half of the general population consume wild meat, while in rural areas and those areas with greater access to wild meat, three-quarters or more of the population consume wild meat. Again, there is a tendency for men and older people to eat more of it than women and younger people.

Quantity consumed: In Africa, the quantities of wild meat consumed are significant, often much higher than livestock meat consumption. Overall, foragers consume on average 38 kg a year and farmers 16 kg of wild meat compared to 19 kg of meat from domestic animals. There is some evidence that extreme poverty is protective to wild animals, as the poorest cannot afford wild meat to purchase or equipment to hunt. In Southeast Asia, where quantitative studies are mainly from rural areas with access to hunting, consumption is around 20 kg per year.

Rural versus urban consumption: In Africa, wild meat consumption is still predominantly associated with rural areas, and there is no strong overall preference for wild meat in urban areas. In East and Southeast Asia, wild meat is often considered a luxury item and status symbol by urban dwellers as well as a healthy food and one that is eaten during special occasions. In urban areas where demand from higher income consumers for traditional meats is high, wild meat may often cost more per unit of weight than livestock meat alternatives. The situation is often reversed, however, in rural areas, particularly in countries where livestock keeping is not a traditional practice.

Contribution to nutrition and food security: Wild meat is often rich in proteins and micronutrients and some species have high energy density. In at least 62 countries, wildlife and wild-caught fish contribute at least 20% of the animal protein in rural household diets, providing calories, essential proteins, fats and micronutrients. In some African countries, wild meat provides up to 90% of animal protein consumption. In East and Southeast Asia, the relative contributions are smaller but the absolute contributions can be significant: for example, 1,711 tonnes of protein are obtained from wild meat each year in China. At least 15 countries, mostly in Africa, would risk food insecurity if wild meat were excluded from human diets. In Central Africa, the low availability of wild meat has been linked to childhood stunting.

Consumption for medicinal use: Over 2,000 zootherapeutic practices have been documented in Africa with around 521 mammalian species being used to treat 371 ailments. Zootherapy often, although not always, involves consumption of wild animals. . This practice is also widespread in East and Southeast Asia, with, for example, around 30% of urban households and 70% of rural households in China consuming wild meat for medicinal purposes.

Zoonotic risks of wild meat

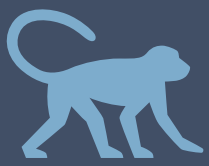
Species consumed and zoonotic risk

A wide variety of species of mammals, birds and reptiles are hunted or caught for wild meat. In Africa, the three taxa most important for human consumption are large-bodied ungulates (such as antelopes, bovines, pigs), primates and rodents. Monitor lizards and snakes follow (Brown et al. 2007). In their review of 36 studies from seven Central African countries, Fa et al. (2005) found that 71 mammal species from 8 orders and 22 families were reported hunted. Ungulates (46.6%) and rodents (37.0%) were the most frequently hunted taxonomic groups in terms of number of animals. In terms of weight, for the combined studies, ungulates contributed 73.2% in weight (Fa et al. 2005), and rodents and primates contributed 12.2% and 12.0%, respectively. Large-bodied species (those animals weighing 15–100 kg) represented over half (54.4%) of the total hunted biomass.

Increasing demand for wild meat and wildlife products, both domestically and internationally, drives unsustainable levels of illegal hunting across East and Southeast Asia countries (Corlett et al. 2007; Hughes et al. 2017). Forest ungulates are popular for their meat as a source of protein for local communities and can be sold commercially (CIFOR 2008). Some parts of ungulates, such as horns and antlers, are used in traditional medicine practices (Lee et al. 2014). The horns and antlers of some ungulate species are prized as trophies by hunters, endangering the survival of populations by illegal hunting throughout the region (Ripple et al. 2016; Nijman et al. 2015).

From a zoonotic risk perspective, all wild meat species are not equal. Several systematic reviews exist that try to answer the question of which wild hosts of zoonotic pathogens pose the greatest risk of transmitting zoonotic disease to humans or of hosting a pathogen with high pandemic potential (Box 4).

Box 4: Zoonotic potential of different wildlife species



Our recent systematic literature review of 273 studies on wildlife zoonoses in Southeast Asia revealed that primates, rodents, bats, and carnivores are the wildlife reservoirs with a higher proportion of zoonotic pathogens than other mammals (Nguyen et al. 2024). This finding supports the broader observation that mammals (around 80%) are the primary hosts for zoonotic diseases, followed by avian hosts (Morse et al. 2012). Woolhouse and Gowtage-Sequeria (2005) indicated that of 816 human pathogen species known to be zoonotic, the most important hosts in terms of diversity of zoonotic pathogens supported were ungulates, followed by carnivores, rodents, non-mammalian species, non-human primates, other mammals and then bats. This is partly mirrored by a recent review by Moloney et al. (2023) rating wild meat from ungulates, followed by rodents and primates, topmost in harbouring pathogens despite primates, rodents and bats having been more researched with regards to spillover potential (Tumelty et al. 2023). Interestingly, a recent systematic review study examined the role of wild animals on impacting public health. Cupertino et al. (2020) found 245 studies that addressed zoonotic disease and wild animals. Bats and (non-human) primates were the most frequent species among those documented as leading to confirmed zoonotic disease in people, followed by wild rodents and, less frequently, buffalo and wild pigs.

The large number of zoonotic pathogens hosted by ungulates and the high frequency of human contact with ungulates (both domestic and wild) and their products is probably responsible for many events of zoonotic disease transmission from these species. Many of these zoonotic diseases, however, are likely to be 'classic' endemic zoonoses, where the constant

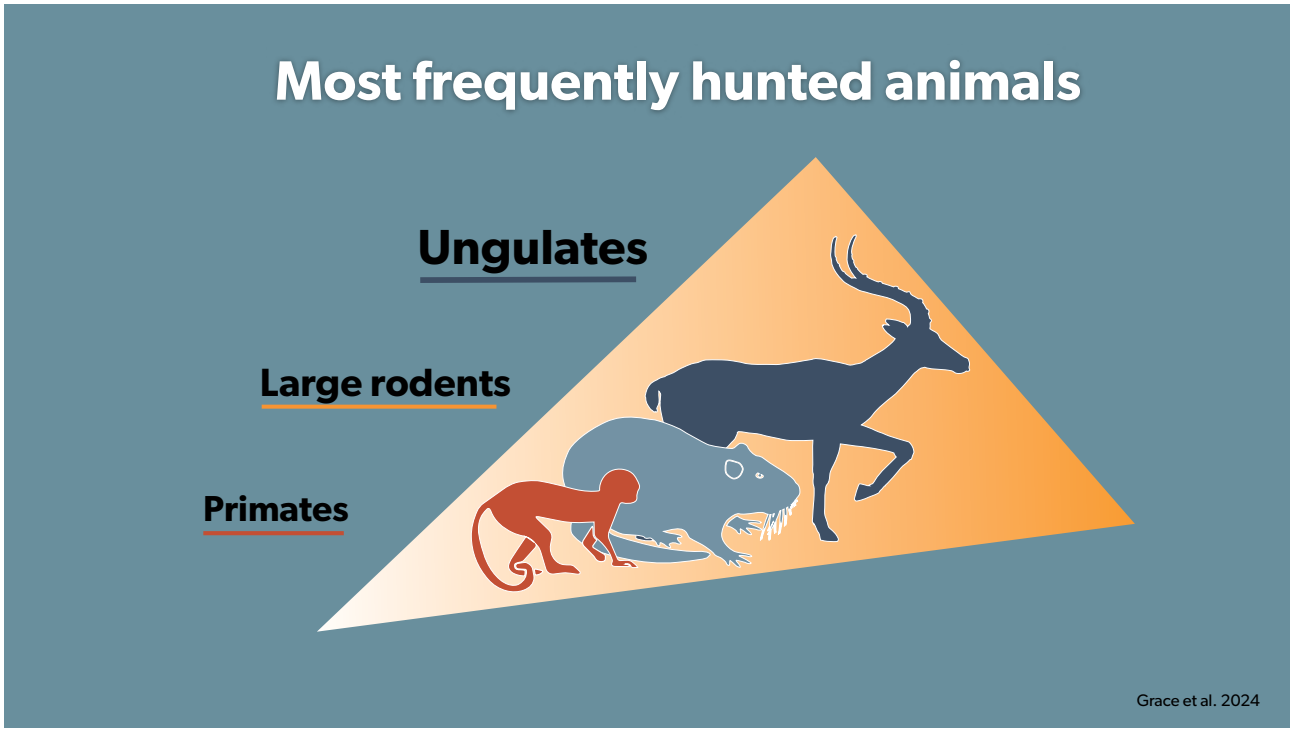
source of infection remains in the ungulate host with little or no onward human-to-human transmission. Analysis of emerging zoonoses indicates that the vast majority of zoonotic pathogens have originated in wildlife rather than domestic livestock (Jones et al. 2008). However, some of the most important zoonoses of recent decades have involved domestic or farmed animals as the original or an intermediary host (e.g. highly pathogenic avian influenza, bovine spongiform encephalopathy, Middle East respiratory virus, Rift Valley fever).

The potential risk posed by specific wildlife species is a product of the number of pathogens for which that species can be host, the likelihood of any one of those pathogens being sufficiently well adapted to transmit to humans, and the number of potential exposure events occurring between humans and that particular non-human host. When it comes to non-human primates, the high degree of primate genetic similarity with humans means the pathogens, although smaller in number, may be more highly adapted for a human host, with a corresponding increase in likelihood of sustained human-to-human transmission after a spillover event. Morse et al. (2012) indicated that pathogens that reached sustained human-to-human transmission were more likely to originate in non-human primates than in other hosts of zoonotic pathogens.

Birds, rats and bats, although hosts with potentially lower zoonotic pathogen diversity, are highly adapted to living within human-dominated environments in large numbers. Species within these orders known to host potential zoonotic pathogens have been seen to increase within human-dominated landscapes more than species that do not host zoonotic pathogens (Gibb et al. 2020). In these environments there is a high potential for transmission events to occur due to environmental contamination with the excreta of the birds, rats and bats and the relative ease of hunting for their meat. In addition to providing potential opportunities for transmitting zoonotic pathogens, bats have been demonstrated to host a high degree of viral pathogen richness, with viruses over-represented among the pathogens with spillover potential, probably due to their ability to rapidly mutate and evolve (Luis et al. 2013).

All the groups of potential zoonotic disease hosts appear in wild meat market studies, but, as indicated above, perhaps in proportions that differ from those that are hunted and consumed in communities.

Infographic 6.



Species hunted in Africa

In an earlier review of 13 previous studies, Wilkie and Carpenter (1999) found that duikers, pigs, primates and rodents are the most commonly hunted forest animals, duikers being the most important both in numbers and biomass. Again, ungulates were the most common species (34–95% across the studies), followed by primates (1–40%) and rodents (1–31%). Rodents were observed to be more important in areas close to urban markets, presumably because duikers were depleted in the forests nearby. Wilkie and Carpenter (1999) suggest that in these forest settings, the ratio of duikers to rodents found in urban markets may provide a rough indication of wild meat overexploitation or diminishing hunter access to dense forests.

Bowen-Jones et al. (2003) also found that in West and Central Africa, duikers are the most numerous species taken and make up 42–84% of the marketed off-take of wild meat by weight. Primates account for an estimated 8–22% of the catch (Bowen-Jones and Pendry 1999). Smaller bodied mammals such as cane rats and porcupines are also important in Africa and are becoming more so as larger game is depleted (Bowen-Jones et al. 2003). In a specific Central African example, in the central market in the DRC's Kisangani, ungulates (including all antelopes, pigs and bovids) are the most sold (40%) followed by primates (mostly guenon monkeys) (38%) (Basa et al. 2017).

Fa et al. (2006) found that of the approximately one million carcasses marketed in the Cross-Sanaga region of Nigeria and Cameroon, 99% were mammals, of which around 40% were ungulates, 30% were rodents and nearly 15% were primates. Further highlighting the diversity of wild meat consumed, a survey in Nigeria's Cross River State found that 48 types of wild vertebrate animals had been consumed by respondents within the past 30 days (Friant et al. 2020). In Togo, Sonhaye-Ouyé et al. (2022) reported that the common taxa targeted for wild meat were ungulates (10 species), followed by carnivores (6 species), rodents (3 species), primates, reptiles and birds (2 species each). DNA-typing revealed that species of ungulates (15), rodents (10), carnivores (7) and primates were commonly targeted for wild meat in Côte d'Ivoire (Gossé et al. 2022). In Northern Ghana, Sackey et al. (2023) documented in one year 11,407 carcasses of 20 mammalian species in wild meat markets, comprising ungulates (9 species), primates (3 species), rodents (4 species), carnivores (3 species) and 1 lagomorph (an animal order that comprises rabbits, hares and pikas). Sackey et al. also reported three amphibian species. Frogs constituted 82% of the total carcasses recorded, with rodents (4%), lagomorphs (4%), birds (3%), and carnivores, primates and ungulates constituting only 2% of recorded carcasses (Sackey et al. 2023). In Guinea's Upper Niger National Park, a three-month survey in 2017 recorded 1,162 carcasses from 42 wild species, from 21 families, with the families of Bovidae (cattle, yaks, bison, buffalo, antelopes, sheep, goats), Hystricidae (Old World porcupines), Cercopithecidae (Old World monkeys, e.g. baboons, red colobus and macaques), Thryonomyidae (cane rats) and Suidae (pigs and hogs) being recorded the most. Consumption and trade also target aquatic megafauna, including Cetaceans (whales, dolphins and porpoises), Sirenians (manatees, dugongs) and Chelonians (turtles, terrapins, tortoises), which are harvested and used for food, shark baits and traditional medicines (reviewed in Ingram et al. 2022). In savannah areas of Southern Africa, wild meat species differ significantly from Central Africa, with hares, jackals, bushbucks and even rock hyrax featuring among a list of 17 hunted species (Kaschula and Shackleton 2009).

In the largest such study, by Taylor et al. (2015), a systematic review of 67 primary sources of the West and Central African wild meat literature, including market, offtake and consumption surveys, documented 177 species from 25 orders that were harvested for wild meat, comprising 134 (76%) mammalian species, 24 (14%) bird species, 18 (10%) reptile species and 1 (<1%) amphibian species. Among mammals, the largest number of species were primates (48 species), including western lowland gorillas, bonobos (related to chimpanzees) and common chimpanzees; followed by ungulates (34 species); carnivores (22 species); and rodents (16 species). Only one species of bat is listed, likely to be the straw-coloured fruit bat, which is commonly eaten, and no relative market share is indicated. The sources identified were biased towards Central Africa in part because the authors suggest that West Africa may largely be in 'post-depletion phase', since the numbers of many large-bodied species have been significantly reduced there.

Species hunted in Asia

Hunting poses the greatest threat to wildlife populations in Asia, particularly in Southeast Asia (Ripple et al. 2016). Most common taxa or species hunted in Southeast Asia are rodents (squirrels, gerbils, bamboo rats), carnivores (civet cats, ferret badgers, dholes [wild dogs], golden jackals, raccoon dogs and occasionally cats), wild boars, birds, deer and bats (Engel and Ziegler 2020). There are differences between countries; a study by McEvoy et al. (2019) identified muntjacs (barking deer), Malayan porcupines, wild boar, three pangolin species (Sunda, Chinese, and Indian) and bamboo rat as the most commonly hunted wildlife in Myanmar. Pangolins and bamboo rats were particularly widespread targets, hunted for consumption throughout their range in the country. The study also found hunting of common palm civet, Asiatic black bear, gaur (wild oxen), and small jungle cats, but

these were reported less frequently than pangolins. Even less frequent mentions included clouded leopards, sun bears, and spotted linsangs (tree-dwelling carnivores).

A 2012 study in India by Gubbi et al. (2012) revealed that mammals were the primary target for hunters, with 90% of respondents hunting them. This was significantly higher than birds (66.7%) and reptiles (45%). Among mammals, ungulates were the most popular, accounting for 31.5% of hunting activity. Sambar deer (56.7%) and wild pig (45.0%) were the most sought-after ungulate species (Gubbi et al. 2012). Similar trends are observed in Malaysia, where Or and Leong (2011) found wild pigs and deer to be commonly hunted for food. A review by Cantlay et al. (2017) analyzing 475 wildlife trade references in Malaysia documented a decline in the availability of several species due to hunting pressure. These included various deer species, sunda bearded pig, Eurasian wild pig, squirrel, and civet species such as common palm civet (*Paradoxurus hermaphroditus*) and Malay civet (*Viverra tangalunga*).

In Vietnam, wildlife meat is considered a delicacy, often served in restaurants or at special occasions, and seen as a rare and luxurious food (USAID 2017). A study conducted by Biller-Sandalj et al. (2016) identified wild pig (*Sus scrofa*), wild goat (*Capra aegagrus*), deer (*Cervus or Hyelaphus* spp.), birds, and snakes as the five most commonly consumed wild species.

Primates are used in traditional folk medicines (Alves et al. 2010) across Southeast Asian countries, including Cambodia (Ashwell and Walston 2008), Indonesia (Nijman 2005), Laos (Sydara et al. 2005) and Vietnam (Van and Tap 2008), where traditional medicine is widely used and perceived as effective. Other species threatened due to demand for medicinal purposes, including sun bears and Indian rhinos in India and Nepal; elephants in India, Southeast Asia and parts of China; tigers in India and Southeast Asia (Clements et al. 2010); turtles in Taiwan (Chen et al. 2009); and pangolins in Southeast Asia and southern China (Wu and Ma 2007).

A study by Evans et al. 2020 in Myanmar found that all critically endangered species (e.g. Sunda pangolin) and endangered species (tiger, Burmese mountain tortoise, elongated tortoise, Phayre's langur [Phayre's leaf monkey]) included in the IUCN Red List (International Union for Conservation of Nature Red List of Threatened Species) were reported as hunted. Most of the vulnerable species hunted (Burmese pythons, king cobras, sambar deer, northern pig-tailed macaques, Asiatic black bears, Malayan sun bears and leopards) also have local medicinal value or are traded for medicinal purposes in other parts of Myanmar and/or China.

Profitable species

Alade and Onadeko (2017) found that mammals brought the highest profits among wild meat traders in Lagos State, Nigeria. In Gabon, it was found that the top five species numerically provided over 70% of the biomass hunted, and that blue duikers and red forest duikers and porcupines are always among these (Abernethy and Obiang 2010). It is unclear whether any novelty among buyers and consumers associated with rarity of a species drives demand, at least in Africa. Wild meat confiscated from airports presumably represents more valued species. In 2012, out of 179 samples of meat confiscated at a Swiss airport, 92% of the samples were identified as from mammals, 4% were from reptiles and 1% were from birds (Wood et al. 2014). Meat from rodents (40%), duikers (18.9%) and pangolins (11.2%) were confiscated the most (Wood et al. 2014). In Equatorial Guinea, East et al. (2005) found no evidence of specific demand for rare animals. In contrast, in parts of Asia, the rarity of a wild species can raise the market value of its meat (Volpato et al. 2020).

Main pathogens posing risks to people through wildlife

Although a wide variety of pathogens pose zoonotic risks, including bacteria and various parasites, much of the attention on risks of wild meat focuses on viruses. Kurpiers et al. (2016) provide an extensive list based on a review of studies of pathogens in wildlife and indicate the associated animal species, ranging from viruses to protozoa to bacteria and helminths. LeBreton et al. (2012) highlight the key viruses of interest as Ebola and Marburg filoviruses, hepatitis viruses, herpes viruses, human T-cell lymphotropic virus, monkeypox virus, paramyxoviruses, simian foamy virus and simian immunodeficiency virus. Milbanks et al. (2022) reported that most spillover events were attributed to bacterial pathogens in ungulates and armadillos; to parasitic pathogens in ungulates; and to viral pathogens in rodents, non-human primates and in cases with undetermined sources.

In a review of pathogens associated with wild meat globally, Moloney et al. (2023) reported 15 genera (32% with zoonotic potential) of infectious pathogens of public health concern having been associated with wild meat. These included 15 viruses (deltaviruses and lentiviruses frequently reported), 40 bacteria (68% environmental contaminants and 30% zoonotic), 54 parasites (26% with zoonotic potential) and 5 fungi. Of the parasitic genera reported, 13 viral, 4 bacterial and 1 parasitic genera had also been documented in humans participating along

wild meat value chains, with antibodies from zoonotic pathogens documented in 3.7% of high-risk humans.

Wolfe et al. (2005a) described three criteria to predict which microbes (although apparently referring specifically to viruses) are most likely to lead to emerging infectious diseases. These include microbes that have a proven ability to a) lead to human pandemics, b) lead to panzootics in (non-human) animal populations, and c) mutate at high rates and recombine with other similar or dissimilar microbes. The high mutation rates of RNA viruses and their predominance within zoonotic emerging infectious diseases that are transmitted from human to human suggest that this group is a key candidate for future emergence. Simian foamy viruses are members of this group, and the high rates of viral chatter observed in Cameroon suggest a strong potential for their emergence as a human-to-human transmitted pathogen.

Reviews conducted by Nguyen et al. (2024) and Nguyen et al. (in press) also found a diverse range of potential zoonotic pathogens and the widespread occurrence of zoonotic diseases originating from wildlife in Southeast Asia. A total of 108 publications reviewed by Nguyen et al. (in press) identified 120 unique pathogens. Viruses were the most prevalent subject of study (47), followed by parasites (38) and bacteria (35).

In a review of zoonotic infection risks associated with the wild meat trade in Malaysia, Jennifer et al. (2017) identified a great diversity of potentially zoonotic pathogens in the wildlife trade there, with 51 zoonotic pathogens (16 viruses, 19 bacteria and 16 parasites) potentially hosted by wildlife and described their human health risks. Some taxa, including Cercopithecidae (Old World monkeys), Suidae (swine) and Cervida (deer), were found to host numerous infectious agents. Similarly, Saba et al. (2023) found that among zoonotic pathogens, viral infections pose a major threat to human health. The key viruses of interest identified were cercopithecine herpesvirus-1, coronavirus, Ebola virus, flaviviruses, hantavirus, hepatitis E virus, Nipah virus, orthomyxoviruses, rabies virus and West Nile virus.

Ebola virus disease (Ebola haemorrhagic fever)

The Ebola virus has garnered global attention due to its disturbingly high mortality outcomes. Outbreaks of the disease in humans have repeatedly been linked to the handling and, potentially, the consumption of infected apes (Leroy et al. 2004). A recent study (Onyekuru et al. 2020) examined risk perceptions and practices associated with the 2014 Ebola outbreak in West Africa, which they describe as one of the longest, deadliest and most complex epidemics ever documented. Consumption of wild meat from primates was believed to have played a central role, although fruit bats have been indicated as the primary host, with the disease transmitted to primates through bat droppings, among other pathways (FAO 2018). The authors surveyed wild meat sellers and consumers in Nigeria for practices and risk perceptions during and after the Ebola outbreak. They found a significant decrease in the levels of sales and consumption of wild meat during the outbreak, including zero sales or zero consumption reported in some cases. Women were 25% more likely than men to consume wild meat during the outbreak, for reasons that were not identified. Before the outbreak, about a quarter of respondents did not perceive that eating wild meat posed an Ebola disease risk, this decreased slightly during the outbreak, but returned to baseline after the outbreak. Risk was associated instead as primarily due to touching an infected person. Respondents were aware of some practices that help to prevent Ebola transmission, but these related almost entirely to mitigating risks through human contact, and there was little to no awareness of risk avoidance practices related to wild meat, and respondents reportedly did not practice them to any significant extent.

These results suggest a relatively low level of awareness of zoonotic risks, in addition to even less frequency of changes in behaviour, if any, to mitigate risks among those with some awareness. There is some evidence, however, that information campaigns by radio, for example, could create greater awareness, if only at a superficial level. Similar to the risk mitigation strategies employed for foodborne zoonoses in general, an approach consisting of both educational and infrastructural improvements is likely to be required to empower actors to take risk mitigation steps (GAIN 2020).

COVID-19

COVID-19, caused by the SARS-CoV-2 virus, has had a profound global impact due to its rapid spread and large mortality and morbidity rates. Understanding the zoonotic origins and transmission pathways of SARS-CoV-2 is crucial for preventing future pandemics. Initial outbreaks of COVID-19 were linked to wildlife markets in Wuhan, China, where various species, including bats and pangolins, were sold. These markets provided an environment conducive to the interspecies transmission of coronaviruses (Nga et al. 2022; Huong et al. 2020). Huong et al. (2020) found that sites of close human-wildlife interactions, such as bat farms and the field rat trade in Southeast Asia, have shown high percentages of coronaviruses in bats (74.8%) and rodents (34.0%). These interactions significantly increase the risk of zoonotic spillover events. Nga et al. (2022) suggested that confined conditions in wildlife farms and markets can act as breeding grounds for viral amplification and recombination, potentially leading to

more dangerous virus strains. This risk is not limited to bats and rodents but extends to other animals such as civets and pangolins. A review by Cipolletta et al. (2022) examining risk perceptions and practices associated with the early stages of the COVID-19 pandemic revealed mixed levels of awareness about zoonotic transmission risks among the public. While some people recognized the risks associated with wildlife consumption, others were unaware of this or did not change their behaviours significantly. Honying et al. (2021) indicated that the pandemic led to a decrease in the sales and consumption of wildlife products in some areas, reflecting increased awareness of zoonotic risks (and increased enforcement). However, this change was not uniform across all demographics.

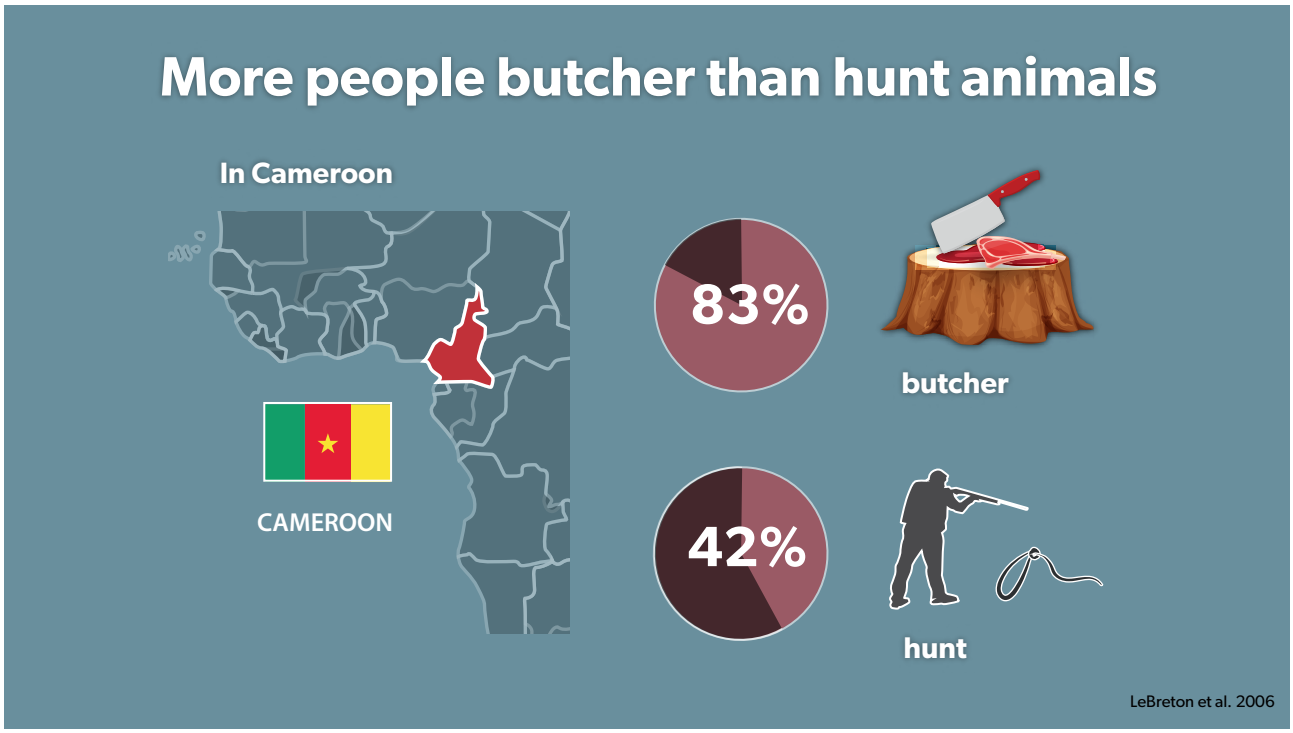
Zoonotic transmission and spillovers

Transmission pathways

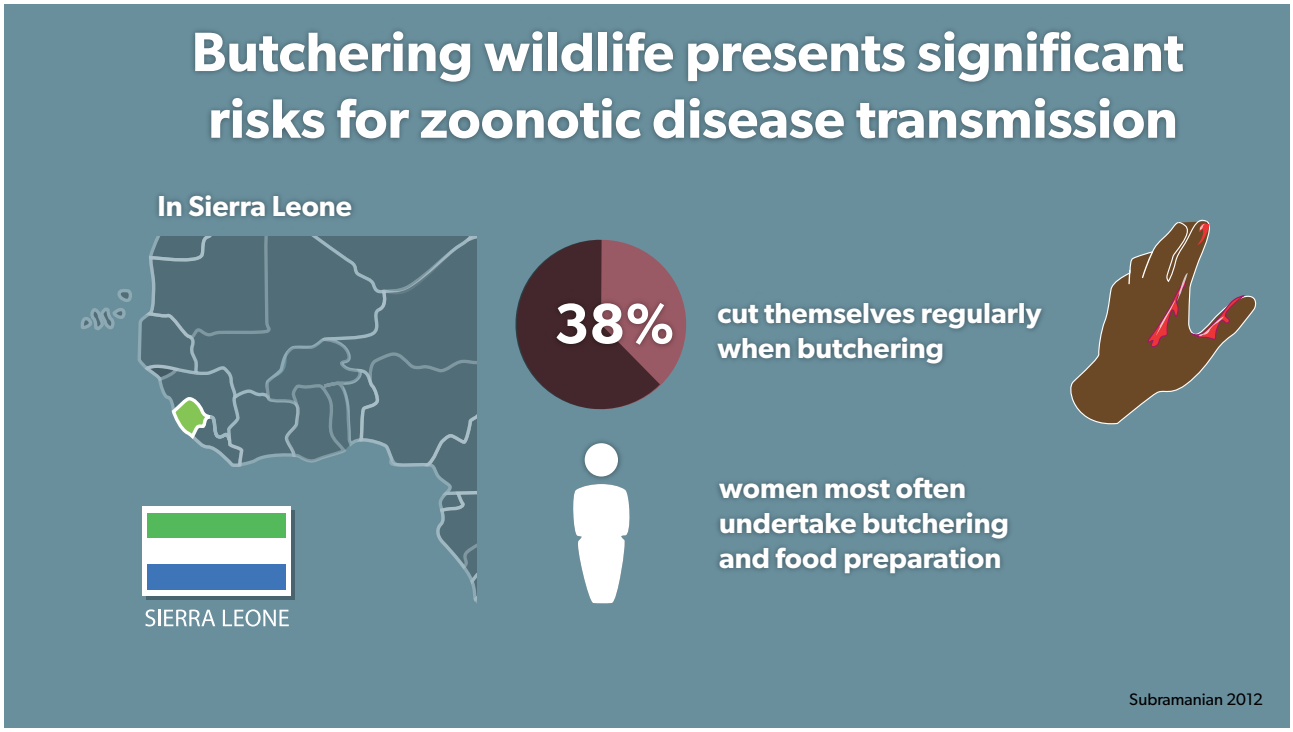
The main avenues by which zoonotic diseases are transmitted, or 'spilled', between animals and humans are also described by Wolfe et al. (2005b) and other more recent studies (Javed et al. 2023; Mohamed and Wali 2023; Tumelty et al. 2023). These avenues are a) through shared disease vectors, such as mosquitoes in the case of malaria; b) through indirect contact in a shared human-wildlife environment, such as exposure to rodent faeces; and c) through direct human contact with animals through their consumption, through animal bites and scratches, or through contact with animal body fluids, tissues or excrement.

- **Butchering:** Kurpiers et al. (2016) suggest that the greatest risk of disease transmission occurs during the butchering of animals, which may include skinning, removing organs and cutting up meat. More people butcher (83%) than hunt (42%) animals in Cameroon (LeBreton et al. 2006), and since butchering involves the use of sharp tools, cuts to practitioners may occur during the process, increasing their disease risks. In Sierra Leone, a survey by Subramanian (2012) of rural wild meat hunters and traders found that 38% of respondents cut themselves on a regular basis during butchering and that women are especially at risk of disease transmission since they more often undertake butchering and food preparation than men, although in other settings men are more likely to undertake initial dismembering of wild animals. Similarly, butchering wildlife in East and Southeast Asia presents significant risks for zoonotic transmission as it involves close contact with various wild animals that can harbour pathogens transmissible to humans. Butchers come into close contact with the blood, organs and bodily fluids of wild animals during slaughter and

Infographic 7.



Infographic 8.

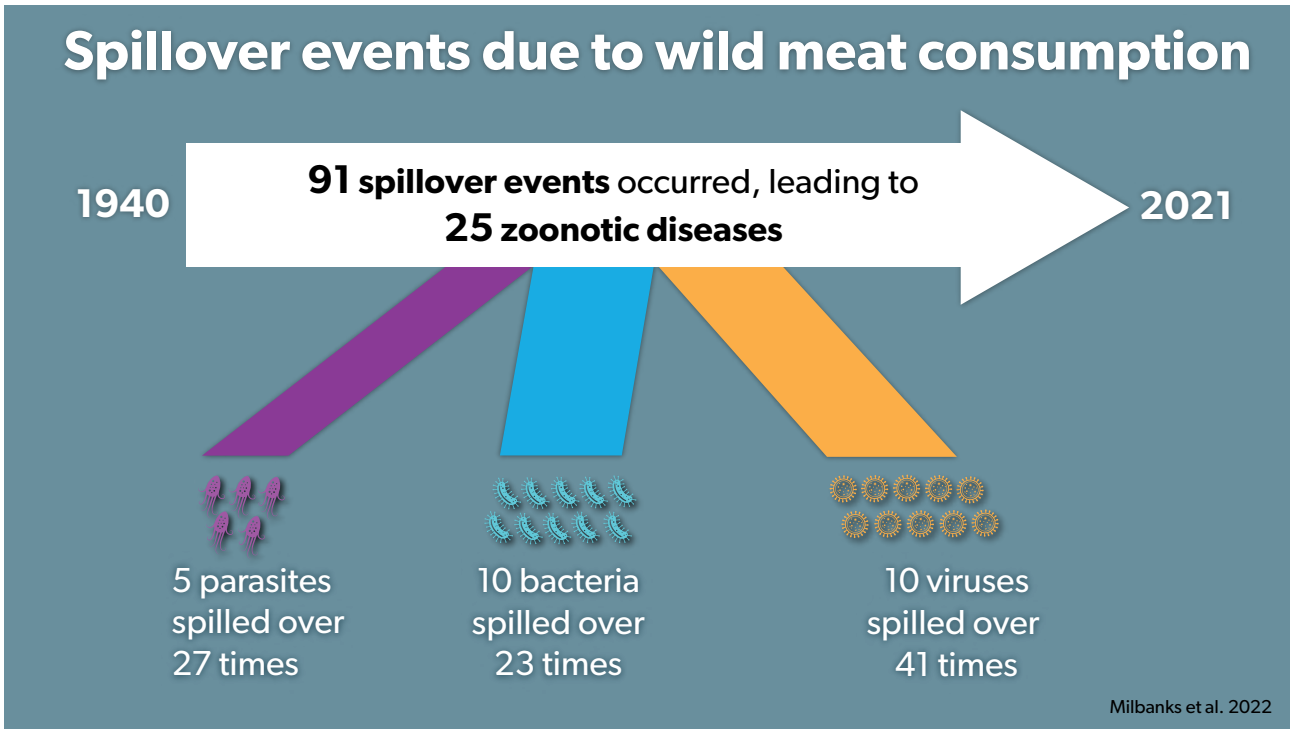


processing. This creates a high risk of exposure to pathogens that can be present in these tissues (Lee et al. 2015). Many Asian regions have informal markets where wild animals are sold and butchered without regulatory oversight, increasing the risk of zoonotic disease transmission (Wolfe et al. 2005). Moreover, improper hygiene practices during butchering can contaminate the butchering area and surrounding environment with infected blood, tissues and fluids. This can then spread pathogens to humans and other animals through contact with contaminated surfaces, tools or water (Karesh et al. 2005) The starting point of safe, hygienic and humane slaughter/butcher/ shooting of wild game is for the initial shot to render it the animal dead instantaneously. Time, technique and temperature are the parameters that determine the safety of the wild meat suitability for consumption and ultimately public health, free from food borne and zoonotic diseases. In keeping with this mantra, the carcass needs to be suspended within a short time of being shot humanely, to allow for sufficient bleeding. Insufficient exsanguination results in the multiplication of bacteria in the tissues especially in the hot humid climatic conditions of Africa. The evisceration of the carcass is of paramount importance and if this is delayed then the gut bacteria multiply, causing the bloating of the carcass and bacteria enters the tissues (Veary1991; Paulsen et al.2011). This then reduces the shelf life of the product. This applies to all wild game products be it for local consumption or export. Once exsanguination has been achieved the carcass, for informal traders, can then be skinned with sterile knives, using just boiling water over a fire to sterilize the cutting knives thereby achieving the universal two knife system for slaughter/ butchering for food safety and cross contamination is avoided. Banana leaves that are washed with potable water, can be used to place the butchered portions of the carcass to avoid dust contamination. This method can be used in the absence of sterile receptacles for the informal trader. These butchered portions can be covered by washed and cleaned banana leaves to prevent flies and other insects from settling onto the meat portions, thereby reducing the likelihood of food borne diseases. The butchered portions can then be transported in large cooler boxes to point of sale, cooked and sold as a stew or to butcheries where a portion of the wild meat maybe displayed in a fly screen proofed glass window. The edible by- products viz; head hooves, red and rough offal can provide job creation and poverty alleviation for women and youth. It can also be used as a renewable source of protein, but the only challenge is that there is no recognised food value chain in the informal markets, therefore highlighting food safety concerns amidst the storage for physical, biological and chemical hazards. All inedible portions should be discarded such as blood and bones can be buried and stones piled onto the burial site to avoid any transmission of disease. The export market for wild game meat in South Arica is

supported by draft regulations enabling traceability and regulated to some extent due to lack of resources. This method of harvesting/ butchering/slaughtering minimises the risk of poaching. In some areas where wild game harvesting is done on a regular basis to maintain the ecological balance, trained teams with registered professional game hunters and trained staff from the local rural communities all work within the parameters of best practices for food safety, food security, public health safety and the preservation of the environment. The entire team must be medically fit, free from zoonotic disease and adhere to all hygienic practice. In South Africa the incidence of cysticercosis is a matter of concern in the rural areas where most livestock are free roaming and wild game too. The absence of ablution blocks or malfunction of those present leave no option for the community but to use the fields as areas to relieve themselves. It is on these same fields that animals and wild game graze. This zoonotic transmission can be overcome by practising better sanitary practices and by proper cooking of the wild meat. Scarcity of water in most rural areas compounded by climatic changes and severe drought hampers the washing of hands as frequently as desired thereby being a potential risk for food borne diseases.

- **Smoking meat:** A large proportion of wild meat is smoked shortly after harvest, including entire carcasses, mainly to increase its shelf like to preserve the product against decay. Whether or not these practices reduce the hazards or risks from viruses is not clear, and at least one study suggests that there is no reliable data on the issue (European Food Safety Authority 2014). Other studies have reported the presence of microbial contaminants and zoonotic pathogen signatures in processed meat, including those that are smoked (Katani et al. 2021; Moloney et al. 2023). Hanging and Drying wild meat after being mixed with condiments and salt is a very popular practice in South Africa for the production of Biltong, which is a sought after protein snack that replaces fried chips/ potato crisps. Biltong has a very long shelf life. The product is not suitable for pathogenic growth as the meat is dried completely most times, however some biltong is preferred slightly wet and this does not exclude the possibility of food borne diseases.
- **Consuming wild meat:** In a review of spillover events documented between 1940 to 2021, Milbanks et al. (2022) reported a total of 91 suspected spillover events from wild meat consumption leading to 25 zoonotic diseases from 10 viral pathogens (41 spillover events), 10 bacterial pathogens (23 spillover events), and 5 parasites (27 spillover events). These, however, could underestimate the actual extent of spillover events because inadequate reporting and diagnostic abilities usually hinder spillover documentation. Spillovers from wild meat consumption were notably higher in Africa (n=38), commonly from viruses, and lowest in Oceania (n=1). Spillovers from bacterial

Infographic 9.



pathogens were frequently reported in North America, while Asia recorded the highest spillover events from parasites. The reported spillover events rarely cause large-scale outbreaks, with only two cases leading to outbreaks of 1,000 or more cases. Men were likely the cause of the first cases, and this could be attributable to men dominating the harvesting node. Some diseases such as mpox (formerly called monkeypox) reported that children younger than 18 were likely the first cases while adults of over 40 years were likely cases for hepatitis E. Ungulates were frequently reported as the source of spillover events and bats the sources least reported. Spillovers from viral pathogens were frequently associated with rodents, non-human primates or undiscerned sources. However, some analysis suggests that consumption of wild meat is less of a pathway for disease spillover than exposure to animal body fluids and faeces during the handling and butchering of wild animals (Kilonzo et al. 2014).

While butchering animals and processing and consuming wild meat provide direct exposure to zoonotic pathogens, these activities can also lead to contamination of water, food and soils, which then also become means for zoonotic diseases to spread to humans and animals (Latifah et al. 2012; Koizumi et al. 2015; Gloriani et al. 2016; Wacharapluesadee et al. 2018; Kudo et al. 2018; Janwan et al. 2020; Heng et al. 2021; Lekko et al. 2021).

Direct or proximate risks

Recent outbreaks of zoonotic human epidemics and pandemics have centred attention on the role of the direct and proximate risks associated with the hunting and handling of wild animals either for wild meat or for medicine. This review distinguishes the disease risks and their causes, the underlying and distal drivers of these diseases, and the actions and multiple channels leading to greater animal-human contacts (IPBES 2019).

Selective hunting: Extraction of high-value species (e.g. trophy hunting) may sustain greater diversity of wildlife (di Minin et al. 2016) and hence the diversity of zoonotic pathogens (Wolfe et al. 2005a). Di Minin et al. (2016) argue that trophy hunting aids biodiversity through a) generating resources used for conservation, b) requiring less infrastructure and fewer personnel and c) taking hunting pressure off less desired species. Hunting that alters the wildlife species mix may also change zoonotic hazards. For example, a reduction in large species may lead to more hunting, and even population growth, of rodents, which are more likely to represent zoonotic disease risks given that the order Rodentia includes the largest number of zoonotic hosts (Ripple et al. 2016; Johnson et al. 2020). A study of a database of 58 studies in 8 countries found that rodent reservoirs became significantly abundant in human-modified habitats (Mendoza et al. 2019). Tumelty et al. (2023) reported in a recent review that 18 mammalian orders have zoonotic links with humans.

Domestic animals: Although most emerging human diseases spillover from wildlife, many of the most important pandemics of recent decades have involved domestic or farmed animal amplifiers or 'bridges' (Liverani et al. 2013). These include highly pathogenic avian influenza (HPAI), the Middle East respiratory syndrome (MERS), and sudden acute respiratory syndrome (SARS). The presence of large numbers of domestic animals kept in close proximity and often genetically similar and immune-suppressed can provide excellent material for novel pathogens to adapt and promulgate. Studies by Takakuwa et al. (2013) and Mohamed et al. (2022) found that migratory birds can spread viruses such as H5N1 avian influenza by coming into contact with poultry farms and human settlements. This emphasizes the role of animal movements in disease transmission. Companion animals are increasingly kept, especially in Asia, and may become increasingly important.

Vectors: The presence of disease-carrying insects such as mosquitoes (Akter et al. 2015; Fungfuang et al. 2020; Novianto et al. 2022) and ticks (Mohd-Qawiem et al. 2022) in human habitats can also act as bridges for zoonotic transmission between wild animals and humans.

Contact zones: Animal-related attractions such as zoos and wildlife parks can also be transmission zones due to the increased opportunities they present for contact between wild animals and people. Three respiratory disease outbreaks among habituated chimpanzee populations in Côte D'Ivoire were traced back to two common human paramyxoviruses, and human illnesses transmitted to gorillas have been repeatedly documented in gorilla tourism sites in Uganda (Weber et al. 2020). COVID-19 has been documented in tigers in several zoos, including in India, Indonesia and the USA (McAloose et al. 2020).

Wildlife transport and sale: The wildlife trade and so-called 'wet markets' where wild animals and wild meat are often sold are conducive to disease emergence as well. Animals typically experience high levels of stress when transported and kept in small, unhygienic cages next to many different animal species, which decreases their ability to fight infections and increases their opportunities to transmit infectious agents. A study showed that civets in markets were disproportionately positive for SARS-CoV-1 compared to civets on the supplying farms (Kan et al. 2005). Another study found isolates of severe acute respiratory virus 1 (SARS-CoV-1) from a civet and a racoon dog at the same market but from different regions of China and with an identical S-gene sequence, which differed

from that of the other civet isolates, indicating that cross-species transmission had occurred at the market (Guan et al. 2003).

International trade in wildlife can cause viruses and other pathogens to emerge in areas far outside of their natural range (Karesh et al. 2005). This was demonstrated when retroviruses and herpesviruses were found in confiscated primates at American airports (Smith et al. 2012). Contributing to this risk is the fact that carcasses can carry viable pathogens for an extended period. Prescott et al. (2015) demonstrated that the Ebola virus remains viable on monkey carcasses for at least seven days. Globalisation is among the main drivers of more than 100 infectious disease threat events detected in Europe as millions of animals and animal products are moved across international borders with little disease surveillance and control measures (Semenza et al. 2016).

Animal age and sex: Some studies suggest animal age might be a factor in susceptibility to certain viruses. For example, younger bats might be less likely to carry astroviruses (Mendenhall et al. 2017) and coronaviruses (Wacharapluesadee et al. 2018). Additionally, Kaewchot et al. (2022) found a higher prevalence of simian foamy virus in non-human primate males than in females.

Human characteristics and behaviours: A review by Nguyen et al. (in press) suggested that factors such as people's age, income and gender might play roles in zoonotic disease transmission, but only a few studies have explored such links. One study linked being older than 30 to a higher risk of contracting tuberculosis (Yakubu et al. 2016), while another found that men with lower incomes were more susceptible than higher-income men to leptospirosis, a bacterial illness associated with water or soil contaminated with animal urine (Suwannarong et al. 2022). Fourchault et al. (2024) reported that children and lactating and pregnant mothers were at higher risk of spillover events from zootherapy following exposure to infectious fluids and tissues during treatment.

Among human behaviours that increase the risk of contracting a zoonotic disease are consuming raw or undercooked wild meat, handling infected animals and the fluids be it in abattoirs or whilst harvesting/ slaughtering animals, disposing of condemned material after slaughter without appropriate protective clothing, eating contaminated food or vegetables, and lacking awareness about local zoonotic diseases.Handling of animals that are infected with a virus eg Rabies or Rift Valley Fever in endemic areas but not displaying many visible symptoms increases the risk of exposure to zoonotic diseases. People working with wild animals, such as Veterinarians, animal health personnel, zoo keepers, farmers, hunters and wildlife traders are also at risk. In addition, activities such as wildlife farming, feeding wild animals, trading wild animals, handling wildlife carcasses, and consuming wild meat can all increase the risk of zoonotic disease transmission.

Distal or underlying drivers

While understanding the direct and proximal risk factors can help predict where zoonotic transmission is most likely to occur and can help identify interventions, the roots of the problem are the distal, or underlying, drivers of zoonotic disease transmission.

Globalization and the interconnectedness of markets and the freer movements of people driven by increased South–South investments and businesses, such as between China and Africa, all lead to increased movements of animals and thus increased opportunities for disease spillovers (Brashares et al. 2011; Kurpiers et al. 2016).

Human population density: Jones et al. (2008) found a connection between high population density and emerging infectious diseases. Southeast Asia covers only 3% of the Earth's land surface but is home to more than 9% of the world's population, which has increased from 214 million in 1980 to nearly 670 million in 2020. Rapid urbanization is transforming social structures and increasing human mobility (Coker et al. 2011), potentially creating new pathways for disease transmission. Along with population growth, East and Southeast Asia has seen a significant rise in meat consumption per person over the past 40 years (UNEP and ILRI 2020). This increase in animal protein consumption, along with a taste for wild meat, leads to more frequent contact between humans and wild animals, creating opportunities for diseases to spread at this 'human-wildlife interface'.

Increased infrastructure for logging and general rural development in previously remote areas leads to greater rural-urban movements of people and animals as well as to environmental degradation and the intrusion of human habitation into wildlife-rich zones, increasing human-animal contacts (Hassel et al. 2023; Mohamed and Wali 2023; Hassel et al. 2017).

Human altered landscapes: Kurpiers et al. (2016) cite several studies that provide evidence of the links between infectious diseases and land-use changes and associated fragmentation of habitats (Gottdenker et al. 2014; Maganga et al. 2014). A recent study found that increases in outbreaks of zoonotic and vector-borne diseases in tropical countries between 1990 and 2016 were linked to deforestation (Morand and Lajaunie 2021). Human-managed landscapes appear to harbour greater zoonotic risk than undisturbed natural environments. Gibb et al. (2020) found that known wildlife hosts of zoonotic

diseases were more abundant in secondary forests and agricultural systems than in undisturbed habitats and that that effect is most strongly associated with the presence of rodent, bat and passerine bird species. Anthropological activities, including replacing wildlife habitats with livestock enterprises and crop farming, reduces original host reservoir habitats and increases contacts between natural and modified environments, leading to the emergence or re-emergence of pathogens in naïve environments (Mahajan et al. 2021; Moreno et al. 2023; Lindahl and Grace et al. 2015).

Corruption: Nielsen (2017) looked at the association between a national corruption perception index and wild meat hunting and trade and found positive correlations. Corruption—here defined as any public official or private individual who abuses their position to benefit themselves, people in their network, their community or their organization—has emerged as a key driver of wildlife trade (TRAFFIC 2008). Corrupt acts fall within the broad categories of bribery, patronage, diplomatic cover and permit abuse (Wyatt and Cao 2015). One of the biggest challenges to preventing wildlife trafficking is the existence of already corrupt structures in the criminal justice system and political environment (Wyatt et al. 2018). Compounding corruption is global neglect, with wildlife crimes often not seen as priorities for law enforcement or criminal justice (Hall and Wyatt 2017).

Climate change: Climate change affects the population and distribution of arthropod vectors (insects and spiders) and their interactions with viral pathogens that could jump to new vectors (Gale et al. 2009). Temperature changes leading to warmer habitats and deforestation increase the presence of rodents in human environments (Naicker et al. 2011). In addition, Prompiram et al. (2022), Low et al. (2022) and Lau et al. (2020) found that global warming, changes in weather patterns, and the spread of ticks can create ideal conditions for pathogens to thrive and increase the risk of zoonotic transmissions. Human displacements and overcrowding due to unfavourable climatic conditions could dramatically lead to rapid and sustained disease outbreaks due to increased human-human and human-animal contacts (Filho et al. 2022; WHO 2022).

Awareness of zoonotic risks

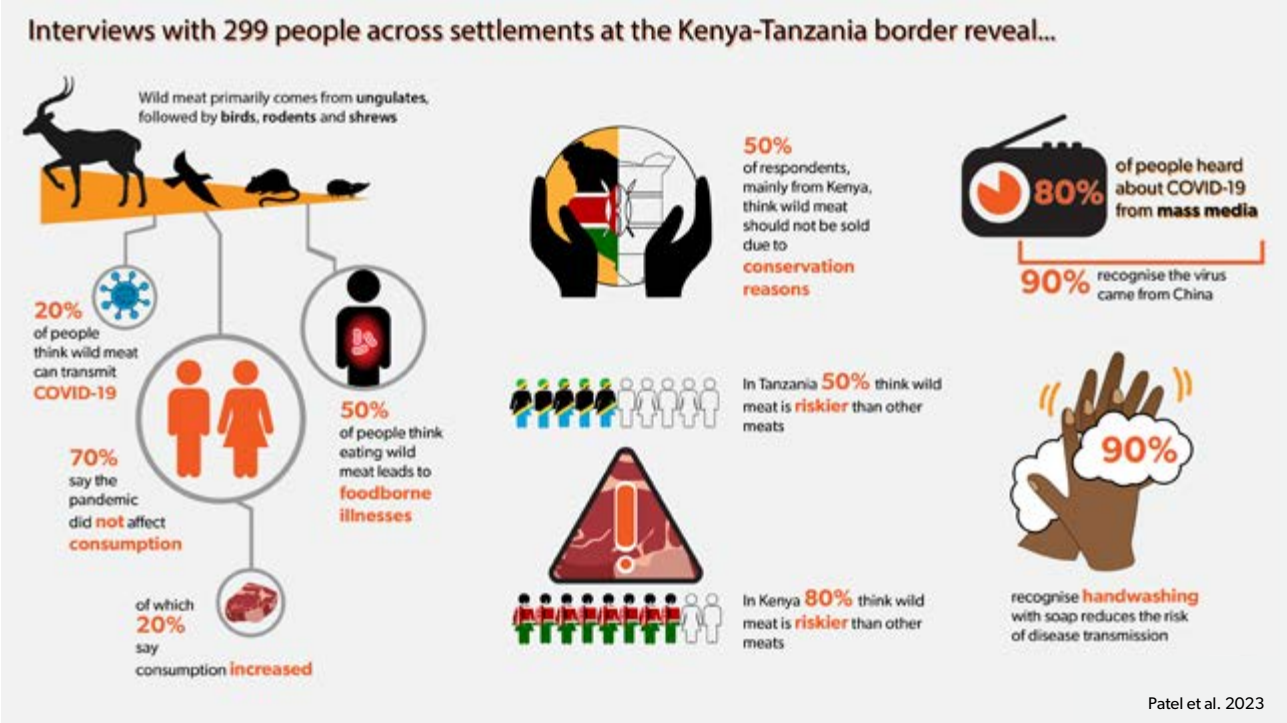
In a survey of wild meat hunters and women cooks in Uganda, both types of respondents indicated that primates were the most likely to carry diseases that pose risks to people. However, neither group took precautions while handling wild meat and regarded gastrointestinal disease as the greatest risk. Most women cooks did not believe that hunters and traders disguised primate meat as something else, but most hunters indicated that they usually disguised primate meat, thus increasing disease risks from those pathogens that are more common in primates (Dell et al. 2020). Similar results by Subramaniam (2012) in Sierra Leone found that 24% of wild meat hunters and traders had some knowledge of disease risk to people from animals, a level of awareness that did not vary according to levels of formal education. A study by Kamins et al. (2015) of hunters, sellers and consumers of straw-coloured fruit bats found little perception of disease risk, except among those who did not consume them.

Most actors in the wild meat value chain in the DRC did not consider hunting as risky, and as a consequence were little concerned about having direct contact with animal blood and tissues during butchering, even when they had open wounds (Lucas et al. 2022). The potential risks were habitually downplayed by actors who took solace in being raised in a culture of hunting, butchering and consuming wild meat. As reported in the same study, actors believed that they were more likely to get infections from domestic than wild animals, the latter of which were deemed pure and sacred creations of God. Actors believed that Ebola was a mystic disease that could result from spells cast on animals stolen from traps. Similarly, van Vliet et al. (2022) reported a low level of concern in the DRC about potential zoonotic exposures to actors along the wild meat supply chains, from villages to urban markets. Priority was given to ensure that meat remains well preserved for traders and end users who were more concerned about food safety (78% and 90% of traders and consumers, respectively).

Kamins et al. (2015) found that respondents who participated in butchering associated less risk from wild animal contact and consumption than those who did not, suggesting some rationalization of their practices. Interestingly, a study in Guyana found that indigenous hunters did not regard cuts during animal butchering as injuries, further reducing the perception of disease transmission risk (Milstein et al. 2021). In the DRC, Lucas et al. (2022) also reported that injuries from cuts were only considered slightly dangerous. In Uganda, hunters reported frequent injuries during butchering and cooks noted that it is the butchering and cutting processes that present the highest risk of exposure to health risks from wild meat (Dell et al. 2020).

At market centres in Ghana, a survey of wild meat hunters, traders and consumers found that just over 50% were aware of the possibility of contracting zoonotic diseases from wild meat consumption, but 33% were not aware. Of those aware, Ebola was cited most commonly, with a few citing anthrax. Nearly one-half had obtained information from radio programs on zoonotic disease risks from wild

Infographic 10.



meat, but one-third had not received such information from any source (Kuukyi et al. 2014). These findings are nearly consistent with a recent study (Abukari et al. 2024) reporting that 62% of respondents from hunting communities were aware that they could contract zoonotic diseases from wild animals, with a majority (91%) having heard about COVID-19 from radio and television. This study by Abukari et al. (2024) reported that declines in wild meat consumption during the pandemics were due to economic shocks and fewer animals but not from fear of the disease.

In a study in western Uganda, Paige et al. (2014) examined both general injuries from animals and contacts with primates. Most animal injuries were dog bites. Among those reporting physical contact with primates (mostly red colobus monkeys), 77% involved touching a carcass, 20% butchering, 10% hunting and 10% touching a live primate. Statistical analysis indicated that men who lived adjacent to forest fragments were at higher risk of primate contact.

In Tanzania, about 57% of local communities were unaware that wild meat is a source of zoonosis through handling and consumption despite brucellosis and anthrax being commonly reported in the villages (Foya et al. 2023). Of 2,965 study responses in 5 geo-ecological zones in Tanzania, 70.6% were unaware of zoonotic viral haemorrhagic fevers, with knowledge levels significantly influenced by one's occupation and education status (Rugarabamu et al. 2023). Radio played an important role in creating awareness among 79% of respondents who were aware of viral haemorrhagic fevers. Along the borderland settlements of Kenya and Tanzania, 50% of communities recognized that wild meat consumption could lead to foodborne illness despite COVID-19 having had no impact on their wild meat consumption habits. Brucellosis and anthrax were recognized as disease risks that could result from poor wild meat handling practices (Patel et al. 2023).

A survey of both hunters and non-hunters among rural communities in eastern Nigeria near forest reserves found 55% of respondents (both hunters and non-hunters) indicated awareness of wildlife zoonoses via broadcast news, forestry/conservation workers or word of mouth. Of those who indicated awareness, however, only 26% reported taking measures to mitigate risks, including avoiding eating wild meat, touching blood, or eating fruit from trees where monkeys had been feeding. Only 5% of respondents reported use of safer meat handling practices, such as cleaning or cooking meat well before eating it. A few indicated the use of additional clothing or gloves when in contact with animals. About one-third reported using traditional and/or commercial medicines as treatments or prophylaxis. Illnesses that respondents believed animals posed included HIV-AIDS as the most cited (over half), followed by cough and malaria. The species they believed posed most risk were monkeys (55% of respondents), pythons and pigs among others, with only 7% indicating chimpanzees.

A similar study was carried out in 17 rural villages in southern Cameroon to understand disease-risk-related practices and levels of risk awareness among community members, irrespective of hunting habits (LeBreton et al. 2006). Hunting in the area was reported to be mainly for local consumption, given the remote setting and poor market access. The proportion of the communities indicating habits associated with zoonotic risk was quite high, with nearly all (98%) of respondents reporting eating wild meat, 83% reporting butchering and 42% reporting hunting. A large proportion of respondents (74%) also reported awareness of the disease risk associated with contact with animal blood or body fluids. Despite that level of awareness, only a negligible proportion of respondents (4% of hunters and 2% of those butchering) reported taking any precautions to mitigate their risks, mainly by simply being careful and washing their hands. Curiously, individuals who perceived disease risk were 27% more likely to butcher wild animals, presumably driven by livelihood necessities despite risk awareness.

Awareness of zoonotic risks varies significantly across different regions in Asia, influenced by cultural practices, economic dependencies, healthcare infrastructure and educational outreach. In Southeast Asia, a review by Nguyen et al. (in press) indicated that lack of awareness about zoonotic diseases can lead to risky behaviours, such as consuming raw or undercooked wild meat (Thi et al. 2014) or using improper hygiene practices around wildlife, increasing the risk of zoonotic transmission. A study by Grace et al. (2012) found that in urban areas, awareness is higher due to better access to information and healthcare services. However, in rural and remote areas, awareness remains limited. Drury (2011) indicated that the use of wild animals in traditional medicine practices, particularly in countries like Vietnam and Cambodia, contributes to the transmission of zoonotic diseases, with limited awareness of the associated risks. Results from a quantitative survey in Thailand found that villagers had a low level of knowledge of zoonotic diseases and inappropriate attitudes and practices about links between contacts with rodents and zoonotic diseases (Suwannarong et al. 2021). In East Asian countries such as China and Japan, people in urban areas have higher awareness than those in rural areas due to better education and healthcare infrastructure (Wiggen et al. 2022). A survey conducted by Li et al. (2021a) found that while most participants (81.9%) recognized the zoonotic origin of HPAI, knowledge about other zoonotic diseases such as SARS (30.9%), HIV/AIDS (21.4%), MERS (21.4%) and Ebola (43.6%) was lower. The use of wildlife in traditional Chinese medicine continues to be a challenge, with various levels of awareness about the associated health risks (Lee et al. 2014).

Box 5: Impact of COVID-19 on wild meat consumption and disease risk perception in Kenya-Tanzania border settlements

A study examined the impact of the COVID-19 pandemic on wild meat consumption and perceptions of zoonotic disease risks among rural settlements along the Kenya-Tanzania border. The primary aim was to understand how education, media and economic factors influence these perceptions. Specifically, the study sought to assess the impact of COVID-19 on wild meat consumption, analyse perceptions of disease risks within the wild meat value chain, and identify the demographic factors that influence these perceptions. The findings show how various social, economic and informational factors shape local attitudes and behaviours regarding wild meat consumption and associated health risks.

Wild meat hunting and trade are common practices in African savannahs. This study was conducted in six villages in Taita Taveta County, Kenya, and Rombo District, Tanzania, where 299 people were interviewed about their wild meat consumption, knowledge of COVID-19 and perceptions of disease risks. The interviews highlighted differences between the two countries in terms of legislation, economic impact and public awareness.

We found that 76% of respondents learned about COVID-19 from the media. Most recognized its origin in China, but fewer believed it originated in wild animals. Regarding wild meat consumption, 70% reported no impact of COVID-19 on consumption, with some even noting an increase. Over half of the respondents believed that wild meat consumption could lead to foodborne illnesses, identifying hyenas, monkeys and snakes as high-risk species. Education significantly influenced disease risk perceptions, and country-specific legislation also played a role, with respondents in Tanzania, where hunting wildlife is allowed, more accepting of the wild meat trade than respondents in Kenya, where hunting wildlife is illegal. In 2020, Tanzanian authorities approved the sale of wild meat under special rules that require licensed operators to slaughter wild animals at special abattoirs.

The study underscores the complexity of wild meat consumption and disease risk perception in rural African communities. Although COVID-19 heightened awareness of zoonotic diseases, economic pressures and cultural practices continued to drive wild meat consumption. Education and media were identified as critical factors in shaping public perception. Those with more education were more aware than those with little education that hand washing reduced disease transmission and that contact with wildlife posed a disease risk. The impact of COVID-19 on wild meat consumption varied between Kenya and Tanzania. Education and effective communication strategies are essential in promoting awareness of zoonotic diseases, and policy interventions must consider local economic and cultural contexts to be effective.

The study found that economic pressures in these rural communities often override health concerns regarding wild meat consumption. Country-specific legislation impacts public attitudes towards wild meat trade, highlighting the need for a better understanding of the difference between official regulations and their practical implementation.

Summary: Zoonotic risks

Species: Ungulates generally tend to be the most frequently hunted animals and are sometimes the most important in terms of overall biomass extracted. These tend to be followed in importance by large rodents and primates. Near human settlements, where hunting pressure is greater, larger bodied animals have over time tended to be 'hunted out' and replaced by smaller species (such as duikers and large rodents), which are faster reproducing and thus more sustainably hunted. The species extraction data available, however, rely heavily on market surveys, which may not closely reflect actual hunting levels or species composition, much of which is consumed locally and so does not appear in markets. Much of the data available come from Central and West Africa and East and Southeast Asia, with fewer data from Southern and East Africa and Central Asia. Primates, rodents, bats and carnivores are the wildlife reservoirs with the highest proportion of zoonotic pathogens.

Pathogens of most concern: Historically, zoonotic spillover events have mostly been attributed to bacterial, parasitic and viral pathogens from ungulates, followed by viral pathogens of undetermined sources, and those from rodents and non-human primates other than great apes. Other major sources of spillover events include armadillos (bacterial) and carnivores (parasitic), while bats have contributed the least to previous spillovers. Microbes of most concern are those that have proven ability to a) lead to human pandemics, b) lead to panzootics in (non-human) animal populations, and c) mutate at high rates and recombine with other similar or dissimilar microbes, with RNA viruses of special concern. Key viruses of concern include Ebola and Marburg filoviruses, hepatitis viruses, herpes viruses, human T-cell lymphotropic virus, mpox virus, paramyxoviruses, simian immunodeficiency virus and simian foamy virus.

Transmission pathways: Between 1940 and 2021 a total of 91 spillover events from wild meat consumption have been documented, leading to 25 zoonotic diseases from 10 viral pathogens, 10 bacterial pathogens, and 5 parasites. Spillovers from consumption were notably higher in Africa than in Asia. However, consumption of wild meat may be less of a pathway for disease spillover than exposure to animal body fluids and faeces during the handling and butchering of wild animals.

Drivers and risks: The direct or proximate risks identified include selective hunting of high-value species; the presence of domestic animal 'bridges' or amplifier hosts, insect vectors and contact zones; wildlife transport and sales; wild animal age and sex; and human characteristics and behaviours. Some of the distal or underlying drivers include globalization, high human population density, increasing infrastructure and human-managed landscapes, corruption and climate change.

Awareness of zoonotic risks: Most studies in Africa find a relatively low awareness of zoonotic risks, except during outbreaks of dreaded diseases such as Ebola. In the DRC, for example, hunters considered wild animals as 'pure' and disease more likely to result from contact with domestic animals. There is also significant misunderstanding of both which diseases present risks (e.g. misperception of malaria risk from animals) and which species of wildlife are most risky to handle and eat. Even when awareness of risk is high, very few take measures to mitigate risk. In Asia, risk awareness has been found to differ between rural areas, where it is generally low, and urban areas, where it is higher.

Strategies and policies for mitigating zoonotic risks from wild meat value chains

This section addresses strategies developed and implemented to ban, limit or control the hunting of wild meat, with a focus on Africa and East and Southeast Asia. Most of these strategies aim to conserve wildlife to retain biodiversity, to support tourism, and/or to comply with international agreements restricting trade in endangered species under CITES. Some strategies—such as banning the hunting of primates, especially apes—also aim to restrict the spread of zoonotic diseases.

Policy and regulatory attempts to limit wild meat hunting and marketing

Reviews of wildlife legislation, including implications for wild meat, find that the objective of conservation of important or vulnerable wildlife species is typically approached through the designation of protected areas or through species-specific regulations against hunting and marketing (Brown and Egbe 2003; Ly and Bello 2002). This sort of 'fortress conservation' was typical of the 20th century (Noutcha et al. 2016b) and has been characterized by some as addressing the symptoms of the problem, which include wild meat hunting, but not the root causes (Rentsch and Damon 2013). Other studies find that any legal use of endangered species will act as cover for their illegal use. This is referred to as 'wildlife laundering' and has been well documented for high-value products such as reptile skins and ivory: around half of all legally traded python skins are believed to come from wild-sourced animals (UNODC 2016).

Protected areas, covering around 15% of the world's land area, are key elements of most conservation policies; however, most protected areas in the Afro-tropics and IndoMalay lack adequate budgets or staff (Coad et al. 2019). Protected areas slow but do not halt human pressures on wildlife (Maxwell et al. 2020). The Post-2020 Global Biodiversity Framework, which was adopted at the UN Biodiversity Conference (CBD COP15) in 2022, has the ambitious target of '30 × 30'—of protecting 30% of land, freshwater, coastal and high-seas in a representative way by 2030. Reaching agreement proved contentious and attaining the target will require both new mechanisms and new funding streams not yet identified (Hughes 2023).

Wildlife protection legislation typically does not include a regulatory framework for managing sustainable harvesting or trade in those wild animals that may not be among the most vulnerable. Enforcement of these policies and regulations is severely limited by a dearth of public resources and political will, particularly where species conservation is viewed as an internationally imposed goal lacking strong national support, and particularly in locally affected communities, especially those that may suffer from wildlife attacks on their livestock that are not compensated for (Wilkie et al. 2001). Although such regulations may make wildlife hunting illegal in formal terms, most of the local population may not perceive the bans as legitimate.

Some studies have investigated the extent to which wildlife laws and regulations are effective in protecting the target species. One study looked at species found in wild meat markets and hunters' catches in eight countries in West and Central Africa and compared them to a list of protected species. Only in two countries was the influence of species-specific laws apparent in the harvest of wild meat (Rowcliffe et al. 2004). In Tanzania, where hunting is often of large game animals, anti-poaching patrols were found to reduce wild meat consumption near national reserves, and the proximity to and the protection level of the nearest protected area had the most significant negative effect on consumption (Ceppi and Nielsen 2014). It is illegal to hunt lemurs in Madagascar but not fruit bats. A survey of a large number of rural and urban households found much more common consumption of fruit bats,

which suggested that the illegality of hunting lemurs has helped to reduce their consumption (Jenkins et al. 2011).

Recognizing the importance of wild meat for local livelihoods, some approaches differentiate local hunting for community consumption from commercial hunting. In Gabon, 'village hunting' laws allow year-round subsistence hunting using traditional methods. Hunting with shotguns and wire snares is legal only in certain seasons for village hunters with licenses, the numbers of animals caught are limited and certain species are protected, as are some female and juvenile animals. Surveys found, however, that in and around protected areas, the laws are generally not respected (Abernethy and Obiang 2010). Among bat hunters in Ghana, Kamins et al. (2015) found that most did not have accurate awareness of the dates of the legal hunting season, suggesting the limited usefulness of imposing seasonal limits.

Some have suggested the use of schemes to legalize and then tax trade in wild meat, which would allow hunters and value chain actors to maintain their livelihoods, make wild meat available for consumption and also generate tax revenue. Selective rules on species would allow conservation of vulnerable species. However, an analysis by Wilkie et al. (2006) using wild meat prices and volumes in Gabon and Cameroon found that the tax revenue generated by such an approach would not even cover the costs of tax collection, much less the additional costs of enforcing the laws.

There are many constraints to the enforcement of wildlife laws beyond limited public resources. Nielsen et al. (2016) conducted a study of the value chain for wild meat in the Kilombero Valley of Tanzania, where illegal hunting is widespread, often of large animals. Limited access to firearms creates an entry barrier but also raises wild meat prices and allows those with access to capture above-normal profits, which also incentivizes rent-seeking by officials. Decentralization of management rights and responsibilities to communities, supplemented by improved firearms control, appears the most realistic option for regulating the trade and preventing further declines of wildlife. In Nigeria, Enianget al. (2008) found that operations to protect parks were constrained by a lack of staffing, equipment (including communications equipment), vehicles and arms and ammunition. Operations often ran into physical confrontations with rural communities that objected to the rules and restrictions. Some researchers suggest that within the more controlled environment of logging concessions, enforcement of hunting rules may be more effective (Wilkie and Carpenter 1999).

All countries in East and Southeast Asia legislate uses of wildlife, with nuances among them (OIE 2020). The key topics covered in most such legislation include: wildlife protection and conservation and infectious disease control (including domestic animal infectious diseases). Some legislations also include quarantine procedures for specific wildlife species (Japan) and prevention of damage to agriculture by wildlife (Japan). China and Laos specifically mention protection of aquatic wild animals. In line with these differing topics, various ministries have different responsibilities. The ministries commonly involved include agriculture, livestock, environment and forestry (Pruvot et al. 2019). For example, animal and zoonotic disease control policies usually fall within the mandate of the agriculture and livestock ministries, which conduct selected disease surveillance (e.g. for HPAI and African swine fever) (OIE 2020), while the wildlife sector is generally the responsibility of environment or forestry ministries, with a level of collaboration in wildlife disease surveillance with veterinary and laboratory services.

Recognizing that COVID-19 may have emerged from the wildlife trade, governments have enacted new or updated regulations to control its trade. For example, China adopted legislation banning the consumption of any field-harvested or captive-bred wildlife, closing the markets for domestic wildlife trade (Rizzolo et al. 2023). In Vietnam, a new directive (No. 29/CT-TTg) banned the sale of protected wildlife at wildlife markets (MARD 2020). These recent actions support both disease prevention and also wildlife conservation.

Generally, attempts to curb illegal trade are sometimes hampered by low enforcement rates and weak wildlife trade laws that can have loopholes. For example, while China banned pangolin trade, there is no legal procedure to prevent the production of medicines that contain pangolin scales, so the trade in pangolin scales continues (Borzée et al. 2020). Some regulations call for more nuanced approaches, since many rural communities rely on wildlife for sustenance and poverty alleviation, as well concerns that bans could lead to further unregulated harvesting of wild animals (Eskew and Carlson 2020).

Market incentives to manage wild meat

In terms of economic incentives, the livelihood implications of wild meat hunting and marketing have already been well demonstrated, as well as the implications of wild meat price and availability on consumption decisions. A number of studies have thus explored the use of market and economic incentives to manage or at least influence the hunting of wild animals and the consumption of wild meat. An interesting and potentially important example of how market behaviour can impact wild meat consumption and zoonotic risks

is addressed in a recent preprint by Xia et al. (2021). They analyze the effects of culling pigs in China in 2019 in response to an outbreak of African swine fever that led to shortages of pork and, consequently, to unusual movements of animals and meat to substitute for pork, including wild animals, in southern China. They suggest that the increased demand for wild meat might be linked to the outbreak of SARS-CoV-2.

In a simulation analysis of incentives affecting hunting behaviour using data from the Ashanti Region of southern Ghana, Damania et al. (2005) found that an increase in wild meat prices due to demand would lead to more efficient hunting (and greater, perhaps unsustainable, depletion of wildlife) as hunters switched to using guns rather than snares, suggesting that improving farm prices for agricultural products could shift labour effort from hunting to agricultural production.

Several studies examined wild meat hunting around the Serengeti National Park, in Tanzania. One found that hunters arrested by authorities were mostly subsistence farmers who sold wild meat to generate an income. Individuals with greater wealth (more sheep and goats) and those with alternative sources of income or protein were less likely to participate in illegal hunting, suggesting that hunting was not a preferred activity if alternatives were available. However, illegal hunting was not reduced by participation in community-based conservation programmes (Loibooki et al. 2002). Another study in the same region also confirmed that the higher numbers of livestock kept by people was associated with lower levels of hunting (Mfunda and Roskaft 2010).

Substitutability of other livestock meat with wild meat has been examined as a market-based avenue to influence demand for hunting. Using a stated preference analysis in northern Tanzania, Moro et al. (2015) found that if other protein alternatives, such as fish and poultry, were cheaper, then demand for wild meat would decline but only slightly. However, a 10% increase in wild meat prices would reduce demand more significantly, by 6–7%, suggesting that restricting hunting and access to wild meat could have a larger effect. Another study of protein alternatives used 30 years of data from Ghana to examine the impact of spatial and temporal availability of fish on wild meat hunting (Brashares et al. 2004). They found that years of poor fish supply were associated with increased wild meat hunting, indicating that hunting is in part driven by demand for protein. Rentsch and Damon (2013), using detailed household food consumption and price data from the Serengeti region of Tanzania, estimated that a rise in the price of wild meat associated with curbs on hunting would have a direct and large effect in reducing wild meat consumption.

Wildlife ranches are privately owned land (or Private Protection Areas) that use wildlife-based activities for income generation. Unlike Public Protection Areas that are subsidised by the state, Private Protection Areas need to be profitable. Over the last 50 years, the South African wildlife ranching sector has grown substantially, mostly through the conversion of marginal land previously used for livestock production, and now encompasses an area of 17–20.5 million hectares, or 17% of the land area. These Private Protected Areas have been shown to be financially and socially sustainable and to increase wildlife abundance (Taylor et al. 2021). An alternative, market-oriented approach to Public or Private Protected Areas and private land conservation is the commercial use of wildlife on land not declared as Public or Private Protected Areas, where the primary goal of keeping wildlife is often profit, but where conservation gains may be an outcome.

Under the hypothesis that external markets can be key drivers of wild meat hunting, de Mérode et al. (2003) suggest that banning external market sales and restricting consumption to local communities may have limited impact, since the evidence is that external markets are not the key drivers of hunting.

Examples of market incentive efforts in East and Southeast Asia include the following.

- In 2009, a local social enterprise in Cambodia, an NGO called Sansom Mlup Prey, enabled farmers to achieve a premium price for their rice in exchange for complying with conservation-friendly practices; these practices include the maintenance of land-use boundaries, a zero-wildlife hunting policy and organic farming (IIED 2022).
- Incentives for wildlife stewardship in many Southeast Asia countries, such as Vietnam, include promoting wildlife-based tourism as an alternative, legitimate form of income generation (Roe and Booker 2019).

Community involvement in wild meat management

Community-based wildlife programs have been a pervasive paradigm since the 1970s. Local communities are given ownership rights or custodianship and management responsibilities over wildlife, from which they gain social and economic benefits from the conservation of those resources. By the 1990s these programs were being widely promoted (Noutcha et al. 2016b) in line with broader community-based resource management strategies, such as for fisheries (Bissonette and Krausman 1995; Dietz et al. 2003). Top-down regulatory approaches to wildlife conservation cannot easily resist the economic and consumption drivers of

hunting and poaching; in many settings, increasing relative poverty in rural supply areas coupled with growing demand for wild meat in urban centres can lead to more organized hunting and marketing. Challender and MacMillan (2014) call for mechanisms to incentivize and build capacity within local communities to conserve and manage wildlife. In theory, community-based approaches would better tailor implementation approaches to specific community needs, could leverage the roles of traditional authorities, and also reduce alienation of traditional hunters who, under the regulatory approach, are often regarded as poachers. Booth et al. (2021a) highlight the importance of participatory processes in managing wildlife in terms of improved data and information gathering, better valuation of trade-offs among community members and market actors, co-learning, and increasing the legitimacy of policy strategy decisions.

Some of the advantages of community involvement in wildlife management are the same as those for forest management and, more broadly, for shared community landscapes and resources. As immediate custodians of wildlife resources dependent on wildlife for multiple livelihood strategies, local populations are key stakeholders land and natural resource management. The typical understaffing and distance of governmental officials provide strong rationales to strengthen the agency and capacity of local residents, and to make better use of their intimate knowledge of wildlife (Bowen-Jones et al. 2003).

A study in the DRC demonstrated the effectiveness of involving local authorities in wild meat markets near protected parks (de Mérode and Cowlishaw 2006). During periods of conflict, when protective military forces fled an area, urban wild meat markets were observed to significantly increase trade in protected species (including elephant), a change that was not observed in rural village markets, which remained stable. The difference apparently resulted from the fact that the latter were administered by traditional chiefs, who discouraged use of automatic weapons.

In one of many examples, an integrated community-based approach met with some success. In a part of northern Kenya where giraffe meat consumption was threatening the giraffe populations, a community-based program for giraffe conservation used ecological monitoring, community outreach and education, and collaboration with wildlife security teams to successfully reduce giraffe meat consumption (Ruppert et al. 2020).

Community conservancies are one such model. They give rural communities rights over local wildlife, which are typically managed in joint venture agreements to generate profits for the communities. They are most extensive in Namibia and Kenya but are also important in South Africa and emerging in other countries such as Mozambique and Tanzania. In Kenya, conservancies (both private and community) cover 11% of the land area compared to 10% covered by state Protected Areas (KWCA 2021). Over 90% of the global population of Grevy's zebra and hirola (Hunter's hartebeest) populations are maintained in conservancies. Conservancies have also been shown to generate large incomes for local households, and to reduce conflict and insecurity, but have equity challenges as the poor and marginalized tend not to share in the benefits (Oduor 2020). These conservancies can be sustainable and prevent poaching when management and ecology allow the generation of significant and transparently distributed revenues and jobs; when the conservancies receive substantial support from donors, NGOs or private investors; and when they are integrated into national policy and legal frameworks (Wenborn et al. 2022).

But rarely do the necessary legislative frameworks exist to support such conservancies. Such frameworks would need to identify the relevant 'community', provide it with some recognized authority and address competing claims by other agencies and actors over land, forest and other resources. The same scarce resources and remoteness factors that impede regulatory approaches also constrain more participatory approaches, leading to high transaction costs of engagement and management (Bowen-Jones et al. 2003).

Attempts have been made to adopt a two-pronged approach to differentiate commercial hunting from village-level hunting for local consumption, or to focus on protecting vulnerable or important species, which may allow more robust species to provide a potentially sustainable harvest and trade (Cowlishaw et al. 2005). For communities that depend significantly on wild meat for local consumption, the sustainability of some level of wild meat harvest could be critical for any management strategy. One study in Ghana tested that hypothesis based on analysis of wild meat market profiles and hunter reports (Cowlishaw et al. 2005). The study confirmed that large-bodied, slow reproducing species are mostly depleted and that smaller and faster reproducing species such as rodents and small antelopes (e.g. duikers), sourced largely from agricultural areas, were those now mostly traded. Biological assessments indicated that these more robust smaller species were being hunted sustainably, confirming the potential viability of the two-pronged approach.

That type of approach has been implemented in Gabon, but Abernethy and Obiang (2010) report mixed results. The use of guns and wire snares are not allowed in village hunting, except under limited and licensed circumstances. Villages therefore have instead to rely on traditional methods such as snares made from plant material. Village

hunting is also officially limited by restrictions regarding catch sizes and the age and sex of the animals. While animals hunted according to these rules can be legally marketed, these restrictions are unpopular and so are often ignored, and a lack of measures to implement the legislation makes it almost impossible to enforce.

Despite the constraints and shortcomings of decentralizing some wildlife management rights and responsibilities to local communities, Nielsen et al. (2016) conclude that this, accompanied by better firearms control, is likely the most effective way to regulate trade in wild meat if not the full scope of hunting.

Community-based interventions can complement formal law enforcement efforts provided local people have sufficient incentives (financial or non-financial) to protect wildlife (Cooney et al. 2017). Community-based monitoring systems can help detect changes in wildlife populations, wildlife health and the environment. Systems that are collaborative rather than externally driven enhance local ownership, which is crucial for developing locally responsive strategies (Lam et al. 2019). The core principle is that communities need to be central—not peripheral—to conservation efforts, given their proximity to wildlife populations, their knowledge of local wildlife, and their wildlife use practices (Pruvot et al. 2019).

A review of community-based approaches to tackling illegal wildlife trade found examples of community-based initiatives more in Africa (25) than in other regions such as Asia (19) and Latin America (6) (Roe and Booker 2019). The review identified four pathways to community engagement: 1) increase the costs of participating in illegal wildlife trade, 2) increase incentives for wildlife stewardship, 3) decrease the costs of living with wildlife and 4) support livelihoods that are not related to wildlife. Detailed case studies from Southeast Asia can be found in a global database called 'People not Poaching' (IIED 2022).

Box 6: A global effort to support community-based, sustainable wildlife management

The merits of community-based approaches to manage wild meat use and associated risks are well known and documented, yet the reality is that rights-holders rarely possess access and management rights over the land they live on and its natural resources, including wildlife. Efforts to devolve these rights in some countries or localities (e.g. under Namibia's and Kenya's community conservancies) have shown some promise, but these successes came following decades of testing and adapting suitable, acceptable and sustainable management models. In an effort to develop robust and adaptable community-based sustainable wildlife management (CBSWM) systems that can be scaled, the Sustainable Wildlife Management (SWM) programme (https://swm-programme.info/fr/homepage) has been developing and testing various CBSWM models across Africa, the Caribbean and the Pacific.*

The SWM programme recognizes six complementary, interdependent components to achieve robust CBSWM:

1. **Understanding the environment and its use:** Communities need to know the abundance of wildlife in their environment, if and how they are currently used and if wildlife populations are stable or declining.
2. **Devolution of exclusionary rights:** Stewardship is predicated on the recognition and respect of communities' rights to their resources.
3. **Local-level management by a competent authority:** Empowered communities are the most appropriate level of organization for managing wildlife locally.
4. **Social cohesion to manage as a community:** Community members should share a common vision to manage wildlife and take collective action together to ensure long-term success.
5. **Effective governance systems:** Communities need recognized governance groups equipped with the technical knowledge and capacity to make informed wildlife management decisions and ensure compliance with their rules.
6. **Sustainable solutions for growth and increasing aspirations:** Producing alternative sources of food and income to prevent overexploitation and ensure wildlife populations persist at ecologically functional densities.

Each CBSWM model promoted by the SWM programme contains these six basic ingredients, but the recipe (the model) is adapted to suit local and national contexts. In Gabon, wildlife exploitation significantly contributes to the food and economic security of many rural populations but hunting pressure is moderate (due to low human population densities). The CBSWM model, piloted by the SWM programme in partnership with 10 communities in the Mulundu Department, revolves around the sustainable management of village-level hunting and the local wild meat trade. Supporting the creation of village hunting associations, participatory gazettement of sustainable management units, and creating a system for monitoring hunting activities and wild meat trade are some of this model's key interventions. More information on the SWM project in Gabon can be found here: https://swm-programme.info/fr/web/guest/gabon.

* The Sustainable Wildlife Management (SWM) Programme is an initiative of the Organisation of Africa, Caribbean and Pacific States that started in 2017. It is funded by the European Union, with co-financing from Fonds Français pour l'Environnement Mondial (French Facility for Global Environment) and Agence Française de Développement (French Development Agency). It is implemented by a consortium of partners with expertise in wildlife conservation and food security: the Center for International Forestry Research and World Agroforestry (CIFOR-ICRAF), the French Agricultural Research and Cooperation Organization (CIRAD), FAO and the Wildlife Conservation society (WCS). The SWM programme works in 15 countries—Botswana, Chad, DRC, Egypt, Gabon, Guyana, Madagascar, Mali, Namibia, Papua New Guinea, Republic of the Congo, Senegal, Sudan, Zambia and Zimbabwe—with a planned expansion to more countries in Africa and Asia.

Education and raising awareness

Some of the studies reported so far have suggested that public information efforts can influence levels of awareness within rural and urban communities of issues around the wild meat trade, including its implications for both wildlife conservation and zoonotic risks. Relatively few studies on this topic, however, were located for this review.

Verissimo et al. (2018) tested the effectiveness of a public information effort aimed at reducing demand for wild meat in northern Tanzania. The intervention comprised multiple short awareness-raising episodes on a local radio show followed by interactive call-in discussions. The before-after evaluation of volunteers, including a control group, revealed no different outcomes, probably due to relatively low listening frequency to the radio program containing the messages. The researchers inferred from this failure that more careful behaviour change analysis is required to guide such mass media interventions.

In contrast, in a situation where people are confronted with stark risks, the effects of raising awareness are more visible. In Nigeria in 2014 following the Ebola outbreak, Akani et al. (2015) linked the sharp decline in the wild meat trade, including the disappearance in markets of the species most closely associated with the disease (monkeys and fruit bats), to the strong public information campaign carried out by Nigerian authorities on the risks of the wild meat trade on the spread of the virus.

In Brazil's Central Amazon, a region where wild meat hunting is deeply ingrained, Chaves et al. (2018) also used a before-after control intervention designed to assess the effects of social marketing with and without an economic incentive (discount coupons for chicken) to reduce wild meat consumption. The social marketing included both an information campaign and direct community engagement, the emphasis being on wildlife conservation and the advantages of livestock meat rather than on any zoonotic risks. Including coupons increased chicken consumption, as expected, but did not reduce wild meat consumption, since apparently consumers did not regard chicken meat as a substitute for wild meat. However, the social marketing without the coupon incentive reduced wild meat consumption by some 62%, suggesting that social marketing alone may be effective. This study demonstrates that social marketing, which in this case was carefully designed and multifaceted, may be effective in reducing demand for wild meat, even when zoonotic risks are not emphasized.

Wilkie and Carpenter (1999) suggest that consumer education, particularly on issues of conservation and zoonotic safety, is likely to work better among more educated and diasporic communities due to their greater ability to absorb information and their tendency to give greater weight to social objectives like conservation, especially with regards to primates. But given that the greatest zoonotic risks have been demonstrated to occur among those hunting and butchering wild animals, interventions to reach those actors still need to be designed and demonstrated to be effective.

A number of awareness campaigns have been conducted in East and Southeast Asia to reduce demand for wild meat, including the following.

- Zero Wild Meat, launched October to December 2022, spotlighted two serious threats—to public

health and to nature—to reduce the consumption of wild meat in Cambodia, Laos and Vietnam (WWF 2023).
- #StopEatingWildlife aims to fight the supply, demand and consumption of wildlife meat by making Cambodian consumers more aware of the health risks of consuming it and of animal welfare (Wildlife Alliance 2021).
- A Biodiversity Conservation project in Vietnam of the United States Agency for International Development (USAID) aims to change individual behaviours and social norms leading to reduced local demand for wildlife meat, including from pangolins, civets and other species of wildlife (USAID 2024).

Harnessing generational changes in attitude

Negative attitudes towards food are influenced by two factors, food neophobia and—what is often related—food disgust. Food disgust is a basic and universal emotion that evolved to protect humans from pathogens. Core disgust is elicited by foods and especially foods of animal origin (e.g. spoiled milk), bodily wastes (e.g. faeces) and small animals, particularly those associated with garbage and waste (e.g. rats and cockroaches) (Rozin et al. 2000). Disgust is a powerful emotion and difficult to overcome. Younger people and women have higher food disgust sensitivity than older people and men (Curtis et al. 2004; Sabbagh et al. 2023); interestingly, youths and women are also less likely to consume wild meat than older people and men.

Food neophobia, the tendency to avoid unfamiliar food, is universal, but what is unfamiliar is culturally dependent. Among cultures or people who avoid wild meat, neophobia and/or disgust may be more powerful motivating factors than concerns over possible zoonotic transmission or wildlife conservation, suggesting that creating or eliciting instinctual disgust may be more effective in reducing wild meat consumption than informing about zoonotic risks or the benefits of wildlife conservation.

In many cultures, including some in Africa and Asia, wild meat is not consumed. Some religions have prohibitions on certain foods, including wild meat. Cultures often have taboos around certain foods for certain people.

Not eating wild meat can be difficult where, as is often the case in sub-Saharan Africa and East and Southeast Asia, there are strong positive emotions and a high cultural value associated with eating it. But meat can also elicit disgust: almost all disgusting foods are from animals or animal products. The disgust response does reduce people's willingness to eat meat, such as when roasted meat is presented with an animal's head attached (Kunst and Hohle 2016) or when meat images are paired with disgust stimuli (e.g. an infected boil or a pile of vomit) (Tybur et al. 2016).

Disgust can also develop after meat is rejected for other reasons. A study of vegetarians found that 53% found meat disgusting but only 14% said disgust was an initial reason to follow a vegetarian diet (moral and health reasons predominated) (Rozin et al. 1997). It has been recently argued that meat is fundamentally a disgust elicitor and meat consumption is made possible only by suppressing disgust for certain types of meat, possibly by social learning, something that requires cognitive effort and can be easily lifted if meat is no longer consumed (Becker 2023). This would explain why disgust can be created relatively easily following interventions or individual decisions to avoid meat.

Food disgust is not only amenable to change through interventions but liable to change over relatively short periods of time. In the UK, offal was traditionally associated with the poor, before becoming an esteemed fashion-food for the English gentry during the early modern period. After falling out of favour in the early 20th century, it was promoted after the Second World War, when it was one of the only animal products widely available during rationing. When meat became more readily available, offal was yet again rejected by many. More recent efforts to promote offal on the grounds of its sustainability (e.g. in 'nose to tail' eating) and animal welfare benefits have met with little success. Box 5 describes a very recent rapid and unexpected fall in the acceptability of eating dog meat in South Korea.

Box 7: Case study: From 'appealing food' to 'appalling food'

In early 2024, South Korea's lawmakers legislated against the breeding, slaughter and sale of dogs for human consumption, a practice deeply rooted in Korean history but now deemed unpopular and rare. Historically, dog meat consumption was more prevalent, especially in the post-Korean War era, when the nation faced severe poverty and meat scarcity. This meat was traditionally used in a well-known dish called 'bosintang', meaning 'soup good for your body'. However, as South Korea's economy developed and incomes rose in the late 20th century, there was a steady increase in pet ownership and a heightened concern for animal welfare, leading to a decline in the practice.

Currently, a significant portion of the South Korean population, particularly the younger demographic, finds the consumption of dog meat appalling. A survey conducted last year by Aware, an animal welfare organization based in Seoul, revealed that approximately 93% of South Korean adults had no intention of consuming dog meat in the future, and 82% supported the ban.

The passage of this ban marks a significant shift in societal attitudes, with Chae Jung-ah, the director of the Humane Society International Korea, noting, 'This is history in the making I never thought I would see in my lifetime.' She emphasized that societal attitudes had reached a tipping point, with most Korean citizens now rejecting the consumption of dog meat.

This legislative change aligns South Korea with other regions and countries that have already prohibited the trade of dog meat, such as Hong Kong, India, the Philippines, Singapore, Taiwan and Thailand. However, the practice remains prevalent in countries like Cambodia, Indonesia and Vietnam, where millions of dogs are still slaughtered annually for their meat, according to Four Paws, an animal welfare organization based in Austria.

The enforcement of South Korea's new ban is anticipated to be officially enacted by President Yoon Suk Yeol's cabinet. President Yoon, alongside the first lady Kim Keon-Hee, both pet owners, have been vocal advocates for the ban. Previous administrations had failed to garner sufficient support to terminate the practice, but President Yoon's administration succeeded where others had not.

The newly passed law, which received broad support in Korea's National Assembly, stipulates that individuals who butcher dogs for human consumption could face up to three years in prison or a fine of 30 million South Korean won (approximately USD 23,000) following a three-year grace period. Furthermore, breeding and selling dogs for this purpose would be punishable by up to two years in prison or a fine of 20 million won.

To support the transition away from dog meat consumption, the law includes financial incentives for dog farmers and restaurant owners who serve dog meat, requiring them to submit phaseout plans to local governments.

As of 2022, there were approximately 520,000 dogs being raised in South Korea for human consumption across 1,150 farms, with about 1,600 restaurants nationwide selling dog meat, according to lawmakers—figures considerably lower than in previous years.

Adapted from 'South Korea bans dog meat, a now-unpopular food', by John Yoon, *New York Times*, 9 January 2024

Once disgust is associated with a meat product, there is extreme unwillingness to eat it and even anger and distress at it being sold and eaten by others. When consumers in Europe were unknowingly sold beef adulterated with horse meat in 2013, many had a powerful, visceral reaction of disgust and moral offence. The resulting scandal resulted in substantial changes to industry, with adoption of routine testing and surveillance and the establishment of the National Food Crime Unit in the UK, with the explicit movement to a 'zero tolerance regime' (Brooks et al. 2017). Once 'strange meat' becomes no longer acceptable and is considered disgusting, the following lack of exposure to it also triggers neophobia, which further reduces any propensity to consume the meat.

However, although disgust and neophobia are powerful emotions, and have been involved in radical dietary transitions as illustrated by the case study (Box 6), they have not yet been investigated for their potential to reduce consumption of wild meat.

Promoting alternative sources of meat: Conventional and 'mini' livestock

In Africa, livestock and fish farming are two of the fastest-growing subsectors in agriculture, presenting opportunities for economic growth and poverty reduction in rural areas (Herrero et al. 2014), as well providing alternatives to the unsustainable use of wildlife as food. Africa's livestock population between 2010 and 2020 grew by 27%, from approximately 331 to 434 billion livestock units, with pig and poultry as the fastest growing subsectors. However, demand for livestock meat on the continent is growing more rapidly than supply and the shortfall is increasingly being met by imports (Ndue et al. 2022).

'Mini livestock', such as rabbits, are typically characterized by a high reproduction rate and so can provide at least some meat in a relatively short period. They may also complement and integrate well into agricultural and household systems by consuming household and farm waste and providing manure for vegetable plots, etc. Keeping rabbits has been demonstrated effectively in Cameroon, especially in areas where wild meat is already scarce (HPI 1996). Since such species have a long history of domestication, they also offer the advantage that methods of husbandry and veterinary care are well established. In addition, many small stock are kept and managed largely by women and youth, offering potential benefits to them. Mini livestock also have the advantage of resembling in some ways the wild meat species they are meant to replace in terms of size and morphology, which means that they fit well within traditional dishes and cooking practices. Where they suit local systems, tastes and practices, the promotion of mini livestock may, however, still require some change in mindset among public officials, investors and veterinarians away from traditional livestock species, which have typically been the basis of their training and experience. Appendix 2 provides information on mini livestock recommended for Africa and Southeast Asia.

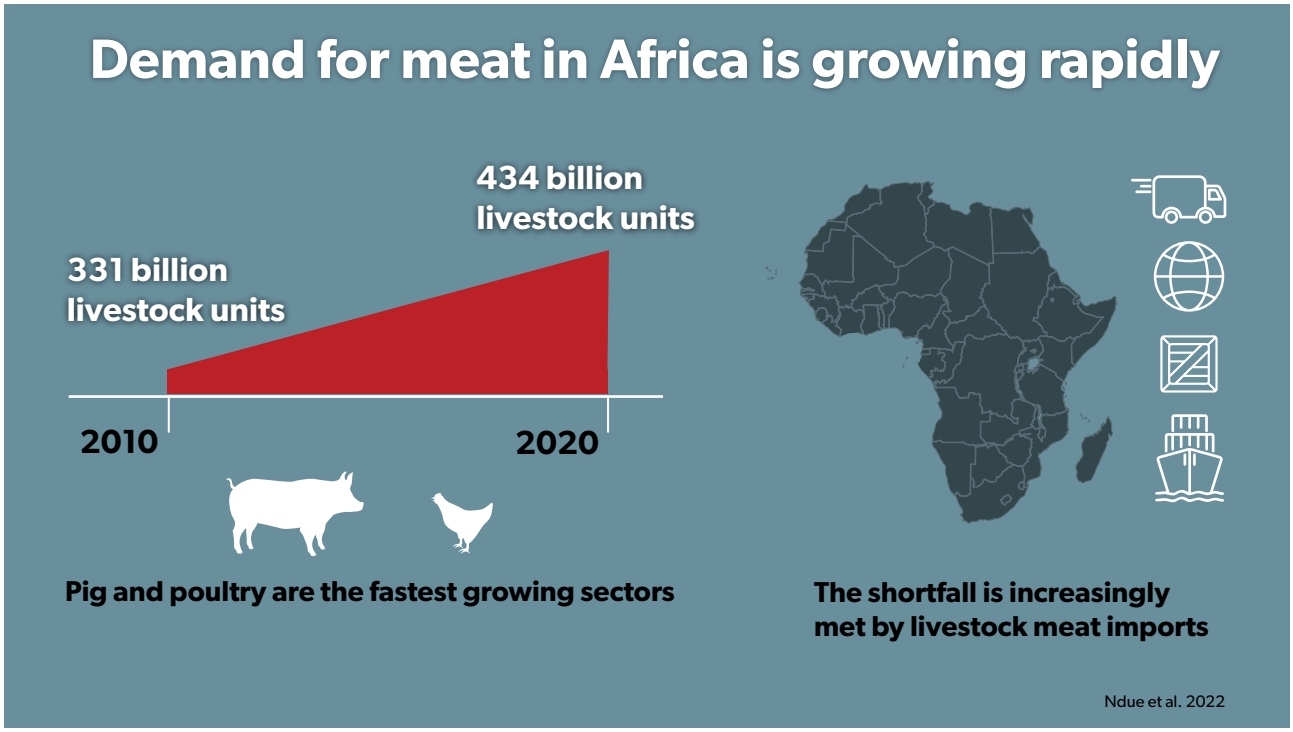
Promoting alternative protein sources: Farmed wildlife
The evidence that has been presented regarding the key factors driving the continued hunting of wild animals for meat shows clearly that, especially in Africa, the limited availability of alternative sources of meat and protein are among the most important reasons for hunting. This implies that making alternative meat sources available would reduce the demand for wild meat. Over the last 12,000 years, domesticated livestock have replaced hunted wild meat in most parts of the world. But much of Africa's forest and forest margins are environments conducive to animal diseases, especially for ruminant animals, due largely to the presence of African animal trypanosomiasis, an economically devastating disease of cattle and other ruminants that is transmitted by the tsetse fly, and also to other diseases of ruminants such as lumpy skin disease and East Coast fever, as well as to frequent and lethal outbreaks of African swine fever in pigs and Newcastle disease in chickens. The presence of these diseases makes it difficult to introduce conventional livestock in many regions of Africa, a fact that has led to numerous calls over the last half century to promote the farming of wild species (Stelfox et al. 1983; Cooper 1995; Cawthorn and Hoffman 2014; Brittain et al. 2022).

The best-known example of farmed wild animals are cane rats (*Thryonomys* spp), also called grasscutters, but giant African snails (*Achatina* spp) and even porcupines and duikers are also farmed in West and Central Africa (Steel 1994), with many initiatives started to introduce the farming of these species, without widespread uptake as of yet.

Others consider that with shrinking habitats and increasing human populations, wildlife will provide an increasingly small proportion of the diets for even rural families living in close proximity to wildlife (Wilkie 2016). The evidence available indicates that the inefficient feed-conversion ratios of wild animals and their long time to reach market weight make wildlife farming uncompetitive compared to domesticated livestock farming (Mockrin et al. 2005). Over the millennia, only a few wild animals have been fully domesticated and bred for their food; the 20 or so selected species were chosen for their docility; a tolerance of handling, crowding, and husbandry practices; and an ability to maximize their feed-conversion efficiency (the ratio of feed consumed to meat produced) and to minimize the time to reach market weight, all traits unobtainable in most wild animal species. Feer (1993) asserts that in terms of meat productivity, pigs are more productive than local cattle, which are in turn more productive than cane rats or duikers.

The limited uptake of wildlife farming for subsistence and local sale in West Africa contrasts with the success (albeit niche) of commercial ostrich and crocodile farming. Commercial ostrich farming began in the mid-19th century in South Africa, originally for feathers (for decorating hats and clothes), much later for leather, and only recently for meat (Huchzermeyer 2002). Ostrich farming became popular in many other, mainly European, countries from the early 2000s, but the only African and Asian countries to have substantial populations are South Africa (130,000 birds) and China (500,000 birds) (Kistner 2019).

Infographic 11.



Commercial production of crocodiles for skins and meat started in the late 1960s, again in South Africa (Hoffman et al. 2000). By the 1980s, programs were being developed in Indonesia and Papua New Guinea. Crocodile meat is sold mainly to restaurants as an exotic delicacy or used as unprocessed feed on farms. While this shows how some wild species can be profitably farmed, the contribution of farmed wildlife to local and national nutrition remains negligible.

As described previously, game ranching and conservancies have been successful in Eastern and Southern Africa. This is made possible where there is abundant land of low quality that is unsuitable for other uses and where there is high potential for tourism, good management capacity, and legal frameworks giving ownership (or legal use) of land and livestock to individuals, groups or companies. Some farmed species of wildlife are raised for high-end specialty restaurants or for high-value non-food uses (e.g. trophies, reptile skins, lions for zoos and private owners). Game ranching as a separate enterprise is, however, often uneconomic unless premium prices are available from tourist outlets, as in Kenya (Wilkie and Carpenter 1999), or where there are alternative commercialization opportunities, such as ecotourism, trophy hunting or live animal sales, as in South Africa (Musengezi 2010). A recent study found that profits were derived mainly from intensive breeding and ecotourism, followed by trophy hunting, and with culling the least important (Taylor et al. 2020). In all biomes, game animals produce less meat per hectare than domestic livestock, suggesting that game ranching is uncompetitive with livestock ranching if meat is the only product being produced. (Wild meat obtained in trophy hunting and culling is essentially a low-value by-product, typically sold to local butchers or ranch workers, although biltong is a high-value product).

In contrast to Africa, the high demand and high value of wildlife for food and medicine in East and Southeast Asia has led to a rapid expansion of commercial wildlife farming in that region, with year-on-year increases in the number of wildlife farms, in species diversity and in larger scale operations (Taylor et al. 2001; Cutler et al. 2010). China started to officially promote wildlife farming in the 1970s as part of the country's agricultural modernization and diversification, and its success in this was followed by other countries in the region. A 2014 survey in southern Vietnam exemplifies this trend, with nearly one million wild animals being farmed across 4,099 active sites (FAO 2015). These farms often raise a mix of species, from rodents, civet cats, pangolins, deer and primates to wild boar and reptiles, which frequently are co-raised with domestic animals. As noted, the farming of wild species in Southeast Asia and China is driven by a high demand for exotic meats and traditional medicines. Species such as bamboo rats, crocodiles, deer, snakes and turtles are farmed extensively. The perceived medicinal properties and luxury status these animals provide contribute significantly to their continued farming (Engel and Ziegler 2020).

Box 8: Case study: Wildlife farms in Vietnam

The COVID-19 pandemic, believed to have originated in wildlife, has caused millions of deaths and disruptions globally. In response, a 2021 study titled 'Dynamics of wildlife trade and wildlife policy implementation in Vietnam', funded by the CGIAR COVID-19 Hub, aimed to explore the locations of the country's wildlife trade, the people involved, their economic and cultural motivations, and potential ways to bring about change.

The study concentrated on legal wildlife value chains, specifically those involving wildlife from captive breeding facilities in Vietnam's Dong Thap Province. This area was chosen due to its extensive captive breeding operations, variety of wildlife species traded, and strong local partnerships. Data were collected in November 2021 through an online survey with 24 local experts, key informant interviews with 28 value chain actors, and a workshop with 28 stakeholders to confirm the findings.

The study found that wildlife farming facilities operated in almost all districts of Dong Thap Province, with the highest concentrations in Tam Nong, Cao Lanh and Hong Ngu City. These areas have abundant wildlife meat sources, a long tradition of wildlife farming, and are close to markets.

The province is home to a diverse range of wildlife, including over 192,394 animals. The main species farmed are civets, crocodiles, snakes and tortoises. Most farms focus on one or two species and trade locally or with neighbouring provinces such as Dak Lak, Dong Nai and Ho Chi Minh City.

Three primary wildlife value chains were identified in Dong Thap:

- **Export species** (e.g. crocodiles and pythons): This chain is straightforward and contract-based.
- **High-value species** (e.g. civets and porcupines): This chain involves more actors and operates on a smaller scale with verbal agreements.
- **Popular species** (e.g. snakes and wild pigs): Similar to the high-value chain, this chain involves more actors and relies on verbal agreements.

The people involved in these wildlife value chains are motivated by a combination of factors. Many participate to generate an income, especially those without alternative livelihoods. Some have inherited businesses or receive support from experienced relatives or friends. Access to infrastructure, feed and other resources also encourages wildlife farming. The high market demand for wildlife further motivates people to participate in these markets.

The challenges faced by local authorities in managing wildlife-related activities include scarce resources, illegal operations and low awareness of wildlife regulations among the actors in these value chains. To address these issues, the study recommends introducing alternative livelihoods, enhancing public awareness, and improving cross-sectoral cooperation. Importantly, involving NGOs and private-sector actors can also lead to more effective wildlife management.

Reference: Pham Duc Phuc, Nguyen Ngoc Ha, Ngo Hoang Tuan Hai and Thinh Nguyen. 2022. *Drivers of human-wildlife interactions: A case study of wildlife value chains in Vietnam*. ILRI Research Brief 111. Hanoi, Vietnam: Hanoi University of Public Health.

The success of wildlife farming in Southeast Asia has, however, given rise to other concerns. Farming wildlife species that are targeted for conservation creates a risk that the markets for farmed animals are infiltrated by wild-caught animals and their products sold as farm sourced. The development of markets for farmed wild animals could thus contribute to increased hunting of the same or related species, threatening the conservation of the latter and potentially increasing zoonotic risks. Similarly, expanding a previously small market for a particular species may increase overall demand for that species.

A review by Nguyen et al. (in press) indicated that the growth of wildlife farming, marketing and consumption systems in Southeast Asia raises concerns about the potential spread of zoonotic diseases (Taylor et al. 2001; Li et al. 2021b). Research showed the wildlife trade to be a significant factor in disease outbreaks within the region. A study by Huong et al. (2020) conducted in wildlife farms from 2013 to 2014 detected coronaviruses of bat origins in porcupines, bamboo rats and field rats in the trade chain, indicating the viral transmission risk among different animal species in wildlife trade and farms. Another study in Vietnam found that farming wild species was not an effective way to reduce demand for illegal

wildlife products (including, in this case, bear bile) and may instead stimulate greater demand for wild-sourced products (Drury 2009). The complex nature of the trade, combined with challenges in maintaining its sustainability and enforcing its regulations, enable the movement of potentially infected animals and their products across borders. This movement increases the possibility of introducing new pathogens, potentially leading to disease outbreaks beyond the region (Sarma 2017).

While wildlife farming can offer economic opportunities and provide a source of food for some communities (TRAFFIC 2008; Huong et al. 2020), it's important to carefully consider these benefits alongside the potential health risks. Implementing disease preventive measures that are tailored to the needs of local communities is crucial to reducing the risk of zoonotic diseases spreading from the wildlife trade.

Transitioning away from wildlife farming in East and Southeast Asia presents a complex challenge. A significant factor is the limited availability of affordable, alternate protein sources (Nasi et al. 2008). Many communities in rural areas rely heavily on farmed wildlife for meat and income (FAO 2018). Replacing this protein source with commercially raised livestock such as chicken or pork can be prohibitively expensive for low-income households. Furthermore, widespread livestock diseases in the region pose another hurdle. Foot-and-mouth disease, classical swine fever, and avian influenza are just a few examples that can devastate domestic animal populations (WOAH 2023). These threats discourage investment in traditional livestock farming, leaving some communities to view wildlife farming as a less risky option, despite the zoonotic disease risks it poses (Nasi et al. 2008).

Summary: Policies and strategies for managing wild meat hunting

Regulation and enforcement: Control and command (or detect, inspect and punish) was the traditional way of limiting hunting and marketing wild meat. Most regulation focuses on establishing wildlife reserves and banning the hunting and sales of wild meat from some or all species. Protective Areas cover 15% of global land and the Global Biodiversity Framework (2022) has the ambitious target of '30 × 30'—of protecting 30% of land and water in a representative way by 2030. However, most African and Asian Protected Areas lack adequate budgets and staff and while Protected Areas slow human incursion, they do not halt it. Anti-poaching patrols can be effective, and, in some countries, protected species are hunted less than non-protected species. In many countries, there is lack of awareness and enforcement of wildlife regulations. In others, corruption limits the implementation of wildlife regulations. In addition, many communities living close to wildlife do not accept the legitimacy of such regulations.

Market incentives: Natural experiments show the importance of incentives in shaping the wild meat sector in Africa and Asia. When African swine fever led to a mass culling of pigs and consequent shortages of pork, there was increased demand for wild meat. In the Serengeti, arrested poachers were mainly poor and those with alternative livelihoods were less likely to hunt. Increasing the price of wild meat is more likely to be effective in poor communities using wild meat for subsistence but there are few examples of interventions that rely on market incentives. Commercial wildlife ranches are common in Southern Africa (they comprise 17% of the land area in South Africa, for example), where they have been economically and socially sustainable and have increased wildlife numbers, but these ranches require large, abundant and low-population density land, high levels of management expertise, and legal changes to\hat give landowners rights over wildlife.

Community involvement in hunting bans: Locally run wildlife conservancies have been promoted since the 1970s with some successes but widespread adoption is limited to a few countries in Africa, notably Kenya and Namibia. In Kenya, conservancies protect 11% of the land area compared to 10% in state Protected Areas. Conservancies can be successful where marginal land is abundant, tourism revenue high, community management supported, and relevant legal frameworks exist. Outside these contexts, community involvement has had limited success as it is constrained by high transaction costs of engagement and limited awareness and enforcement. Nonetheless, there is widespread agreement that local communities need to be central—not peripheral—to wildlife conservation efforts, given their proximity to wildlife populations, their intimate knowledge of local wildlife, and their wildlife use practices.

Education and awareness raising: Raising awareness of wildlife trade issues is difficult to achieve, especially among the most relevant actors—hard-to-reach hunters and butchers in rural areas. During health crises associated with wild meat, such as Ebola outbreaks, there are typically sharp declines in the consumption of wild meat, although it is difficult to attribute this to public awareness campaigns as opposed to other kinds of communications. Disgust and neophobia are easily triggered by meat products and these are promising channels for changing consumption behaviour.

Livestock as an alternative food source: In Africa, livestock and farmed fish are two of the fastest growing sectors in agriculture. Africa's livestock population between 2010 and 2020 grew by 27% from approximately 331 to 434 billion livestock units: pig and poultry are the fastest growing subsectors. However, demand is growing more rapidly than supply and the shortfall is increasingly met by imports. It is likely that domestic and imported livestock will be increasingly price competitive with wild meat, removing a major incentive for hunting. In East and Southeast Asia, however, wild meat consumption is not driven by protein or meat scarcity, outside of some poor, remote areas, so this is unlikely to be an important consideration there.

Farmed wild animal species as an alternative to hunting: In a context of shrinking wild habitats and increasing human populations, it seems inevitable that wildlife will provide an increasingly smaller proportion of the diets even of rural families living close to wildlife in Africa. Despite decades of promotion, most farmed wildlife (e.g. cane rats and giant African snails) are still caught in the wild. In Southeast Asia, in contrast, wildlife farming has seen continuous growth driven by high-value wildlife products, high demand, and skills in farming wild animals. However, this has given rise to further concerns: a) wildlife farming allows the laundering of wild-caught animals, b) farming wildlife may stimulate increased demand for wild-sourced wildlife products, and c) farmed wildlife may be especially risky as sources of zoonotic pathogens.

Recommendations

Recommended strategies

There is little consensus on what are likely to be the most effective means of managing wild meat hunting while addressing the needs of rural communities. The starting point would be a blueprint of how to safely butcher/slaughter wild animals depending on the species and category. An ideal gold standard would be the following method used for both export as well as informal wild game meat value chains. Firstly, identification of a healthy animal that is shot humanely for compliance with animal welfare protocols. The throat is severed on site to enable speedy exsanguination into the surrounding field. The carcass is then loaded for transportation in an open truck ideally but can be carried to a spot where it is offloaded and hung at an approved mobile abattoir or alternatively to a spot nearby without a structure or at a registered abattoir. The primary meat inspection is then conducted using the parameters of best practices. First the head is removed followed by the legs and feet. These are examined for zoonotic diseases before being discarded or entering the informal market for trade. The next step is the evisceration of the carcass, here the pluck, rumen and intestines are examined before being removed and transported to be included into the informal chain for the markets. The stomach content can be emptied and used to make compost or sent to the vulture restaurants where the vultures feed. Most often the stomach and intestines are given to the helpers and staff or alternately it enters the markets via informal traders to be cooked into a stew and sold to passing traders and truck drivers. The carcass is then ready after inspection for weighing, labelling and loading into a refrigerated truck fitted with a thermo logger to record maintenance of the temperature and any fluctuations that could compromise the shelf life and safety of the product, during transportation to the export registered abattoir. If the carcass is for local and informal trade and consumption then it is not loaded, and the skin is removed on site and sent for drying to be used as traditional attire or sold to traders as rugs and wall hangings. The rest of the carcass is then cut into quarters and sold immediately or refrigerated and sold daily to be cooked on open fires for rural trade and markets. On the other hand the carcass intended for export is off loaded at the export abattoir, refrigerated immediately and skinning takes place when scheduled. The trimming of the exposed edges is first undertaken followed by the skinning of the entire carcass done hygienically within a controlled environment thereby rendering it safe for public health. The secondary meat inspection for wild game is unlike that for livestock whereby the wild game carcass is only skinned after being received at the export abattoir. The skin is then taken to the tannery and the condemned portions are incinerated. The carcass is then deboned, and prime cuts are packaged for export with compliance to country of destination requirements. If sold locally it is packaged and distributed to wholesalers and retailers for sale in supermarkets, butcheries and other food outlets like restaurants and sports bars. The off cuts are used for processing of other wild meat products especially biltong, a dried meat snack very popular in South Africa that can be considered a protein substitute for potato chips or crisps. The local sale of wild meat products is closely monitored by the environmental health personnel for compliance with hygienic standards of food safety especially for public health. Until recently most authors have focused on biodiversity and conservation, with little attention to zoonotic risks. For example, a major report to the British government on research recommendations for wild meat does not mention zoonotic risks (Brown et al. 2007). Recent analysis by Booth et al. (2021a) shows the importance of wildlife hunting and trade generally for meeting several of the United Nations' 17 Sustainable Development Goals in diverse ways, including by facilitating synergies among them. Thelimited benefits in terms of reduced zoonotic risk. For example, increased livestock production to replace the loss of wild meat could significantly increase deforestation and require some 124,000 km^2 of additional agricultural land (Booth et al. 2021b).

Overall, given the interdependencies of livelihoods, food security, markets and zoonotic risks, it appears that an integrated strategy is needed (Box 9), one that specifically recognizes the objectives of: a) wildlife conservation and biodiversity, with attention to valuable and vulnerable species; b) livelihoods associated with wild meat value chains, at least in a transitional period; c) food security and access to animal protein and micronutrients, specifically in rural hunting and vulnerable communities; and d) zoonotic risks, awareness and the practices that affect them and those species that pose the greatest hazards. Nevertheless, the feasibility of implementing such an integrated strategy—in terms of obtaining the necessary resources, stakeholder interests, political will and legislative frameworks—needs to be assessed (Booth et al. 2021a).

Box 9: Towards an integrated strategy for wild meat use: ecological, epidemiological, human well-being and animal welfare considerations

When prioritising wildlife three paradigms have dominated. The first is ecological, which categorises wildlife according to aspects relevant to biodiversity and role in the ecosystem. Ecological categories include indicator, keystone, umbrella and flagship defined as follows:

- Indicator species: act as proxy for, the state of an ecosystem or of a certain process within that ecosystem e.g. crayfish as indicators of freshwater quality.
- Keystone species: play an essential role in the structure, functioning or productivity of a habitat e.g. elephants in maintaining savannah habitats.
- Flagship species: selected to act as an ambassador, icon or symbol for a defined habitat, issue, campaign or environmental cause. Flagship species are often "charismatic megafauna" that is large terrestrial mammals whose preservation elicits strong public support (e.g., pandas, lions, elephants).
- Umbrella species: chosen because when protected this indirectly protects other species which share the same habitat e.g. wide-ranging species such as the Amur tiger. Umbrella species are often keystone or flagship species.

A second, but much less prominent approach, is centred on human well-being and considers the benefits of wild meat especially to vulnerable communities. From this perspective, wildlife species are prioritised according to their contribution to livelihoods and nutrition, with an emphasis on sustainability and safeguarding long-term benefits. As described in this report, this aspect has been neglected and there is often a disconnect between the ecological and conservation communities on the one hand and development researchers and practitioners on the other.

In recent years, following major outbreaks of avian influenza, Ebola virus disease, COVID-19 and mPox, disease considerations have become more important. From an epidemiology perspective, species prioritisation focuses on the role of animal as a reservoir host for known, endemic zoonoses (such as brucellosis or rabies), or its potential as a source of new pathogens that could spillover from wild animals, or its ability to act as a "bridge" or secondary host which can act as stepping stone in the transmission from animals to people.

Animal welfare is not usually a direct consideration in wildlife prioritisation, although it is a major concern of the public, especially in high income countries but increasingly in low-and middle-income countries. Animal welfare concerns are based on the number of animals experiencing negative emotions and the level of negative emotion experienced. A common ethical framework, originating in research is the 3Rs which aims to Reduce the numbers of animals used, Refine how animals are used to keep any pain and suffering to a minimum, and Replace where possible more sentient animals with less sentient or non-sentient alternatives. Applying this to wild meat, it is preferable to obtain meat from larger animals as this requires fewer animals to experience negative emotions, for example, an eland produces about 400 times as much meat as a guinea fowl so producing the same amount of meat requires keeping and killing far few individuals. Similarly, all else being equal, larger and longer-lived animals should have higher priority, because they animals tend to have more complex nervous systems, and thus be more likely to be sentient and to have the capacity for more happiness and suffering. Likewise, animals with longer lifespans will tend to be able to experience more happiness and suffering across time. Priority is also influenced by social networks of animals and the consequent disruption caused by culling of individuals. In many wildlife species, culling can lead to changes in behaviour, immunological response, movement frequency and dispersal propensity, which have long-term implications for health and welfare. In highly social and highly sentient animals such as elephants such culling-related perturbations have been shown to persist for decades (Shannon et al., 2013).

We recommend an Eco-Epi-Well-Wel approach which integrates all four goals including trade-offs and synergies (Ecological betterment, reducing Epidemiological risk for people and animals, improving Wellbeing of people, and Welfare of wild and domestic animals). One Health, with its emphasis on system thinking and collaboration across sectors and integration of social economic and environmental factors, provides an ideal implementation framework for this new approach.

Elements of such an integrated approach could include the following.

- **Adopt a community-based approach.** Although a community-based approach faces resource constraints, among other barriers, because wild meat hunting is primarily locally driven, local communities need to be part of decision-making and given authority and responsibility for managing the wild meat trade. In addition, zoonotic risks are likely to occur mostly at the community level, where hunting and butchering mostly happens. The type of community-based authority that is feasible and effective may depend in part on the legislative frameworks available.
- **Differentiate local from commercial hunting.** The evidence is relatively clear that hunting small robust species (e.g. duikers and rodents) can be sustained, even in partly degraded forests, and that what Kurpiers et al. (2016) refer to as the 'farmbush' can provide a significant supply of protein, the demand for which has been shown clearly to be the main driver of hunting. With support from local communities, attention and monitoring should be on controlling commercial-scale hunting and the hunting of vulnerable (slow-reproducing) species, both at source and in markets. This would provide a continued supply of meat to rural communities and some degree of local livelihoods in wild meat value chains.
- **Raise awareness.** Engagement with local hunting communities should take the same integrated approach, highlighting the importance of limiting hunting to certain robust species, to obtaining alternative or supplementary sources of protein wherever possible, and, importantly, to understanding the zoonotic hazards of the wild meat trade and how to mitigate the resulting risks. That could include information on which species pose the greatest zoonotic risk and the best practices for butchering, handling and cooking wild meat (Friant et al. 2015). Following formative research to understand local practices, this communication could take the form of social marketing (Drury 2009), with specific attention paid to women, who are typically responsible for household food preparation and whose role in wildlife hunting is often neglected (Lowassa et al. 2012). Information campaigns in urban areas could similarly highlight the importance of transitioning to livestock meat to help conserve wildlife and to reduce the zoonotic risks of wild meat handling and consumption.
- **Better enforce wildlife laws.** Providing adequate resources to Protected Areas, including investing in new technologies such as drone surveillance, to prevent wildlife crimes is crucial, as is enhancing the saliency and governance of wildlife.
- **Support successful wildlife management.** The evidence from multiple sources is clear that game ranching in Southern Africa and conservancies in Kenya and Namibia have been successful in reducing poaching, increasing wildlife numbers, and generating benefits for local communities (although the contribution of game ranching to food production on a national scale is minimal and even on marginal lands wild game produce less meat than livestock farming). These wildlife management strategies should be supported by national governments, NGOs and donors where conditions enable success.
- **Encourage alternative protein sources.** Reducing the costs of domestically produced acceptable protein in Africa and Asia by supporting livestock and fish farming and facilitating national and regional livestock and fish trade will reduce demand for wild meat.
- **Improve monitoring and surveillance.** Wild meat as a category distinct from game meat (which includes ranching) should be integrated into national and international data collections and statistics (including FAOSTAT). Data collection systems focused on wildlife conservation should include zoonotic disease monitoring, rural poverty and human nutrition, and changes in land use and livestock keeping incorporating participatory/community-based methods and using risk-based approaches. Improved monitoring of trade can benefit from new technologies such as RFID tagging, blockchain and DNA analysis.
- **Commit to the Global Biodiversity Framework (2022) target of '30 × 30'.** Protect 30% of land and water in a representative way by 2030, a target that will not be met without considerable additional investments.
- **Monitor passenger movements.** Require all travellers in the Global South to declare to border control authorities any food, animal materials or plant products they may be carrying under penalty of a heavy fine, similar to such enforcement in high-income countries.
- **Employ One Health.** Adopt a multi-sectoral, One Health approach involving wildlife and conservation sectors to collaborate and collectively come up with solutions to wildlife meat management.
- Specifically, adopt a new Eco-Epi-Well-Wel which integrates Ecological betterment, reducing Epidemiological risk for people and animals, improving Wellbeing of people, and Welfare of wild and domestic animals.

Recommended research

The following are some research ideas emerging from this review.

- Within studies on zoonotic spillover events, viruses have received the most attention; direct more research at spillovers from bacterial or other non-viral pathogens.
- Much of the research on wild meat hunting and value chains has focused on West and Central Africa. Gain broader understanding of wild meat practices, species and zoonotic disease threats across all parts of Africa and East and Southeast Asia to better target interventions and to promote cross-site learning.
- Further target research to ensure better information is available, particularly around consumer demand, risk drivers, practices and trade routes.
- Continue research on the impact of agrifood system drivers on wildlife and wild meat (demographic, socio-cultural, environment, geo-political).
- Given the dramatic lack of awareness in many hunting communities of the actual zoonotic hazards associated with wild meat and also of best practices for mitigating risks, undertake formative research to understand the sources of zoonotic risk knowledge and drivers of behaviour, followed by piloting and evaluating the effectiveness of targeted social marketing campaigns.
- Recent years have seen many research, development and policy initiatives to improve food safety in traditional, informal food systems. Learnings from these (especially training value chain actors, simple technologies, and introduction of incentives to improve hygiene) are relevant to de-risking of wild meat chains.
- Explore the potential of reducing demand for wild meat by creating or triggering food disgust and food neophobia.
- Consider digital and technological innovations as well as participatory/community-based approaches to improve wildlife monitoring, surveillance and crime detection (e.g. drones, artificial intelligence, blockchain, tagging, DNA analyses).
- Since evidence of the success of community-based approaches to managing wild meat hunting is mixed and still emerging, undertake cross-site and cross-country comparisons to determine best practices and the resource, legislative and regulatory environments needed to facilitate success.
- Conduct research into the links between livestock keeping and reduced wild meat hunting and how these patterns differ across production systems and settings. For example, do livestock constitute a direct consumption effect on wild meat or a wealth effect? Employ a spatial econometric approach where data are available.
- Employ specialized survey and monitoring techniques to elicit accurate information both on wild meat activities and wild meat consumption that respondents may consider illegal and on their associated zoonotic risk-related activities. Conduct research to assess and improve these tools, particularly where information is gathered as part of community-based management.

Appendix 1: Wild meat value chains

People and practices in the wild meat value chain

Brown et al. (2007) note the following characteristics of the wild meat value chain system.

- Generally high social inclusivity due to few barriers to entry such as capital costs, relatively low risk and the fact that skills can be obtained through familial and community ties. Kinship networks can be important for market entry and access to credit and to low-cost family labour.
- Wild meat value chains comprise many actors: hunters and traders (including long-distance traders), restauranteurs and traditional 'chop bar' owners, and venders, retailers and exporters.
- When smoked, as it often is, wild meat can be stored for relatively long periods, is easily transported and has a high value-to-weight ratio.

Wild meat value chains as described in the literature vary widely by region, market and environmental setting (Table 6). Participation in wild meat supply chains can be widespread. Abernethy and Obiang (2010) found that around 11% of all Gabonese families make some money from the wild meat trade in some way. In the many locations where wild meat is consumed, mostly by hunting households and their communities, the chain is very short. Longer and more complex chains of three to four steps occur where there is market demand and/or access to urban markets. Commercial or farmer rural hunters may supply traders, who are often women (Green et al. 2024; Jenkins et al. 2024) operating along roads to urban centres, or wholesalers using vehicles to serve restaurants (either chop bars and other simple roadside eateries or higher end specialty restaurants) or retailers, also typically women, who sell foods in open air markets or market stalls (Gideon 2014; Saylors et al. 2021; van Vliet et al. 2022). Supply can also be across international borders (Morrison-Lanjouw et al. 2023; Wood et al. 2014). Ethnomedicine sellers also play a role, and in Nigeria, Soaga et al. (2014) found that they outnumbered wild meat retailers. The importance of chop bars at the end of the value chain is highlighted in several studies in West and Central Africa (Cowlishaw et al. 2005; East et al. 2005; Brown et al. 2007; Ebersole et al. 2023). Commercial group hunters may deliver in bulk directly to middlemen (Eniang et al. 2008; Tagg et al. 2018), and in South Africa, Martins and Shackleton (2019) reported no visible wild meat markets, with hunting occurring instead with orders from customers. Typically, market activities are largely unregulated, although sellers may pay local market licenses. In Cross River State, Nigeria, Eniang et al. (2008) found that market actors took steps to avoid authorities where wild meat trade was banned or restricted by relying on early morning and weekend sales by hunters to traders.

Table 6. Actors in African and Asian wild meat value chains

Location	Actors	Source
	Hunters	
Lagos State, Nigeria	All men, 21–40 years old	Alade and Onadeko 2017
South Africa, 20 sites	Mostly men or adolescent boys	Martins and Shackleton 2019
Tanzania	91% men, but women trapped birds, etc.	Ceppi and Nielsen 2014
Togo	Total estimated hunters were 29.3 ± 14.7 (n=352) All men 25–62 years old	Sonhaye-Ouyé et al. 2022
Cameroon	All men	Tagg et al. 2018
Kwara State, Nigeria	90% men 60% 31–40 years old 45% had no formal education 80% practised Islam	Babalola et al. 2023
Uganda	Hunters were generally younger adults (33 years ± 10.9); 76.1% had only a primary education Women were household cooks with an average age of 37 (± 14.2) years; 59.9% had a primary education	Dell et al. 2020
North-central Nigeria	18.4% of persons interviewed were hunters	Alhaji et al. 2022
DRC (Weko to Yagambi)	All men 25–40 years old	van Vliet et al. 2022
Cambodia, Indonesia, Laos, Vietnam	Mostly men	TRAFFIC 2008
Myanmar	All men, aged 16–67 years old (median age = 33 years) 88% had finished primary school or a lesser equivalent	Evans et al. 2020
Vietnam	Primarily males 10–40 years old, most active in their 20s and 30s	Drury 2011
Laos	Dominated by men, with supportive roles by women	Johnson et al. 2016
Indonesia and Malaysia	Boys as young as 10 years old	Nasi et al. 2008
Cambodia	Primarily men while women were involved in processing and selling the meat	Gray et al. 2017
Philippines	Mostly men but women took part in the hunting and trapping alongside men	Garcia and Sheherazade 2016
	Traders and marketers	
Lagos State, Nigeria	78% women, adults 41–60 years old	Alade and Onadeko 2017
Takadori, Nigeria	60% of marketers were male, 30% were 31–40 years old	Gideon 2014
Akwa Ibom State, Nigeria	55% men, 81% were 21–40 years old, 68% were literate	Jacob et al. 2018
Ogun State, Nigeria	69% women, 87% of the traders had poor education	Soaga et al. 2014
Ibo State, Nigeria	Almost 100% women doing processing and marketing; 50% were 41–50 years old, 60% had some formal education	Igene et al. 2013
Libreville, Gabon	Sellers of wild meat were 100% women, assisted by their daughters	Steel 1994

Location	Actors	Source
Yaoundé, Cameroon	Most venders were women, with some men	Ellis 2000
Kwara State, Nigeria	80% retailers and 85% wholesalers were women, 30% 31–40 years old 46.7% of the wholesalers had no formal education; 75% of the retailers had attained secondary school 66.7% of the retailers were Islamic; 70% of the retailers were Christian	Babalola et al. 2023
Cameroon Côte d'Ivoire Benin	63.6% of vendors were women; most vendors had a college-level education 98.8% of vendors were women; most vendors had no or primary-level education 71.7% of vendors were men; most vendors had no or primary-level education	Gaubert et al. 2024
Cameroon	Over 70% of vendors were women Average age of traders: 37.5 ± 5.7; vendors: 36.8 ± 5.8; meat cleaners: 25.0 ± 4.8	Randolph et al. 2022
North-central Nigeria	16.3% of persons interviewed were vendors	Alhaji et al. 2022
DRC (Weko to Yagambi)	Ages of the market traders ranged from 29 to 45 years	van Vliet et al. 2022
	Slaughtering wild animals was positively, but not significantly, associated with being male	Evans et al. 2020
Cambodia	Men 30–40 years old primarily managed the logistics of trading and transporting wild meat to markets	Gray et al. 2017
Laos	Women were frequently seen selling wild meat in local markets, often working alongside their male counterparts or independently	Johnson et al. 2016
Indonesia	Entire families were involved in the wild meat trade, with men handling hunting and transportation while women managed sales	Wadley and Colfer 2004
Vietnam	Traders ranged in age from young adults to middle-aged; Men dominated the trading roles with women in the marketplaces	Drury 2009
Cambodia, Indonesia, Laos, Vietnam	Processors and retailers were usually the same people	TRAFFIC 2008

However, these supply linkages are flexible and opportunistic and may not include all links in the chain. For example, in Lagos State, 74% of hunters sold exclusively to wholesalers or traders, but the rest sold directly to end consumers (Alade and Onadeko 2017). In Gabon, around half the catch was found to be commercialized, with a smaller share (18%) entering a recognized market chain—being sold at fixed wild meat markets. Much of it is sold by commission-order hunters or opportunistically on roadsides or to restaurants (Abernethy and Obiang 2010).

In a study in Taraba State, Nigeria, which the author suggests is typical of many parts of West Africa, wholesalers comprise the smallest group of market actors but handle the largest per capita market share, with chop bars being the most numerous group, accounting for 85% of retail sales (nearly all of the proprietors being women) (Gideon 2014). Kin support networks play important roles, such as with market entry; almost half of all wild meat traders inherit their business, use low-cost family labour and share knowledge and credit. In an example of the estimated returns along the supply chain, Gally and Jeanmart (1996) traced the profits from the sale of three monkeys killed: the hunter made 30% profit, the trader 19% and the restaurant 21%. This demonstrates that, as is typical in rural supply chains, a relatively small share accrues to the primary source, in this case the hunter. In Gabon, it was found that carcasses of wild meat may double in value between initial sales by the hunters and the price paid by retailers in the capital (Abernethy and

Obiang 2010). In the DRC, van Vliet et al. (2022) reported that hunters deliver part of their meat to transporters who in turn transport the meat to traders in Yangambi. The hunters use what has not been sold for family consumption and these mostly consist of small animals, cooked viscera, and the heads and legs of the hunted animals. In Togo, great apes are hunted for consumption and sale (61%) or specifically for profit by 25% of the hunters, who deliver the wild meat to traders via porters and are facilitated by middlemen, including forestry administration personnel (Tagg et al. 2018). In Nigeria, 66.7% of hunters sold their meat directly to wholesalers, while 13.3% and 20% sold directly to consumers and retailers, respectively (Babalola et al. 2023). In Côte d'Ivoire wild meat was mainly supplied to restaurants and households by commercial hunters (84.8%), wild meat traders (12%) and subsistence hunters (3.25%), indicating the vital role wild meat plays in income generation among commercial hunters (Kouassi et al. 2023). In Ghana, 60% of the total biomass transiting through local markets was intended for other locations, with up to 98% of local traders selling exclusively to distant market traders (Sackey et al. 2022).

Some of these occupations are sidelines to other sources of incomes, including salaried jobs. In Nigeria, Alade and Onadeko (2017) found that most traders had other occupations, such as working as civil servants, teachers or clothing merchants. This extends to hunters as well. Noutcha et al. (2016a) found that in Rivers State, Nigeria, nearly 70% of hunters were involved in other occupations and only 30% were unemployed before taking up hunting. More than 35% of vendors were civil servants. In Togo, 66.7% of hunters were engaged in farming and 7.8% in fishing; 6% were gatherers, domestic farmers and healers, and 13.7% were employed (Tagg et al. 2018). Traders reported by Tagg et al. also had other sources of income, including agriculture (82%), small enterprises (9.1%) and beekeeping and poultry keeping (each 4.5%). A study of determinants of income among wild meat traders in Akwa Ibom State, Nigeria, found that better educated men generated higher wild meat incomes than other traders (Jacob et al. 2018).

Wild meat trading, at least for domestic markets, may nevertheless be regarded as a low status occupation, as Gideon (2014) points out it is in Nigeria, but one that may depend on the level of individual achievement. The author also suggests that there is little evidence of market power by individuals or groups of market actors through collusion.

Similarly, in Asia the wild meat value chain is a complex network involving various actors, each with distinct roles, livelihoods and practices. These actors range from hunters and farmers to traders, middlemen, butchers and consumers, both local and international (Song 2008; Campbell et al. 2022). Hunters are primarily rural inhabitants who depend on wild meat for subsistence and income. They typically live in or near forests and other wildlife-rich areas. In regions such as Southeast Asia and parts of India, hunting is integral to the livelihoods of indigenous and local communities, which have limited access to alternative sources of protein and income (Rao et al. 2011). The income from selling wild meat can be substantial, often surpassing earnings from agriculture or other local employment options (Bennett and Rao 2002). Hunters generally see higher profits than traders due to the latter's additional costs for transportation, fines and bribes (Nasi 2021). Hunting methods vary widely, from traditional techniques including traps and snares to more modern practices involving firearms. The intensity and methods of hunting can significantly impact local wildlife populations. In some areas, organized hunting expeditions are common, targeting specific species for their high market value (Rao et al. 2011). Pangolins and wild pigs were targeted due to their high market value, prized as meat, pets or ingredients in traditional medicine (MacMillan and Nguyen 2013). In rural areas, particularly those with high childhood malnutrition rates (Pruvot et al. 2019), hunting remains a vital source of subsistence and food security for many communities. In urban settings, consuming wild meat is often associated with luxury and prestige, seen as a healthier alternative to farmed animal products or simply more 'natural'. Wildlife is hunted for sale to urban markets, particularly in China and Vietnam, but also across Southeast Asia (Lee et al. 2014; Greatorex et al. 2016; Sandalj et al. 2016; Haffner 2020).

The overall evidence available, however, suggests that local consumption and nutrition needs are also important (Thomas-Walters et al. 2021; Zyambo et al. 2022) and that incentives for hunting are complex and vary significantly by location. There is evidence to indicate that in some settings, particularly in those parts of forested Africa that have little to no tradition of livestock keeping, wild meat is often the most readily available and least-cost meat. The large investment costs needed to establish some types of livestock production may also be a barrier to supply when wild meat is relatively available. Other studies (Nasi et al. 2008; Takforyan 2001; de Mérode et al. 2003) show that most people in tropical forests hunt and that meat sales within the community can be significant (30% in Cameroon, up to 90% in the DRC), suggesting that external markets may not uniformly be a key incentive for hunting but that intra-community transactions also play a role.

Table 7. Destinations of wild meat in selected African and Asian countries

Country	Wild meat destination		Source
	Locally consumed/traded (%)	Externally sold (%)	
Cameroon	34	40	Delvingt 1997
Cameroon	68	14	Dounias 1999
Cameroon	58	38	Delvingt et al. 2001
Cameroon	63	15	Takforyan 2001
Congo	28	68	Delvingt 1997
Central African Republic	45	35	Delvingt 1997
DRC	10	90	De Mérode et al. 2004
Equatorial Guinea	57	34	Fa and Garcia Yuste 2001
Northern Congo	The rest	36–52	Wilkie and Carpenter 1999
Equatorial Guinea	29	68	Fa and Garcia Yuste 2001
Côte d'Ivoire	93.5	6.5	Kouassi et al. 2023
Global South	87	2	Nielsen et al. 2017
China	23	77	Nijman 2010
Malaysia	80	20	Nijman 2010
Vietnam	98	2	Nijman 2010
Vietnam	80	20	Pham et al. 2021

Hunters

The wild meat value chains start with hunting. The multi-country and multi-continent analysis by Nielsen et al. (2017) shows that wild meat hunting is widespread and common in the tropics but varies significantly by location and is more prevalent in Latin America and Africa—corresponding to larger forest zone populations—than in Asia. For Africa overall, among sampled households in their dataset, there was 44% prevalence of hunting, from a low of 3% of sampled households in Ethiopia to a high of 97% in Cameroon (Nielsen et al., 2017). Another study by Nielsen et al. (2018) based on a survey of some 8,000 households across 24 countries in the Global South found that 39% of households consumed wild meat, representing 150 million households.

Table 8. Prevalence of hunting in sample communities in Africa and Asia

Location	Proportion of community that hunts	Source
Gabon	Over 70% of rural families	Abernethy and Obiang 2010
Africa, selected forest margin sites	44% of rural households on average across sites	Nielsen et al. 2017
Tanzania, Manyara ecosystem	10% of respondents (higher among Maasai than others)	Kiffner et al. 2015
Cameroon, selected sites	42% of rural respondents	LeBreton et al. 2006
Malawi	4–19% of the population	Van Velden et al. 2020
South Africa	8%–82%	Martins and Shackleton 2019
Cameroon	64%	Tagne et al. 2022
Cambodia	27% of households reported hunting (n=33)	Ibbett et al. 2020
Thailand	9% of the respondents (n=372)	Suwannarong et al. 2021
India	33% of the respondents (n=183)	Gubbi et al. 2012
Laos	18% of the respondents (n=320)	Johnson et al. 2003
China	18% of the respondents (n=1267)	Monagin et al. 2018

The type of hunting employed influences the types of species hunted, but is also driven by species availability, although not all hunting methods may be locally available (e.g. guns). Greater importance of land species means easier hunting via snares. Hunting with guns facilitates more selective and efficient hunting of large-bodied and arboreal animals, particularly daytime hunting of primates. Nocturnal hunting with shotguns is practiced commonly when hunting duikers.

Animals are often killed in proportion to their presence and not necessarily targeted. This creates some degree of 'by-catch' since all animals are killed if encountered, even if rare and/or protected by law, although in many cultural settings, any animal caught can typically be eaten or sold for meat (in the Fang language of southern Cameroon and northern Gabon, the same word is used interchangeably for meat and animal). Snaring, using wire cables, local plant fibres or tough plastic snares is regarded as the most widespread method but may be wasteful and is non-selective of species. Some 27% of snared animals are reported in one study to be lost to decomposition and scavenging due to the inadequate frequency of monitoring of snares (Noutcha et al. 2016b). In Nigeria there are reports of groups of hunters using trained hunting dogs and hunting for several days at a time, with the meat products being preserved along the way (Eniang et al. 2008). Across several sites in South Africa, a review by Martins and Shackleton (2019) reported the use of wire snares, but the favoured method (up to 80%) was hunting by groups of men and boys with dogs and clubbing the cornered animals. Guns were reported used less frequently: 11% of the time. Similarly, a study by Ibbett et al. (2019) revealed that dogs were the primary hunting method employed by hunters in Cambodia, with 87% of the 60 surveyed individuals using them. Other commonly reported methods included slingshots (47%), snares (13%) and crossbows (3%). Notably, 35% of current hunting households utilized several methods to capture wildlife. The study also found that respondents generally perceived guns as being used by outsiders or authorities, such as police or military personnel. Several participants reported witnessing soldiers using guns to hunt primates. Additionally, one respondent described seeing men with rifles in four-wheel-drive vehicles equipped with coolers to transport the hunted meat. In one instance, a participant even admitted to borrowing a gun from the police to shoot a black-shanked douc langur (*P. nigripes*). In India, Gubbi et al. (2012) found a diverse range of hunting methods employed in the area. Notably, traditional techniques dominated, with 85% of respondents using methods including snares, scavenging kills from predators like dholes, hunting dogs, and smoking animals out of hiding spots. However, a significant portion (36.7%) of respondents also acknowledged using modern methods for hunting, such as firearms, explosive baits, and blinding prey with bright lights, methods that are typically used to target larger animals that yield more meat, such as gaur, sambar deer, wild pigs, langur monkeys, mouse-deer, barking deer and sloth bears.

The non-selectivity of many hunting methods implies that efforts to reduce hunting of certain species for either conservation or zoonotic risk mitigation reasons are

unlikely to be effective. On the other hand, the association of certain hunting methods with some species may also provide opportunities: reducing access to guns and ammunition may reduce the hunting of some primates and large-bodied species.

The choice of hunting method is likely driven by the return to effort, material and labour. Blake (1994) compared estimated rates of return to alternative types of shotgun hunting in a logging concession in northern Congo. The estimated rates of return for hunters travelling into the forest by vehicle was higher than those for hunts conducted on foot from settlements because animal densities increased with distance from settlements. In addition, night-time flashlight hunting was more efficient than daytime shotgun hunting due to reduced fear/awareness of game. They found that in these settings, rates of return to shotgun hunting are 7 to 25 times higher than those for hunts using traditional weapons such as bows and nets, results also found by Wilkie and Curran (1991). Hunters' access to guns may be increasing in part as a by-product of civil strife and in part because of the increase in the supply of ammunition and shotguns by professional wild meat traders (Gadsby 1990). In rural sites in Cameroon, Lebreton et al. (2006) found that most hunters used wire snares (81%) and 31% used guns. In Asia, the earliest method involved teams of hunters strategically positioning large rocks to crush animals in vulnerable areas, like narrow trails (August and Burian 1963). This method likely targeted ibexes along with other techniques, such as ambushing animals or forcing them into deep snow. As technology development progressed, hunters utilized more sophisticated tools such as spears, darts with stone or bone tips, batons, slings and daggers crafted from animal bones. Hunters also employed more elaborate techniques and used nets, traps and other tools for hunting. They dug and concealed deep pits, or herded animals into marshes, swamps or dead-end canyons to secure large kills (Derevianko 2011). A study by Johnson et al. (2003) in Laos found that guns were the most common method reported for capturing most wildlife, followed by snares. The availability of firearms significantly influences hunting methods. In regions with widespread gun ownership, firearms become the preferred tool. Conversely, stricter gun control regulations, as seen in some parts of Southeast Asia, such as in Indonesia and Vietnam, can lead to a rise in alternative methods such as snares (Harrion et al. 2016).

Wild meat hunting is often associated with logging concessions and the new roads that are inevitably built to support them. These have become significant drivers of wild meat extraction. The new roads increase hunters' access to deeper parts of the forest, typically in gun hunting, lowering transport costs to markets, including on returning logging trucks, and the logging settlements increase the demand for wild meat (Wilkie and Carpenter 1999; Wilkie et al. 2000; Bowen-Jones et al. 2003). Blake (1994) found that rates of return to hunting were higher outside of logging concession areas, where hunting pressure was still low, but also declined quickly with time (25% over a three-week period). The expansion of logging is closely intertwined with the dynamics of wild meat hunting in those parts of Central Africa and Southeast Asia where logging of new forest remains important. A study by Johnson et al. (2003) in Laos found that logging activities can fragment and degrade wildlife habitats, impacting animal behaviour and food sources. This can force animals into smaller areas, making them easier targets for hunters. Other studies also found associations of remoter forest with better hunting. In Gabon, an analysis found that snare catch rates for larger bodied, commercial species were highest in traps furthest from the village, in good quality forest, with low hunting pressure (Coad 2007).

Wildlife farmers

In East and Southeast Asia, although not in Africa, there has been widespread adoption of wildlife farming for meat and other products. Wildlife farmers in Asia come from both rural and urban backgrounds. In rural areas, wildlife farming often serves as an additional income source alongside traditional agriculture. In urban settings, wildlife farms can be more commercialized and integrated into broader economic activities, such as tourism and trade (Dutton et al. 2011). While wild species such as civets, softshell turtles, deer and porcupines are commonly raised for food (Bell et al. 2004; Zhang et al. 2008), other animals are farmed for medicinal or other purposes. These include crocodiles, peafowl, Asiatic black bears (*Ursus thibetanus*), cobras (*Naja* sp.) and even tigers (*Panthera tigris*) (Harrison et al. 2016). The primary motivation for engaging in wildlife farming is economic. Farmers are driven by the high market demand for wildlife products, including meat, skins, medicinal products and exotic pets. This demand is particularly strong in countries such as China, Malaysia, Thailand and Vietnam, where wildlife products are highly valued in traditional medicine and luxury markets (Nijman 2010). In many regions, wildlife farming is influenced by traditional practices and cultural beliefs. For example, in China, bear bile farming is rooted in traditional Chinese medicine, where bear bile is believed to have medicinal properties (Feng et al. 2009). Similarly, farming certain bird species for songbird competitions and religious ceremonies is common in Indonesia (Robinson et al. 2016). In Vietnam, the government promotes captive breeding of wildlife to reduce pressure on wild populations, though captive-wildlife farming does not necessarily reduce demand for wildlife products (Elves-Powell et al. 2023). A policy framework regulates the growing number of commercial wildlife farms, which raise various animals, many for meat consumption (WCS 2008).

The COVID-19 pandemic raised concerns about the risk of wildlife farming in Asia leading to disease spillover and as a result both declines in demand in some places as well as efforts by national governments to discourage wildlife farming. A study in two provinces in Vietnam found that the numbers of wildlife farms and farmed wildlife animals have declined since the pandemic, mainly as a result of declining market demand and wildlife farm owners experiencing difficulties accessing markets due to travel restrictions (Pham et al. 2022).

Traders

Middlemen and traders act as links between hunters and farmers and the market. They purchase wild meat from hunters and farmers at relatively low prices and sell it to urban consumers or export it, often at significant markups. These actors are crucial in the distribution network, ensuring that wild meat reaches broader markets (Biller-Sandalj et al. 2016). Small rodents, bats and other species such as palm civets that are not subject to wildlife trade restrictions are openly sold in physical markets throughout China and Southeast Asia. In Laos, wildlife meat is on sale in hundreds of small-scale markets in villages (Greatorex et al. 2016). Vendors' livelihoods are closely tied to the fluctuations in demand and supply of wild meat (Challender and MacMillan 2014). Traders and middlemen use various methods to transport wild meat and proper storage and preservation techniques are employed to maintain the meat's quality during transport (Drury 2011). The illegal wildlife trade operates through a diverse network of channels. In established physical markets, such as Mong La, in Myanmar (Nijman et al. 2016), sales are often covert and made under the counter. However, the trend is shifting towards online platforms. Social media platforms such as Facebook, Instagram and WhatsApp, particularly through their group chats, are becoming the primary channels for illegal wildlife trade, reflecting the increasing internationalization of the crime (Krishnasamy and Zavagli 2020; Siriwat and Nijman 2020). On the other hand, upscale restaurants cater to a specific clientele, with urban consumers viewing the consumption of exotic wildlife as a prestigious social event (Song 2008). These establishments offer a wide range of species, from commonly available palm civets and wild pigs to strictly protected animals such as leopards and pangolins.

Butchers and retailers

Nijman (2010) found that in rural areas, butchers often operate within close-knit communities where hunting and wildlife consumption are part of traditional livelihoods. In urban areas, they may cater to a broader market, including restaurants, traditional medicine shops and exotic pet markets. Wildlife butchers process a wide range of species, including mammals, birds, reptiles and amphibians. The choice of species often depends on regional availability and market demand. Commonly butchered animals include deer, wild boar, pangolins, snakes, and various bird species (Challender and MacMillan 2014). The methods and tools used by wildlife butchers vary. Traditional tools such as knives and machetes are common in rural settings, while more advanced equipment might be used in urban butcheries. The butchering process involves skilled techniques to ensure minimal waste and maximum economic return. The practices may also include smoking, drying and other preservation methods to extend the shelf life of the products (Corlett 2007). According to a TRAFFIC 2008 report, the processing facilities for wildlife products used in traditional medicine are typically small-scale, family-owned businesses. This is especially true in Vietnam, where processors and retailers are often the same entity. However, in countries such as Indonesia, where tiger-based medicine is uncommon, the raw materials are exported after some basic processing (e.g. skinning or bone removal) for further processing elsewhere.

Consumers

In some countries, much or most wild meat is sold locally to rural consumers who are mainly attracted by the availability and low prices of the wild meat. Urban consumers of wild meat, especially in East and Southeast Asia, typically come from middle- to high-income brackets. In some countries, such as Vietnam, this consumption is further associated with high-ranking government officials and the business community (TRAFFIC 2008). These consumers are often from affluent backgrounds and drive the demand for wild meat in cities. They purchase wild meat as a luxury item, seeking it out in specialty restaurants and markets. Wild meat is often perceived as healthier and more natural than farmed meat. This belief drives consumption among those who seek organic or less processed food options. Consumers believe that wild meat is free from antibiotics and hormones commonly used in livestock farming (Corlett 2007). In China and Vietnam, consuming wild meat is linked to traditional medicine beliefs and is thought to possess various health benefits (Drury 2011). This consumer base includes locals as well as international tourists looking for exotic culinary experiences. Their willingness to pay high prices makes the wild meat trade lucrative (Shairp et al. 2016). Consumption of wild meat in urban areas is often associated with social status and cultural prestige. It is typically served in upscale restaurants and during special occasions, symbolizing wealth and sophistication. This demand incentivizes the continuous supply chain from rural areas to urban centres (Zhang et al. 2008).

Gender implications

In many ways, wild meat hunting and value chains can be seen to offer important positive opportunities for women, with women and men typically having different roles along different points of the value chain, although they vary by locale and system (Table 6). In all zones, men are reported to do the bulk of the hunting, particularly the more commercial forms such as with guns. However, it is clear that women often play an important role in trapping small animals such as birds (Ceppi and Nielsen 2014; Taylor et al. 2015), in cooking (Dell et al. 2020) and in gathering other wild animal foods such as snails and insects.

Among rural hunting households, although women's roles in hunting may be smaller, the access to wild meat has consequences for women and their children, the most obvious being the nutritional benefits (discussed in detail below). In a study in central Gabon, Coad et al. (2010) looked at the relationship between hunting, wealth and spending patterns and found that most purchases by women were of (non-wild meat) food but those purchases were lower in absolute terms and as a share of total purchases in households that hunted more. This reduced dependence on food purchases by women confirms the importance of the availability of wild meat, even if hunted by men, and that important benefits accrue to women.

The largest economic role of women, however, is seen along the downstream parts of the value chain: as wholesale or retail vendors and processors, all of which comprise important value addition roles and livelihood opportunities. In a survey of community members in rural southern Cameroon, men reported being 39 times more likely to hunt than women and women were 2 times more likely to butcher than men, highlighting the latter's role post-harvest (LeBreton et al. 2006). In East and Southeast Asia, wildlife butchering is predominantly a male-dominated activity, though women also participate, particularly in the preparation and sale of wildlife products in markets (Golden et al. 2013). As seen in Table 6, women typically comprise 50–100% of venders and sellers of wild meat, aged 30–50 years, with mixed educational levels. The relatively low barriers to entry to these enterprises in terms of capital requirements and women's access to social and kinship networks to make contacts and gain skills, along with the fact that food preparation and selling are often associated with women in many settings, means that wild meat value chains may offer better opportunities for women than other available enterprises.

Economic relevance

The low cost of hunting equipment and the high value of wild meat create favourable profit margins for hunters and traders. In many cases, the returns from hunting wild animals are substantially higher compared to other forms of livelihood for a subset of the rural populations. This economic rationale is a powerful motivator, encouraging individuals and communities to engage in hunting activities despite the risks of legal penalties or the long-term depletion of wildlife resources (Rao et al. 2011).

Market price formation may be relatively competitive, with little evidence of information asymmetry. A market study in Cross River State, Nigeria, found that for common species such as cane rats and porcupines, transactions followed somewhat standard prices, and negotiation only affected prices if demand was unusually high (Eniang et al. 2008).

Table 9. Earnings from hunting in selected African and Asian countries

Location	Earnings	Hunting method	Source
Dzanga-Sangha, Central African Republic	USD 400–700 per year	Snare hunters	Noss 1998
Northern Congo	USD 300 per household per year, 6–40% of daily income	Logging camp	Wilke et al. 1999
Cameroon	USD 330–1,058 per year		Gally and Jeanmart 1996
Congo	USD 250–1,050 per year		Dethier 1995
Dia, Cameroon	Up to USD 650 per year		Ngnegueu and Fotso 1996
Africa, selected forest margin sites	USD 55 per adult equivalent per year	Wide variety of sites and hunting practices	Nielsen et al. 2017
Korup, Cameroon	33% of village income		Infield 1988
Gabon, selected sites	USD 2/day (1/6 of daily income)		Abernethy and Obiang 2010
Kilombero Valley, Tanzania	Estimated cost-benefit ratios for hunters of 0.15–0.43	Large game animals such as buffaloes, hippos and warthogs	Nielsen et al. 2016
Nigeria	Highest selling price was USD 18.75 and USD 31.25 per animal (USD 1 = 320 naira)	Selling price of monitor lizard and crocodile at hunting level during the dry season	Babalola et al. 2023
Cambodia	USD 250–500 per month	Dogs, slingshot, snares and crossbows	Ibbett et al. 2020
	USD 30–100 per month		Gray et al. 2017
Vietnam	USD 50–200 per month	Snares, guns and dogs	Drury 2009
Vietnam	USD several hundred to more than USD 1,000 for a single pangolin		Challender et al. 2015
Indonesia	USD 10–30 per animal (wild boar or deer)	Traditional methods such as blowpipes and handmade traps	Wadley and Colfer 2004
Indonesia	USD 1,000 per animal (orangutan)		Nijman 2010
Indonesia	USD 50–150 per month Birds and reptiles: USD 1–5 per animal		Nijman 2010
Indonesia	Civets and other small mammals: USD 10–20 per animal		Harrison et al. 2016
Laos	USD 30–100 per month		Johnson et al. 2016

The evidence on household returns to hunting are mixed at best: Table 9 shows some of the studies available that measure returns to hunting. Household benefits include monetary income as well as food security provided by wild meat as a source of diet diversity and a cheaper source of alternative proteins (Janssen et al. 2024). In a study in Gabon, Abernethy and Obiang (2010) found that successful hunters can make up to USD 5 a day, but only around 5% of households that hunt achieve these sorts of returns. Instead, 90% of hunters make less than USD 2 a day for all sales averaged over the year. With relatively few wealthy households hunting most of the meat, and given that the average rural household income in Gabon (an upper-middle-income country) is around USD 12 a day from all activities, wild meat hunting may be regarded as not a major economic activity at the level of hunting households (Abernethy and Obiang 2010), although value addition along the supply chain is more concentrated and so important for participating market actors. In general, however, they estimate that wild meat is a significant part of the rural economy, with nearly 80% of rural families dependent, in part at least, on the benefits. Higher returns

have been documented in the last couples of years in Ghana, as traders made up to USD 7.82 per carcass of wild meat (Sackey et al. 2023). In Nigeria, a lower net profit of naira 3,565.53 (USD 8.64) per month was realized per trader (2021) in Osun State, while hunters in Ogun State got overall higher monthly profits (ranging from naira 4,000 [USD 9.69] to naira 50,000 [USD 121]) (Ulunusi et al. 2022).

In spite of the case studies indicating relatively high economic importance to households in selected sites, the wider data does not confirm that level of importance more broadly. In a wide-ranging study using data from forest margin sites across Africa, Asia and Latin America, Nielsen et al. (2017) found that for those African households that reported hunting, overall wild meat income, including consumption, was about USD 55 per adult equivalent per year, although it was much higher in Latin America. That result meant that household reliance on hunting for total income was very low—about 1.9% on average of total household income in African sites, although the average was 4.3% for those households that generate cash from hunting versus those that only consume the meat. This cash versus consumption difference underlies the important differences in hunting for market versus hunting for home and community consumption. Nielsen et al. (2017) further found that among the African households sampled, the cash income was only 10.7% of total wild meat value, with the largest share by far being the consumption value of the meat. The authors suggest that some other studies of returns to hunting fail to estimate the subsistence value of hunting, thus inflating the cash returns in relative importance (e.g. Kümpel et al. 2010; Golden et al. 2014), even though the Nielsen et al. (2017) sample showed that some 40% of income for rural agricultural households is derived from consumption of their own products.

Based on studies such as Nielsen et al. (2017), the evidence suggests that wild meat is not essential to rural households generally as an income source, although exceptions can be seen in specific settings (East Africa, Nigeria, Indonesia) where there are high levels of trade, large species are available and wild meat consumption has unique cultural importance. However, wild meat appears to remain important to rural households, particularly the more remote, as a source of protein and micronutrients, particularly where livestock production is constrained by disease or not traditionally practiced.

Similarly, a study by Nielsen et al. (2018) across 24 countries found that wild meat comprised only 2%, on average, of household income, nearly all in the form of consumption. Along the same lines, Abernethy and Obiang (2010) found that hunters in Gabon sold about 40% of the animals they catch, comprising about 50% of the caught biomass, reflecting the market value of larger animals and the importance of household consumption. The same study estimated that wild meat supplied up to 90% of the protein consumed by more remote rural households and that other non-market hunting objectives were also important, including the traditional use of wild meat in ceremonies, which can increase hunting by up to 30% during certain seasons. In a study in one community in Congo that appears to be an outlier, de Mérode et al. (2004) found that wild meat and wild foods play a small role in household consumption but an important role in household income, with over 90% of both sold to the market. In a set of rural villages in Gabon, income from hunting was 15–72% of total household income, the highest found in the more remote communities (Starkey 2004).

Household demand for wild meat is a significant driver of hunting activities in various parts of East and Southeast Asia. This demand is particularly pronounced in rural areas where wild meat is a critical component of local diets and livelihoods, as well as in urban areas where it is seen as a luxury item. In many rural regions of Asia, wild meat serves as a vital source of protein and other nutrients. Agricultural productivity in these areas is often low, and access to affordable domesticated meat can be limited. As a result, households turn to hunting wild animals to meet their dietary needs. This is especially true in remote areas where market access is restricted, making wild meat an essential part of the local food security strategy. Studies have shown that in parts of Indonesia and Malaysia, wild meat constitutes a significant portion of the diet, providing crucial sustenance for rural populations (Bennett and Rao 2002).

For many East and Southeast Asian rural households, wild meat also represents an economic resource. The sale of wild meat can provide significant income, which is crucial in regions where other economic opportunities are scarce. Hunters often sell surplus meat in local markets or to intermediaries who transport it to urban areas, where it fetches higher prices. This trade can be a critical source of cash for families, supporting other household expenses such as education, healthcare and housing. The economic reliance on wild meat hunting is a major driver of continued hunting practices, despite the potential negative impacts on wildlife populations (Nasi et al. 2008). In Southeast Asia, pangolin meat is considered a luxury item in Vietnam, often served in high-end restaurants. Prices can reach up to USD 250 per kilogram (Newton et al. 2008). Wild boar meat is commonly available and fetches around USD10—20 per kilogram, depending on the region and quality (Drury 2009). In regions like Kalimantan and Papua in Indonesia, deer and wild pig meat are common. Prices for wild pig meat range from USD 5–10 per kilogram, while deer meat

can be priced at around USD 10–15 per kilogram (Wadley and Colfer 2004). Or in Malaysia, wild meat such as deer, wild boar and small mammals can be found in local markets, with prices ranging from USD 8–15 per kilogram. The price varies widely based on the species and region (Bennett 2002). In Hong Kong, in 1970 one kilo of bear gall bladder cost around USD 200, but by 1990 the price had risen to between USD 3,000 and USD 5,000 per kilo (Gabriel 1999). Feng et al. (2009) found that the more recent market price with legal certification has risen to between USD 30,000 and USD 50,000 per kilo, with the data collected from a legal market.

In regions where employment opportunities are limited, the revenue generated from selling wild meat can significantly support household economies. This is particularly evident in forested areas of Southeast Asia, where local communities rely heavily on hunting to supplement their income. Ibbett et al. (2019) found the majority of households (68%) reported hunting solely for subsistence purposes, with about (28%) engaged in hunting for both food and income and one household relying exclusively on hunting income. In one wildlife-rich area, hunters reported earning USD 250–500 per month from selling meat to villagers or external traders, a considerable increase compared to the average monthly earnings (USD 80–150) of a casual labourer in the area. The commercialization of wild meat provides a financial lifeline, enabling households to afford necessities such as food, education, healthcare and housing (Nasi et al. 2011). This economic dependence on hunting poses a significant challenge to conservation efforts, as the immediate financial benefits often outweigh the long-term ecological costs.

Economic drivers

Some studies in East and Southern Africa have shown a more market-driven wild meat hunting system. For example, in Zimbabwe, Lindsey et al. (2011) found that wild meat hunting of large animals is conducted in or near protected wildlife areas, mainly by unemployed young men using dogs and/or snares. The wild meat was sold in nearby population centres, with the cash—accruing to USD 0.2 million and up to more than Euros 40 million annually in Tanzania (Nielsen et al. 2016)—used mostly to purchase food, apparently reflecting the higher value of wild meat versus domestic meat alternatives. They found the key drivers of that wild meat trade to be poverty, unemployment and scarcity of food, but also weak disincentives for poaching and relatively good access to animals. These incentives have also been documented in other recent reviews (Janssen et al. 2024; Zyambo et al. 2022). Similarly, in Tanzania, Nielsen et al. (2016) found that wild meat hunting, again of large animals, including buffalo and hippo, was commercialized and constituted a year-round economic activity. Cost-benefit ratios for hunters were estimated at less than 0.5, somewhat higher for traders and retailers along the supply chain. Inadequate or ineffective enforcement was a factor in access to large valuable animals, with the meat of some species, such as bush pigs and warthogs, obtaining premium prices. These cases illustrate that in settings where large valuable animals are accessible and market demand exists, largely commercial wild meat hunting can be the norm.

The Nielsen et al. (2017) study is apparently the widest and most comprehensive examination across countries of wild meat hunting practices and the factors driving them, or at least associated with them, as well as the observed outcomes. They used a dataset from the Poverty Environment Network that was aimed at proximity to forests and forest margins. Greater importance of wild meat hunting in terms of prevalence and incomes was found to be associated with:

- smaller and more remote communities (distance to district market and lower population density)
- places with higher rainfall
- communities in the middle of the cash income distribution
- communities with few domestic animals
- countries characterized by poor governance
- countries with rising costs of living.

Hunting varies by ecosystem. On average in Africa, 51% of wild meat was derived from forests compared to agricultural and fallow land, grassland and swamps. However, the proportion of household wild meat income in cash was higher from forest than non-forest areas, which suggests that forest hunting is more commercialized and may be associated with larger-bodied and more marketable animals. However, the authors found only a weak correlation between wild meat income, including consumption, and wild meat trade. Greater use of wild meat for subsistence in non-forest areas may be associated with hunting for both pest control and consumption. The numbers of livestock kept was significantly and negatively correlated with both the prevalence of hunting and wild meat income at the community level, although Africa-specific results were not presented. This mirrors the data showing the importance of wild meat for subsistence, which apparently declines when livestock protein alternatives are more available.

A study across 10 ecoregions of Tanzania, however, found that livestock-keeping was not significantly associated with wild meat consumption either way, although cattle-keeping and the availability of sheep and goats were weakly associated with less frequent wild meat, and it is important to note that results differed by ethnic community (Ceppi and Nielsen 2014).

Another study across 24 countries by Nielsen et al. (2018), however, found statistically strong evidence that reliance on livestock meat was associated with less reliance on wild meat. The presence of crop cultivation was not associated with reduced hunting, again suggesting the importance of animal-sourced portions for consumption even when staple crops are more available.

Distance from the community to the district market was associated with an increase in prevalence of wild meat hunting and in total wild meat income. However, distance to market was not associated with differences in the level of wild meat trade (cash share of income). This suggests that in relatively remote rural areas, wild animals may be more available, but also that alternative rural enterprises may be less remunerative due to lower market access. Increased human population density was associated with lower levels of wild meat hunting and importance but did increase the cash share of wild meat income, suggesting that the presence of more people locally offered a better market for that wild meat that was caught. The authors found evidence that older settlements have depleted neighbouring wildlife populations, a long-term negative effect of increased human populations.

In some sites there were controls or bans on wild meat hunting and trade, and generally natural resource management strategies that included forest lands. The authors (Nielsen et al. 2017) looked at the association between a national corruption perception index and wild meat hunting and trade and found positive correlations. The immediate inference may be that corruption reduces the effectiveness of enforcement of any control or management strategy, but in addition poor governance is also likely to be associated with weak services and poor rural infrastructure, hampering alternative enterprises and increasing the reliance on natural resources, including wild meat.

Commercial economic drivers for wild meat hunting in Asia are pivotal in understanding the extensive and often unsustainable exploitation of wildlife. These drivers are multifaceted, involving market demands, economic incentives, and the interplay of local and international trade dynamics. The high market demand for wild meat, both within Asia and globally, significantly drives commercial hunting activities. Wild meat is often perceived as a luxury item, especially in urban centres and among affluent consumers (Shairp et al. 2016). This perception elevates its market value, making it a lucrative commodity for hunters and traders. In countries like China and Vietnam, wild meat is marketed as an exotic delicacy. The premium prices that wild meat commands in these markets providing strong economic incentives for hunters to supply these products, often leading to overexploitation of wildlife populations (Drury 2011).

The international trade in wild meat and wildlife products further exacerbates hunting pressures. Thousands of tonnes of wild meat are estimated to be smuggled into Europe each year by diasporic African populations, both for personal use and for commercial trade. While legal goods are usually carried in iceboxes, wild meat is often concealed in suitcases, hermetically sealed in plastic to prevent leakage of juices and odours, suggesting passengers are aware that wild meat imports are illegal (Chaber et al. 2023). Asia is both a major supplier and a major consumer of wild meat, with extensive networks facilitating the trade across borders (Engel and Ziegler 2020; Nijman 2010; TRAFFIC 2008). Wildlife products, including meat, are often smuggled to meet demand in countries where exotic wildlife is highly prized. The illegal trade routes span several countries, involving complex supply chains that connect hunters in rural areas to consumers in distant urban markets and even internationally (Challender and MacMillan 2014). This international demand amplifies local hunting pressures, as wildlife is harvested not only to meet local needs but also to supply global markets.

The links between household wealth and the importance of wild meat are complex. Nielsen et al. (2017) found that wealth in terms of land owned was correlated with increased wild meat income. Other studies have found a positive association between household size and assets and wild meat hunting and income, such as Coad (2007), who found that hunters were predominantly from the top half of households in terms of wealth. In a related study, Coad et al. (2010) found that hunting households were significantly wealthier than non-hunting households. Wealthier households, typically those with more land and in some cases more wives, may have access to better hunting equipment and may also have more labour and time available for specialized hunting. Nielsen et al. (2017) also found a weak positive relationship between total income and wild meat income but also point out that, like other environmental sources of income, wild meat income was unreliable. In the DRC, Bakkegaard et al. (2017) found evidence that larger households with greater assets showed greater risk-taking capacity associated with hunting. In one community in the DRC, de Mérode et al. (2004) found that households with a higher wealth index had better access to more and higher value wild meat. It is probably in this regard that Chausson et al. (2018) discussed that wild meat in the DRC is sometimes a reserve for those 'who can afford', associating it with important or respected individuals and ceremonies. Contrasting results have been reported in parts of Tanzania (Rentsch and Damon 2013).

Nielsen et al. (2017) hypothesized that wild meat hunting and trade were likely to increase in times of economic stress, such as during periods of inflation in food prices.

Their dataset was not able to address that issue specifically but, based on other studies (e.g. Coad et al. 2010), they found evidence of a positive correlation between increased hunting and trade when food prices increase. The inference could be that during those periods the relative value of wild meat as a substitute to higher price domestic meat increased, thus providing new incentives for both additional hunting and for sales of wild meat.

Similarly, household wealth can be a complex driver for wildlife hunting, with the relationship varying depending on context. In many rural and low-income households in East and Southeast Asia, wild meat is a crucial component of food security. These households often have limited access to affordable domesticated meat and other protein sources, making wild meat an essential part of their diet. Hunting provides a reliable source of protein and other nutrients that might otherwise be inaccessible. This reliance is particularly pronounced in remote areas where agricultural productivity is low and markets are distant or poorly developed. For example, in the forests of Indonesia and Malaysia, wild meat is a significant dietary staple for many rural communities, directly contributing to their nutritional needs (Bennett and Rao 2002).

The market dynamics of the wild meat trade also reflect the links between household wealth and wild meat consumption. Challender et al. (2015) found that wealthier households may engage in commercial hunting, targeting high-value species for trade. The income from these activities can be substantial, contributing significantly to the household economy. Wadley and Colfer (2004) found that in Indonesia, larger households with more labour often engage in extensive hunting to meet their nutritional needs. Asset-poor households rely heavily on wild meat, with limited alternative livelihoods available. A study by Madhusudan and Karanth (2000) in India revealed similar findings. Drury (2009) found a direct link between household assets and hunting practices. In Vietnam and Laos, asset-rich households can invest in efficient hunting tools, increasing their capacity to hunt commercially. In contrast, asset-poor households depend on hunting as a subsistence strategy.

Summary: Wild meat value chain actors and practices

Wild meat value chains are composed of a wide variety of actors pursuing several different livelihood opportunities, from rural hunters and traders to urban venders, retailers, processors and roadside restaurant owners. These opportunities are often available to resource-poor individuals given the typically low costs of entry, but they often depend on kinship and other social networks to gain access and skills and to be economically viable. For many, these roles are sideline occupations and are sometimes seen as relatively low status except for more successful agents. Hunters are generally men, at least for the main larger species hunted, and are relatively young. Traders are both men and women and traditional processors (e.g. for smoking of animals), retailers and chop bar sellers tend to be women, depending on local cultural and social norms. The specifics of value chain interactions vary widely by location, by proximity to supply and demand areas and by types of species available. In many if not most value chains, the bulk of wild meat supply does not enter recognized market chains but comprises direct sales to consumers and rural households and to travellers along roadsides. For wild meat that travels along the value chain to an urban area and is finally sold as a prepared meal, a third of the end value of the wild meat may accrue to the hunter, with the rest distributed along the value chain.

Appendix 2: Alternative protein sources

Here we describe species that may be best suited for alternative protein supply in African and Asian forest margin settings, where wild meat hunting is arguably most prevalent.

Cane rats (grasscutters)

Two species of cane rats are found in the rainforest and savannah zones of West and Central Africa. These are strongly built rodents that feed on the roots and stems of grasses and on valuable crops such as sugarcane, rice, maize and cassava. In the wild they can reach up to 60 inches in length and 10 kg in weight, although farmed animals are typically smaller when harvested. Controlling their pest behaviour, in addition to sourcing meat, has long been an incentive for hunting cane rats through trapping, shooting, etc. (Fayenuwo and Akande 2002). Even before systems were developed for farming cane rats, they played an important wild meat role. Somewhat dated estimates suggest that the annual hunting of cane rats in Benin amounted to 500 mt, and in Ghana 70% of the estimated wild meat revenue of USD 247 million in 1997 was thought to be derived from cane rats (Fayenuwo and Akande 2002). Now, with the addition of small-scale and even commercialized cane rat farming, the species has increased in value and importance.

Cane rat farming has been well established in parts of West Africa, building on previous traditions of sometimes capturing and fattening the wild animals. They can be reared with relatively low capital outlay or intensively in cages and fed Napier grass and agricultural scraps and food wastes (Wilkie and Carpenter 1999). They are prolific, reaching sexual maturity at six months, with females producing at least one litter per year of three to six young (https://en.wikipedia.org/wiki/Cane_ rat). The meat has higher protein and lower fat content than livestock meat, and the taste suits those consumers with a tradition of eating wild meat. An analysis by Chardonnet et al. (2002) of cane rat farming shows it generated higher returns than poultry or rabbit production and was comparable to the most profitable cropping enterprises. The promotion of cane rat production by extension services has been observed in Cameroon, Côte d'Ivoire, Gabon, Ghana, Nigeria, Senegal and the DRC (https://en.wikipedia.org/wiki/Cane_rat).

Studies of commercial cane rat 'colonies' in Ghana and Nigeria, each of which raised up to and over 90 animals at a time, found a number of constraints as well as relatively high farmer dropout rates. The difficulties encountered included lack of training in management practices and housing design, feeding and health management, sex determination and the acquisition of initial stock (Adu et al. 1999; Anamayi et al. 2018). Considerable investment has been made in improving the stock through selective breeding (Jori et al. 1995), particularly in Benin in collaboration with Germany (https://en.wikipedia.org/wiki/Cane_rat), but it is recognized that continued research is needed in all aspects of the productivity of captive cane rats (Adu et al. 1999).

Bamboo rats

Bamboo rats, also called bamboo bandicoots, are rodents native to Southeast Asia prized for their lean meat. Farming them has gained popularity in some regions, particularly southern China and Vietnam. Bamboo rat farming is not legal or widespread in all parts of Asia. In addition to their lean meat, bamboo rats are known for being a good source of protein (FAO 2018). They adapt well to captivity and can be raised relatively easily compared to other livestock (Vu et al. 2017). Farming bamboo rats offers a potential source of income for rural communities (TRAFFIC 2018). A recent report from Vietnam (https://www.selinawamucii.com/insights/) suggests profitability, with farmers raising 200 bamboo rats and selling them for a good price per kilogram (Nguyen et al. 2024); in Vietnam, the price of bamboo rat meat is about USD 30–32/kg.

However, large-scale farming raises concerns about the sustainability of wild bamboo rat populations, potentially leading to their overexploitation (TRAFFIC 2018). The

close proximity of farmed animals to humans and domestic animals increases the risk of zoonotic disease transmission (WOAH 2023). In addition, questions exist about the welfare of bamboo rats in farming operations, especially regarding cage size and hygiene (World Animal Protection 2024). While bamboo rats offer potential economic benefits, developing more sustainable and humane farming practices for them is crucial (Do Linh et al. 2017).

Civet cats

Civet cats, also known as civets, are small, nocturnal mammals native to Asia and Africa. They are most commonly associated with the production in Southeast Asia of *kopi luwak*, a coffee consisting of coffee cherries that have been eaten and defecated by the Asian palm civet. A lesser known but growing trend is raising civet cats for meat, which is considered a delicacy in certain regions. Farming civet cats has gained some popularity in parts of China and Vietnam. However, civet cat farming is not legal or widespread in all parts of Asia.

The meat of civet cats is known for its distinctive flavour, which is prized in some traditional cuisines and considered a luxury item in some areas (Thi et al. 2022). Civet cats can be kept in captivity, but the conditions are often poor, leading to significant animal welfare concerns. They are typically housed in small cages and provided minimal care, which results in stress and health issues for the animals (Nijman et al. 2024).

Farming civet cats can be a potential source of income for rural communities. It offers economic benefits, especially in regions where traditional livestock farming is not viable. However, the practice raises several ethical and conservation issues. Additionally, civet cats have been implicated in the transmission of zoonotic diseases, such as SARS, raising public health concerns. A review by Whitfort (2021) indicated that two studies investigating SARS-CoV in civets at a market found extremely high infection rates (78% and 100%), with one study suggesting a link between infection and the length of time spent at the market due to increased stress and viral load. Overall, civet cat meat farming in Asia raises significant concerns about sustainability, biosecurity, animal welfare and zoonotic diseases. More research is needed to understand the full scale of this practice.

Cavies (guinea pigs)

Cavies, also known as guinea pigs (*Cavia porcellus*), are rodents native to South America. They are well-documented as an established mini livestock species in parts of Africa where wild meat has otherwise been a source of protein. They are well established in the eastern parts of the DRC, where more than two million of them are estimated to be regularly kept by hundreds of thousands of households in both rural and urban areas, and possibly by as many as half of all farmers (Maass et al. 2014; Klapwijk et al. 2020). About half a million cavies are also raised in Cameroon (Odenthal 2019), and in both regions were apparently introduced some decades ago through NGO and development agency efforts, in some cases as part of 'rehabilitation kits' in conflict-affected areas. Those conflicts also contributed to livestock destocking and deforestation, reducing the supplies of both domestic and wild meat, so providing further incentives for raising cavies (Draulans and Van Krunkelsven 2002; Klapwijk et al. 2020). The suitability of cavies as a replacement for wild meat in the local diet is demonstrated by adaptations of traditional DRC recipes, such as 'smoked cavy in groundnut sauce' and 'cavy in tomato sauce' (Celtnet 2013). Home consumption is reported as the main incentive for keeping cavies, but they are also sold, and sometimes raised by youth for income generation or, more generally, by women in the households (Niba et al. 2012; Klapwijk et al. 2020). A study in the DRC found that poorer households in particular marketed cavies more than wealthier households, suggesting both protein consumption and income-generating objectives. Cavy manure, which is relatively dry and rich in nitrogen, is valued by some for horticulture, and there are beliefs of medicinal benefits associated with their consumption (Mugisho 1995). In a study of cavy production among smallholders in the western highlands of Cameroon, Manjeli et al. (1998) documented reproduction rates of just over nine kids per doe per year, and average weight at 15 weeks of more than 400 g, with males being larger. Cavies are easily fed since they eat a range of grasses and vegetation, as well as kitchen and farm waste. They are often raised in a semi-scavenging manner as they remain close to the homestead. There remain considerable constraints to sustainable production. Mortality rates among young animals are high if birth weights are low due to inadequate feeding of pregnant females. Large, higher productivity breeds imported from South America to Cameroon were apparently not observed within the target communities a few years later, suggesting that there was inadequate local expertise in managing the improved breeds (Niba et al. 2012). In South Kivu, farmers reported constraints due to lack of knowledge of breeding and feeding, as well as predation and theft, which the use of cages by some farmers was able to mitigate (Klapwijk et al. 2020).

Although constraints exist, the significant presence of cavy culture in several parts of Africa suggests that for some vulnerable households, raising these mini livestock may be an affordable way to mitigate malnutrition and provide income for rural women and their families while

potentially reducing demand for wild meat. The significant experience and wealth of research on commercial cavy production in South America is a resource that could be applied in more African settings.

Aquaculture

As an alternative protein source to wild meat, some mention should be made of the potential for aquaculture, more specifically fish raised by smallholders in stream-fed ponds in a semi-intensive manner. In the relatively moist tropics where wild meat hunting is important, the relative abundance of surface water not only makes aquaculture generally feasible but also guarantees that consumption of fish is a cultural tradition. The most common aquaculture species across Central Africa is Nile tilapia, although often raised in combination with higher-market-value African catfish (Clarius), sometimes inadvertently due to the latter's ability to migrate to ponds across land. Feeding is generally a combination of fertilizing ponds with compost to create an algal bloom, supplemented with brewers' waste, cassava leaves, rice bran and even wild termites. Tilapia reproduce prolifically, often leading to overstocking, which is controlled by regularly draining ponds and by the presence of catfish. Smallholder aquaculture development programs are found across a number of African countries and could be considered wherever protein alternatives to wild meat are viewed as part of the effort to mitigate hunting (Gupta and Acosta 2004; Toguyeni 2004).

Other species

The farming of capybara, a large rodent native to semi-aquatic settings in hot and humid lowlands in Latin America, is well established. Breeding programs started in the 1970s have generated foundation stock of suitable genotypes for farming. When domesticated they are easily handled and can be raised on a variety of vegetation, including grasses such as Napier grass supplemented with concentrates. They thrive in high-temperature settings where some livestock species are constrained. Their annual productivity may exceed that of cattle in their native range. The white meat produced contains only 4.5% fat but 25% crude protein. Females reach sexual maturity at about 1.5 years, and offspring can reach a live weight of more than 40 kg in about 18 months. However, limitations include aggression and disease among animals housed together and the need for access to a semi-aquatic environment. They are also susceptible to disease (brucellosis and surra) and may harbour foot and mouth disease. There is no clear evidence that farming capybara has been established to any extent in Africa, but it may remain an option to be explored (Moreira et al. 2012).

Farming giant African snails is a relatively well-established enterprise in parts of Africa. Growing to over a foot in length, they have long been part of the harvested meat supply in relatively moist areas of the continent. They require little capital investment or space requirements, and labour requirements are minimal, so the enterprise is suitable to the resource poor and even those with disabilities (Agbogidi and Okonta 2011). They can subsist and grow on a wide variety of household food waste, crop residues, vegetables and fruits. In many settings, such as in Nigeria, they are regarded as a nutritious delicacy and are ascribed a number of medicinal and cultural/social values (Abdogigi and Okonta 2011).

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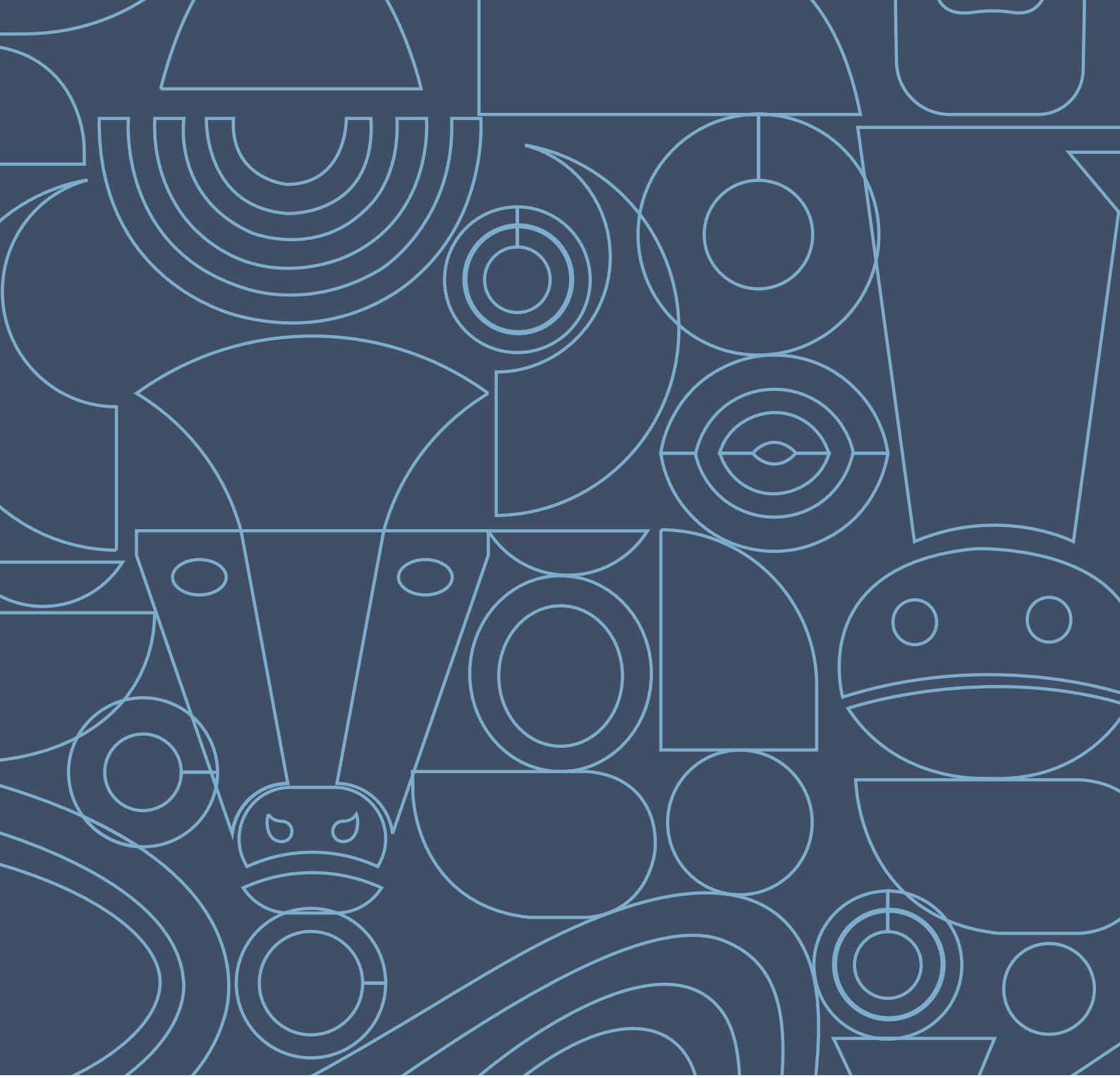

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