Vulnerability and coping strategies within wild meat trade networks during the COVID-19 pandemic

Enns, Charis; van Vliet, Nathalie; Muhindo, Jonas; Nyumu, Jonas; Bersaglio, Brock; Massé, Francis; Cerutti, Paolo Omar ; Nasi, Robert

DOI:
j.worlddev.2023.106310

Document Version
Publisher's PDF, also known as Version of record

Citation for published version (Harvard):
Enns, C, van Vliet, N, Muhindo, J, Nyumu, J, Bersaglio, B, Massé, F, Cerutti, PO & Nasi, R 2023, 'Vulnerability and coping strategies within wild meat trade networks during the COVID-19 pandemic', *World Development*, vol. 170, 106310. https://doi.org/j.worlddev.2023.106310

World Development 170 (2023) 106310

Contents lists available at ScienceDirect

World Development

journal homepage: www.elsevier.com/locate/worlddev

Vulnerability and coping strategies within wild meat trade networks during the COVID-19 pandemic

Charis Enns [b,*], Nathalie van Vliet [a], Joseph Mbane [a], Jonas Muhindo [a], Jonas Nyumu [a], Brock Bersaglio [c], Francis Massé [d], Paolo Omar Cerutti [a], Robert Nasi [a]

[a] Center for International Forestry Research–World Agroforestry (CIFOR-ICRAF)
[b] University of Manchester, United Kingdom
[c] University of Birmingham, United Kingdom
[d] Northumbria University, United Kingdom

ARTICLE INFO

Article history:
Accepted 23 May 2023
Available online 26 May 2023

Keywords:
Wild meat
Vulnerability
Environmental coping strategies
Value chains
COVID-19
Africa
Latin America

ABSTRACT

Measures adopted to prevent the spread of COVID-19 and economic shocks caused by the pandemic have affected food networks globally, including wild meat trade networks that support the livelihoods and food security of millions of people around the world. In this article, we examine how COVID-related shocks have affected the vulnerability and coping strategies of different actors along wild meat trade networks. Informed by 1,876 questionnaires carried out with wild meat hunters, traders, vendors, and consumers in Cameroon, Colombia, Democratic Republic of Congo (DRC), and Guyana, the article presents qualitative evidence as to how COVID-19 impacted different segments of society involved in wild meat trade networks. Our findings largely align with McNamara et al. (2020) and Kamogne Tagne et al.'s (2022) causal model hypothesising how the impacts of the pandemic could lead to a change in local incentives for wild meat hunting in sub-Saharan African countries. Like McNamara et al. (2020) and Kamogne Tagne et al. (2022), we find that the pandemic reduced wild meat availability for wild meat actors in urban areas while increasing reliance on wild meat for subsistence purposes in rural areas. However, we find some impact pathways to be more relevant than others, and also incorporate additional impact pathways into the existing causal model. Based on our findings, we argue that wild meat serves as an important safety net in response to shocks for some actors in wild meat trade networks. We conclude by advocating for policies and development interventions that seek to improve the safety and sustainability of wild meat trade networks and protect access to wild meat as an environmental coping strategy during times of crisis.

1. Introduction

Although the origins of the COVID-19 outbreak remain debated, it is widely believed that transmission may have first occurred at a market in Wuhan, China, where wild meat was sold (Zhou et al., 2020). Reports linking the emergence of COVID-19 to wild meat threw the wildlife trade into the global spotlight as a potential interface for the transmission of zoonotic diseases. This motivated proposals to strengthen regulation of wildlife trade, including calls to ban the commercial wildlife trade altogether. At the outset of the pandemic, 241 influential conservation and animal rights organisations, including the Zoological Society of London, Born Free Foundation, World Animal Protection and Humane Society International, released a formal position statement calling for the end of wild meat trade to prevent future zoonotic outbreaks and halt and reverse biodiversity loss (WCS, 2020). Governments responded to the suspected link between COVID-19 and wild meat trade in various ways, from closing wildlife markets in China to banning the consumption of certain species in Gabon to ramping up enforcement against unauthorised wildlife trade in Peru.

Alongside the growing stigma of wild meat consumption, measures adopted to prevent the spread of COVID-19 alongside economic shocks caused by the pandemic have had notable repercussions for wild meat trade networks (Kamogne Tagne et al. 2022), with uncertain implications for millions of people

* Corresponding author at: Arthur Lewis Building, The University of Manchester, Bridgeford Street, Manchester M13 9PL, United Kingdom.
E-mail address: charis.enns@manchester.ac.uk (C. Enns).

https://doi.org/10.1016/j.worlddev.2023.106310
0305-750X/

around the world who use and depend on wild meat[1]. Some have speculated that policy responses to COVID-19 resulted in the removal of wild meat from food systems and increased food insecurity (Booth et al. 2021; Roe et al. 2020). Others have hypothesised more complex causal networks, suggesting that the pandemic reduced wild meat availability in urban areas while increasing reliance on wild meat for subsistence purposes in rural areas (McNamara et al. 2020; Kamogne Tagne et al. 2022). So far, however, there remains limited empirical evidence concerning how these – or other – impacts have varied across different segments of society involved in the hunting, trade, and sale and consumption of wild meat.

In this article, we respond to the question: How have COVID-related shocks affected the vulnerability and coping strategies of different actors along wild meat trade networks? Informed by 1,876 questionnaires carried out with wild meat hunters, traders, retailers, and consumers in Cameroon, Colombia, Democratic Republic of Congo (DRC), and Guyana, the article presents qualitative evidence of how different segments of society involved in wild meat trade networks coped with the multiple crises caused by the COVID-19 pandemic. We use the causal model of the probable impacts of COVID-19 related shocks on wild meat trade developed by McNamara et al. (2020) and revised by Kamogne Tagne et al. (2022) to frame our analysis and discussion. Our study broadly affirms this model; however, as our discussion outlines, we find some casual pathways more pertinent than others in our case studies. We also identify additional impacts and pathways of impact at work in our case studies. In addition to testing this model, we further disaggregate the impacts of COVID-19 on wild meat trade networks by examining how these impacts vary across different trade network actors. We conclude by discussing the importance of wild meat trade as an environmental coping strategy during times of crisis. We also reflect on the potential for this environmental coping strategy to provide development and conservation benefits when supported by appropriate regulations to ensure sustainable wildlife management.

By examining the impacts of COVID-19 on actors involved in the wild meat trade across the four countries of Guyana, Cameroon, Colombia, and the DRC, this article also contributes to a growing body of research on the implications of the COVID-19 pandemic for welfare and wellbeing in the global South. This emerging body of literature has found that responses to COVID-19 – such as lockdown, home quarantine, travel restrictions and social distancing – had especially severe livelihood consequences for many in the global South (Uddin et al. 2022; Mansour et al. 2022). This is because market closures and travel and trading restrictions failed to account for livelihoods that require movement, resulting in lost income, while at the same time, leading to rising food costs, which threatened peoples' food security (Bassett et al. 2021; Belton et al. 2021; Lai et al., 2020; Leach et al. 2021; Krauss et al. 2022). When states' lack widespread health, social security and public policy assistance measures, this further contributed to the depth and scale of disruption caused by responses to the COVID-19 pandemic (Dutta and Fischer 2021; Kansiime et al., 2021). At the same time, some of this research points to a small silver lining, as disruptions to global supply chains sometimes resulted in greater support for local markets, agroecological practices and food sovereignty (Bennett et al. 2020; Fennell, n.d.). We add to this existing literature further examples of unanticipated secondary effects of the COVID-19 crisis.

2. Wild meat trade networks and COVID-19

Wild meat refers to meat sourced from non-domesticated terrestrial mammals, birds, reptiles, and amphibians (Coad et al. 2019). Wild meat does not come from animals that are captive or farmed but instead from those that roam freely. Although wild meat is consumed and traded all over the world, it is a particularly important staple in many tropical and sub-tropical areas, where it contributes to food security (Alves and van Vliet 2018). The common perception that wild meat is only consumed due to a lack of alternatives or as a last resort is misguided (Lindsey et al. 2013). Wild meat often plays a pronounced role in peoples' health in contexts where other sources of protein are either unaffordable or unavailable (van Vliet et al. 2012; Fargeot et al. 2017). Wild meat provides nutritional diversity, including access to important vitamins and minerals that might otherwise be missing from peoples' diets (Cawthorn and Hoffman 2015). It also contributes to wellbeing and serves as a source of cultural and spiritual value and collective identity, consumed during festive events, as part of certain traditions, and as a delicacy (Wilkie et al. 2016; Luiselli et al., 2020). In this regard, wild meat is not only important to nutrition and food security but also to food sovereignty (see Ibarra et al., 2011; Morrison 2020).

Beyond subsistence, wild meat is also traded as part of peoples' livelihood portfolios, with income earned from wild meat sales often used to purchase other food items and necessities and to pay for school fees or medical care (van Vliet et al. 2019). The importance of this source of income varies from place to place and has changed over time. For instance, wild meat provides a fall-back source of income during periods of hardship in some places, while it serves as a primary source of income in many other places. In some parts of the world, there is evidence that the economic value of wild meat has grown in recent years with rising demand in urban centres and expanding international markets (Lindsey et al. 2013). In other areas, people – and particularly youth – may be shifting away from relying on wild meat for income as alternative employment opportunities become more readily available (Coad et al. 2013; Gill et al. 2012). Regardless of these contextual differences and changing trends, the contribution of wild meat to global household cash income is significant. A recent study estimates that informal and local wild meat trade may be worth approximately USD 7.8 billion across Central and South America, Eastern, Southern and South-eastern Asia and Sub-Saharan Africa (Nielsen et al. 2018). These estimates are also 'likely to be conservative' (Nielsen et al. 2018), as reliable statistics are hard to come by due to the wild meat sector's informality, illegality and stigmatisation in many contexts.

In light of the importance of wild meat to food security, incomes and wellbeing, there is growing interest in understanding the structure and operations of wild meat trade networks. This information is essential to increasing the sustainability of wild meat use. Several published case studies detail the organisation of wild meat sectors across different parts of sub-Saharan Africa (Lescuyer and Nasi 2016; Nielsen et al. 2018; van Vliet et al. 2019), Southeast Asia (Pattiselanno et al. 2020), and Latin America (van Vliet et al. 2015b). These studies have shown how the sector operates through complex networks comprised of rural hunters, urban and rural traders (including market vendors restaurateurs), and consumers. They have also attempted to estimate the contribution of wild meat to the livelihoods of different actors within these networks. Studies that track how wild meat trade networks contribute to economies, livelihoods, and food security both indi-

[1] Although accurate estimates of the scale and prevalence of wild meat use are lacking in many countries (Ingram et al. 2021), it is widely accepted that wild meat supports the food security and livelihoods of tens of millions of people throughout the world (Brashares et al., 2014; van Vliet et al. 2015).Even though trade networks are typically talked about and understood in economic turns, wild meat trade networks encompass cultural, social, spiritual, and other values attached to certain species, the ecosystems where they originate, and the practices behind harvesting, preservation, and preparation for consumption.

vidually and at a societal level reveal just how important the sector is to a variety of actors in all sorts of settings around the world.

Despite the potential for wild meat to contribute positively to economies and livelihoods, it is common for the wild meat trade to be mischaracterised in the academic literature and misrepresented in policy processes (Challender et al. 2022). For instance, links are often made between wild meat, illegal trade, and organised crime, including the trafficking of protected species across borders (Cardoso et al. 2021; Gluszek et al., 2021; Gore et al. 2021). The sector is also pointed out for its negative impacts on ecosystem services, contributing to biodiversity decline (Ripple et al., 2019; Cardoso et al. 2021). These characterisations of wild meat use and consumption remain predominant. Yet, not all flows of wild meat or forms of wild meat trade are illegal or unsustainable. Wild meat is usually only illegal when species being traded are protected by law, hunted without following the premises of the law (e.g banned hunting methods, hunted in close seasons, hunted without the required permits etc.) or when they are procured from protected areas where hunting is disallowed (van Vliet et al. 2019). Additionally, wild meat trade becomes unsustainable when it reduces wildlife populations (Willis et al. 2022) or contributes to increased extinction risk and breakdown in ecological processes (Dirzo et al. 2014). The capacity of a given species to withstand hunting pressure highly depends on its reproduction characteristics, habitat preferences, behaviour towards anthropogenic presence, and geographical distribution; not to mention other harmful anthropogenic forces at work, such as industrial and infrastructural expansion, natural resource expansion, and flawed protected area models.

Biases against wild meat trade have been further accentuated by recent zoonotic outbreaks, because wild meat trade networks can serve as interfaces where diseases spill over from wild animal hosts to human populations and, potentially in some situations, back to animals. Even in cases where links between wild meat consumption and zoonotic disease outbreaks are unproven, some conservation and animal rights organisations are often quick to harness the spectacular nature of outbreaks to inspire calls for urgent action in support of their broader agendas. In response to past outbreaks, governments have answered such concerns with new policies and more stringent regulatory measures to limit public consumption of and access to wild meat, such as closing markets where wild meat is sold or increasing hunting regulation and protected area enforcement. For example, wild meat was subject to great scrutiny by the media and conservation organisations during Ebola outbreaks in central and western Africa between 2014 and 2016, resulting in national and local regulations banning the consumption of bushmeat (Bonwitt et al. 2018).

Several recent studies have attempted to capture the specific impacts of the COVID-19 pandemic on the wild meat sector (Funk et al. 2021; Harvey-Carroll et al., 2022; Kamogne Tagne et al. 2022; McNamara et al. 2020; Roe et al. 2020). McNamara et al. (2020) developed a causal model that hypothesises the probable impacts of COVID-19 related shocks on wild meat trade in sub-Saharan Africa, which Kamogne Tagne et al. (2022) recently tested in Cameroon and updated based on their results (Figure 1). In brief, McNamara et al. (2020) and Kamogne Tagne et al. (2022) agree that a likely impact of the pandemic on wild meat economies was reduced demand for wild meat in urban areas due to the depression of local economies and employment levels, as well as increased attention directed at zoonotic disease. At the same time, demand for wild meat and hunting for subsistence purposes in rural areas increased, at least partly due to urban–rural migration. Kamogne Tagne et al. (2022) also found that national government responses to the pandemic, such as travel restrictions and market closures, may reduce incentive to hunt for commercial purposes. These studies suggest that the overall impact of the pandemic on wild meat use varies across different areas (Kamogne Tagne et al. 2022, 136).

Building on this recent work that identifies spatial differences in wild meat market responses, we are interested in understanding how different trade network actors have been impacted by and responded to the pandemic. As noted above, wild meat trade networks are comprised of multiple actors (e.g. hunters, brokers, traders, retailers, and consumers) who operate in different locales (e.g. rural and urban) and at different scales (e.g. local, national, and international). Existing research has shown that these actors have diverse interests, needs, and motivations for using wild meat, and that these actors are also differentially affected by interventions to regulate or alter the wild meat sector (Cowlishaw et al., 2005; Lescuyer and Nasi, 2016; Nielsen et al., 2018; van Vliet et al., 2015a; van Vliet et al. 2019). For example, interventions aimed at encouraging urban wild meat consumers in shifting towards alternative protein sources may have no adverse impacts on urban consumers but can have devastating impacts on commercial hunters if their income-earning opportunities are not replaced.

With this in mind, our study aims to capture how different segments of society involved in the hunting, trade, sale and consumption of wild meat have been differentially affected by shocks trigged by COVID-19. We use a model developed by McNamara et al. (2020) and revised by Kamogne Tagne et al. (2022) to frame our analysis and discussion of the shocks created by the COVID-19 pandemic for wild meat trade networks. We then discuss vulnerability and coping strategies in response to these shocks across different trade network actors. Informed by similar work by Krauss et al. (2021) on other rural trade networks during the COVID-19 pandemic, we define vulnerability as, "the degree to which a system, subsystem, or system component is likely to experience harm due to exposure to a hazard, either a perturbation or stress/stressor" (Turner et al. 2003, 8074), and coping strategies as, "shorter-term ways of dealing with stresses, especially those [stresses] linked to economisation of food" (Quinn et al. 2011). This conceptualisation of vulnerability is useful as it draws attention to the fact that vulnerability is not merely a function of exposure to hazards, but also of the ability of the system to cope with perturbations and stresses associated with hazards (Turner et al. 2003).

3. Research methods

In this article, we use a comparative case study approach. Comparative case study involves the systematic comparison of data across comparable cases to identify patterns or formulate generalizations about a phenomenon of interest (Bartlett and Vavrus, 2016). Our cases are comparable in the sense that each represents the phenomenon we are interested in understanding: a wild meat trade network with the potential to have been impacted by the COVID-19 pandemic. Using a comparative case study approach allows us to identify patterns in the impacts of COVID-19 on wild meat trade actors across these cases. At the same time, as illustrated in the following section, there are notable differences in the wild meat trade networks across our five cases in four countries. These differences make it possible for us to examine how the impacts of COVID-19 were mediated and shaped by context-specific factors.

Data was collected using semi-structured questionnaires. The authors conducted a total of 1,876 questionnaires during the COVID-19 pandemic with key actors across the value network in each case study area (Table 1). The trade networks studied were chosen based on the availability of previous baseline information to characterize them before COVID-19. The type and number of actors interviewed varied from case to case as a result of differences in the structure of the wild meat sector in each country as

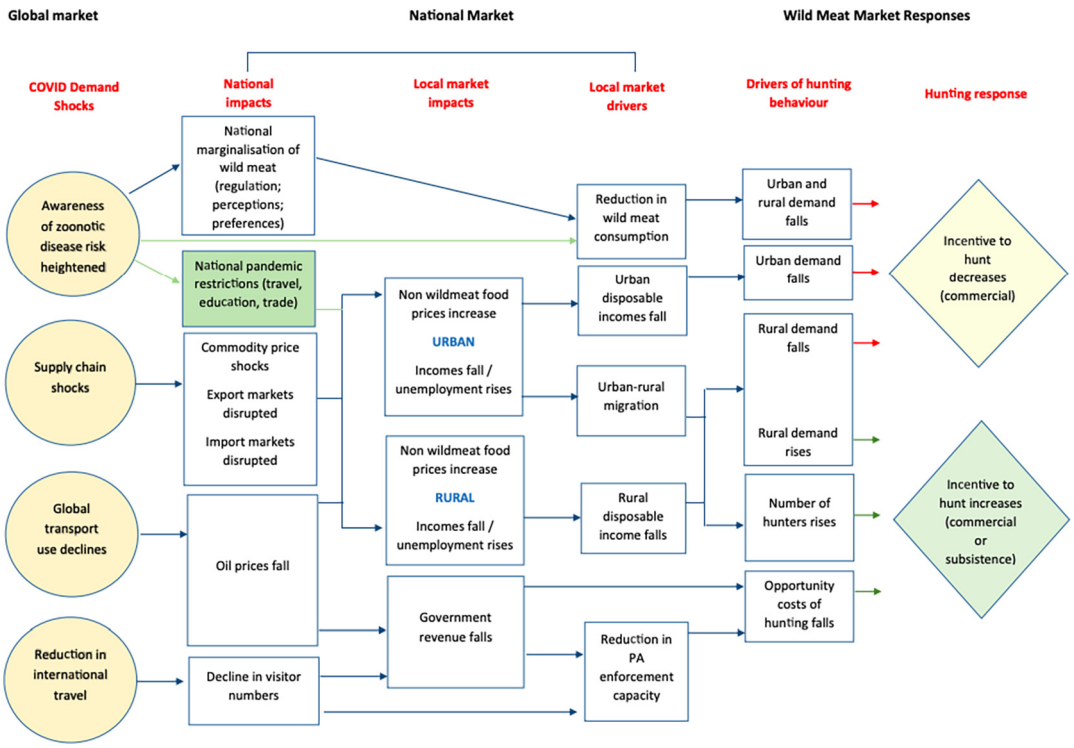

Figure 1. Kamogne Tagne et al.'s (2022) updated version of McNamara et al.'s (2020) causal model describing key linkages between global COVID-linked shocks and wild meat market dynamics. Reproduced from Kamogne Tagne et al. (2022)

described in previous literature. Where the total number of hunters, retailers and consumers was above 100, we interviewed between 5% and 15% of the total number of stakeholders involved in the wildmeat trade prior to the pandemic. Where their number was below 100, we interviewed them all. As such, in Colombia, we only interviewed 2 traders, but these represent 100% of the known sample size. Also in Colombia, where traders completely closed their business during the first months of the COVID-19 outbreak, consumers were not interviewed. KoboCollect was used to design questionnaires and store and manage data in a systematized way. Semi-structured questionnaire interviews were carried out in the official language of each country and translated into other languages spoken by respondents when needed.

The questions asked during this research focused on understanding the potential impacts of COVID-19 on the sector, including questions related to: changes in consumption and trade patterns relative to pre-COVID-19 operations; changes to how wild meat was handled, transported, and prepared relative to pre-COVID-19 operations; changes in the availability of supply, price, species, and preferences relative to pre-COVID-19 operations; and presumed reasons for any changes (see Appendix A for questionnaire). Notably, we describe our approach to data collection as 'semi-structured' because questionnaires were used to loosely guide, rather than dictate, conversations, so that participants could contribute information they deemed relevant but that the research team may not have considered (Brinkmann 2014). Each participant answered all questions included in the questionnaire, but their answers may have come out in conversation without being explicitly asked and the order of questions asked depended on how the conversation unfolded. Our use of semi-structured questionnaires enabled us to collect data that was comparable across cases without sacrificing detailed qualitative insights and information that we might have missed otherwise.

Prior to beginning this research, this study underwent a Research Ethics and Integrity review at the University of Birmingham (ethics application number: ERN_20-1400) and necessary research permission were obtained for national and/or local government authorities in each case study country. In-country research teams were comprised of experienced researchers and local enumerators who were familiar with the wild meat sector and able to ensure the research was sensitive to ethical and political considerations associated with wild meat hunting and trade. At the start of data collection, in-country research teams explained the aims of the research to relevant stakeholders and potential participants to obtain informed consent before proceeding with the research. Care was taken to protect the confidentiality of participants and anonymise data. As data was collected during the COVID-19 pandemic, guidance from national and World Health Organisation authorities was adhered to throughout our research activities, including: regular hand washing with water and soap for both researchers and participants; wearing of face masks; and keeping a distance of at least 2 m, preferably outdoors. Participants were provided with face masks by the research team when needed.

4. Description of wild meat sectors in case study sites

4.1. The coast of Guyana

In Guyana – a country on the northern mainland of South America – wild meat is a festive food. Eating wild meat is associated with happiness, flavour, health, and childhood. Wild meat consumption takes place at special events, particularly Christmas, birthdays, or heritage months, such as Indigenous month celebrated in September. Beef, chicken, and pork are roughly half the price of the mean price of wild meat (van Vliet et al. 2022). The top five most commonly consumed species are labba (*Cuniculus paca*), bush deer (*Mazama nemorivaga*), tapir (*Tapirus terrestris*), collared peccary (*Dicotyles tajacu*) and capybara (*Hydrochoerus hydrochaeris*) (van Vliet et al. 2022). Other species listed among those most often traded are agouti (*Dasyprocta*), powis (Crax alec-

Table 1
Questionnaires by trade network actor and case study site.

	Coast of Guyana, Guyana	Dja South, Cameroon	Yangambi & Kisangani, DRC	Leticia, Colombia
Hunters	188	156	205	46
Traders/retailers	73	91	72	2
Consumers	121	540	74 (Yangambi) + 308 (Kisangani)	N/A
Total	382	787	659	48

tor) and iguana (*Iguana*). Of these, only the tapir is listed as threatened, and none are protected in Guyana (van Vliet et al. 2022).

On the coast of Guyana, wild meat is traded in markets, restaurants, rum shops (bars), grocery stores, home based shops, and roadside stalls. In total, 73 traders and retailers were actively trading wild meat prior to the pandemic: 17 market retailers, 14 restaurants, 17 rum shops, 10 home-based traders, 7 grocery stores, and 8 roadside traders (van Vliet et al. 2022). The business is dominated by men (75%) (van Vliet et al. 2022). In addition to physical sale points, wild meat is also advertised online via WhatsApp and social media. Van Vliet et al.(2022) estimated that about 132 tons of wild meat are traded per year on the coast of Guyana. Most wild meat retailers on the coast of Guyana (70% of those sampled) reported that wild meat reaches them either already gutted on ice or as freshly killed, but is then frozen for storage before sale.

About 50% of retailers active in the wild meat trade on the coast of Guyana sell their own catch and have no intermediary (van Vliet et al. 2022). In such cases, traders tend to organise hunting trips on regular occasions to known hunting grounds where they have acquaintances or family. These traders are usually passionate hunters who provide the cartridges, fuel, coolers, and ice and make arrangements with local contacts to organise hunting parties. The other half of the traders have agreements with 1 or 2 commercial hunters (mostly Indigenous or African-Guyanese living in the interior) with whom they have good personal relationships and who supply them with wild meat on a regular basis (van Vliet et al. 2022). Only four of the retailers (6%) use a middleperson to obtain the wild meat for sale (van Vliet et al. 2022). Such personal relationships are important as, unlike other cases considered in this article, only Indigenous communities have the right to hunt on titled lands in Guyana while others must obtain a license based on the new regulations issued in 2019 (Coad et al. 2019). However, the new licensing system is not yet implemented and as such the sector remains largely unregulated. Hunting incomes are important for many Indigenous communities in Guyana – sometimes earning households 10-times more than the revenue they might earn in other sectors, such as tourism (Wenner and Johnny 2015).

4.2. Yangambi and Kisangani, DRC

Yangambi is a town in the northeast of DRC surrounded by the Yangambi Biosphere Reserve. Traditional agriculture, including cultivating cassava, banana, maize, rice, cowpeas, beans, and groundnuts, is a primary livelihood activity in and around the town; however, two-thirds of households experience insufficient food availability to meet 2,000 calories per day, falling below the recommended intake (Nowak et al. 2019). Apart from fish, there are few other sources of meat available (van Vliet et al. 2019). As a result, wild meat demand is high and contributes significantly to peoples' protein needs with over 60% of households eating wild meat more than once a week (van Vliet et al. 2017).

Yet, the consumption of wild meat in Yangambi is not purely out of necessity: it is also associated with happiness (van Vliet et al. 2022). Most of the wild meat consumed in Yangambi originates from the Turumbu sector and particularly from Weko, a village about 30 km north of Yangambi town. Most meat is smoked at the level of the rural hunters to conserve the meat for transportation and sale in town. As many as 34 species of wild animals are hunted and traded in the area. The most traded species are small monkeys (38% of the biomass), red duikers (*Cephalophus natalensis*) (31%), blue duikers (*Philantomba monticola*), bush pigs (*Potamochoerus larvatus*) and bush tailed porcupines (*Atherurus*) (van Vliet et al., 2019). Several species of small carnivores and rodents are also hunted, traded, and consumed.

As wild meat sales are very attractive in an area with limited other income earning prospects, hunters from Weko sell more than 80% of what they hunt, sometimes prioritising sales over family food security (van Vliet et al. 2019). Most wild meat in Yangambi is traded at the market, forming the end point of a complex trade network that involves hundreds of people. The wild meat trade network is complex, involving widespread participation and exchanges among a large number of individuals, as a result of ease of access to the market. About 845 people were involved in the wild meat trade network as their primary livelihood activity in 2018: 253 market traders and brokers (153 women and 100 men), 539 commercial hunters, and 53 women who participate in hunting trips with their husbands (van Vliet et al. 2019). About 145 tons of wild meat are traded per year in Yangambi (van Vliet et al. 2019).

Kisangani, the provincial capital of the Tshopo Province and the third largest city in DRC, lies along the Congo River. During the last 15 years, the urban population from Kisangani exploded from 247,000 inhabitants in 2002, to 628,000 in 2009, and 1,600,000 in 2015 (RDC 2015). In Kisangani, agriculture and livestock production dramatically dropped during conflict in the region in the early 2000 s. Consequently, the population heavily relied on wild meat as a main source of protein and income (de Merode et al. 2004; van Vliet et al. 2015a) and urban wild meat markets flourished. Kisangani became a central marketplace for wild meat to feed the growing urban population (van Vliet et al. 2012).

However, while a decade ago, wild meat and fish were still the most frequently consumed animal proteins in Kisangani, particularly among poorer households (van Vliet et al. 2015b), meat from domestic animals has recently become more affordable, reducing reliance on wild meat. Imported chicken and pork are now competitive with wild meat (van Vliet et al. 2017) and increasingly popular among wealthier households. Nevertheless, because smoked wild meat is traded in piles that can be as small as a Maggi cube of stock or seasoning, whereas chicken or pork are only traded per kilogram, it remains more affordable to those who manage on small daily budgets.

Most wild meat carcasses come from Ituri (63%), Lubutu (34%), and Ubundu (3%) (van Vliet et al., 2012). Five species account for 89% of the carcasses traded: small diurnal monkeys (30%), Emin's pouched rats (*Cricetomys emini*) (24%), blue duikers (17%), brush-tailed porcupines (13%), and bay duikers (*Cephalophus dorsalis*) (5%) (van Vliet et al. 2012). Wild meat is hunted either using traps (54%) or guns (46%) and is traded smoked (van Vliet et al. 2012). About 250 traders sell wild meat in the five main markets of Kisangani (with 154 registered traders at the central market). The trade network in Kisangani has multiple barriers to market, including the poor state of roads between hunting grounds and Kisangani, and

the depletion of species hunted for meat (van Vliet et al., 2017). The most up-to-date figure from 2016 accounts for 293 tons of wild meat traded per year in the central market alone (van Vliet et al. 2017).

4.3. Dja South, Cameroon

Dja et Lobo has 8 subdivisions of which five, including Djoum, Meyomessala, Meyomessi, Mintom, and Dja South, that were part of our study. Sangmélima town (82,513 ha) is the centre of the Dja et Lobo division in southern Cameroon. These subdivisions are located south of the Dja Faunal Reserve and constitute major consumption and transit hubs for wild meat harvested in the southern part of the reserve and transported to Yaoundé and Douala. Communities around Dja Reserve largely rely on subsistence farming for food security and livelihoods, making use of wild meat and other forest products (Bobo et al. 2015). Hunting and logging are also important sources of income.

In Dja South, wild meat is consumed because it is considered a nutritious source of food, but it also plays an important role in culture and tradition, often being associated with medicinal use. Taste is also an important driver of wild meat consumption (Nguyen et al. 2021). Over the last decade, wild meat has become more expensive than beef and fish (personal communication, Dja South, October 2021). It is also considered scarcer due to the illegality of the trade, which has created new barriers to transporting wild meat from villages to towns (personal communication, Dja South, October 2021). On the southern part of the Reserve, the N9 road links medium sized towns, such as Dja South, Djoum, and Meyomessala, to more remote villages where hunting takes place. Hunting is carried out throughout the year with steel-wire traps and shotguns. Traps are placed near or around the fields to prevent crop damage by rodents, ungulates, and monkeys (Sakanashi 2011). In villages north of Dja Reserve, hunting serves primarily a subsistence role, because the state of the road does not allow easy access to the markets (Ávila et al. 2019).

Meat is brought from the forests around the Dja reserve to markets either directly by hunters, transporters who buy meat from hunters and deliver it to the markets, or middle people who travel to villages to buy from multiple hunters and then resell wild meat to retailers (Saylors et al. 2021). Saylors et al. (2021) identified 48 retailers engaged in the trade network who depend on wild meat as their main source of income. When brought to market, the meat is usually carried in large rice sacks and sold on roadside stands, displayed on cardboard, plastic sheeting, or wooden planks, often on the ground (Saylors et al. 2021). Wild meat is traded in different forms: fresh (carcass as a whole or in piles of meat), smoked, or cooked (Sakanashi 2011). Pangolins (*Phataginus*), brush-tailed porcupines, and duikers are the most frequently consumed in restaurants from Dja South (Nguyen et al. 2021).

4.4. Leticia and tri-frontier region of Colombia

Leticia is the capital city of the Amazonas state in Colombia (48,144 inhabitants) and is located on the Amazon River, at the southern end of the country, in the tri-frontier region between Brazil, Colombia, and Peru. The local economy is mainly based on slash-and-burn cultivation (*chagras*) and some trade. Agricultural food production, which is often protein poor, is complemented by hunting and fishing. Tourism provides some alternative income, as do drug trafficking and the illegal extraction of cedar (van Vliet et al. 2014).

In Leticia, wild meat consumption is more frequent in wealthier families and could be considered a festival food, referring to the use of food to express cultural values (van Vliet et al. 2015, Morsello et al. 2015). In contrast, chicken is the primary protein of poorer populations. Wild meat is cheaper than beef but more expensive than most fish, chicken, and canned meats (van Vliet et al. 2014). Despite its low frequency of consumption, wild meat continues to play an important role in terms of dietary diversity (van Vliet et al. 2015).

The most commercialised species are paca (*Cuniculus*), tapir, collared peccary, deer and white-lipped peccary (*Tayassu pecari*). Wild meat at the market is almost exclusively sold fresh (92%). It is estimated that about 250 tons of wild meat are sold in Leticia per year (van Vliet et al., 2014). Wild meat is sold at the main market (2), in restaurants (16), and in food stalls on streets (14) (van Vliet et al. 2017). In total, 32 wild meat traders were identified in Leticia. The structure of the trade network follows the 'gate keeper' type described in Phelps et al. (2016), where a few traders control the business due to its illegality. All sales are clandestine, hidden from the general public. Trade occurs within a trusted network of customers and retailers who communicate by phone or regular visits. Wild meat is never openly offered on the menus of restaurants and at the market; it is hidden under ice in refrigerators placed at the back of market stalls. Given enforcement, wild meat traders are unable to increase prices when wild meat becomes scarce, such as during dry seasons (van Vliet et al. 2018). Wild meat traded in Leticia comes from the Javari River in Brazil, from the Atacuari and Amazon River on the Peruvian side, and from *peri*-urban communities near Leticia (van Vliet et a. 2015a).

5. Results: The varied impacts of COVID-19 across wild meat trade networks

5.1. Consumers

Across cases, the most significant impact of the pandemic on consumers was shifts in the price and availability of wild meat. Especially during the early months of the COVID-19 pandemic, wild meat prices increased and availability decreased, leading consumers to eat less wild meat. In Kisangani, this had significant effects on food security, with a majority of consumers (58% of 308) mentioning they worried about their food security during the early months of the pandemic. These impacts were experienced less acutely in Yangambi, where consumers reported no price increase for wild meat or fish but a slight decrease in supply. Despite small decreases in availability of wild meat, only 4 out of 74 households interviewed expressed concern because most households could produce their own food.

Of the 540 consumers interviewed in Dja South, 23% had been forced to reduce their consumption of wild meat because it had become hard to find. These consumers described, "During COVID-19 period, retailers in the market increased the bushmeat prices saying that it was no longer easy for them to get supplies of bushmeat from rural areas" (Dja South, October 2021). Another consumer explained, "Bushmeat was more expensive during [the beginning of the pandemic] because many hunters had stopped hunting and bushmeat did not get to the city as before due to multiple checks by the forest and wildlife enforcement officers" (Dja South, October 2021). In Leticia, access to food was a real concern for urban dwellers, despite the distribution of food baskets through a government programme. Supply of the most common sources of protein (imported processed meats and industrial chicken) was disrupted due to the closure of the border with Brazil, and local fish and wildmeat were scarce as a consequence of mobility restrictions totally preventing fishers and hunters from supplying the market.

Across the 540 consumers interviewed in Dja South, Cameroon, 5% said they stopped eating wild meat altogether after hearing that COVID-19 could be transmitted via wild animals, but 26% reported

being more concerned about the links between zoonotic diseases and wild meat during the pandemic. As one regular wild meat consumer explained, "During the COVID-19 crisis I avoided eating pangolin, because it was said that pangolin was transmitting COVID to humans" (Dja South, October 2021). Growing concern about the links between zoonotic diseases (e.g. COVID) and wild meat in Sangmélima was linked to increased public health messaging around wild meat consumption during the pandemic using print media, social media, and radio. NGOs and IGOs were involved in running campaigns about the disease risks associated with eating wild meat. For example, WildAid ran a campaign in Cameroon with the message "Don't eat, buy, or trade in risky bushmeat" (WildAid, 2020). Such messaging appears to have had at least some effect on perceptions of the risks wild meat trade poses to human health.

In other cases, there was no reduced demand for particular species from consumers, but their overall awareness of the risks associated with wild meat consumption increased, along with attention to handling practices. For example, most urban consumers on the coast of Guyana (58% of the 121 interviewed) reported that, despite hearing about potential links between zoonotic diseases and consumption of wild meat, they would have continued eating it if it had been available. However, 12% of the households agreed that the pandemic had made them think about the zoonotic risks associated with handling wild meat more broadly. Such findings reflect how urban consumers' perceptions of disease risk may have shifted with the pandemic.

As such, COVID-19 had significant impacts on wild meat consumers in urban settings. Across cases, market and border closures, social distancing advice and mobility restrictions contributed to less supply and higher prices for wild meat in urban settings. In some cases, awareness raising campaigns further effected peoples' options, with consumers becoming more selective about the type and quality of meat they would eat. Alongside rising non-wild meat food prices and falling urban incomes due to COVID-19 related shocks, these trends significantly impacted on the food security of urban households.

5.2. Traders and retailers

During the earlier months of the pandemic, the temporary closure of food markets and restaurants that sell wild meat had a significant impact on traders and retailers in wild meat trade networks. On the coast of Guyana, restrictions were placed on domestic travel and social gatherings were prohibited. Restaurants, bars, and rum shops were closed and a nightly curfew was imposed. In Guyana, 55 of the 73 retailers stopped selling wild meat for at least a period of time during the first months of the COVID pandemic. In Kisangani, the effects were even more severe with all retailers (72 out of 72) closing for at least some time during the same period. In Colombia, wildmeat supply from neighbouring communities and from across the border in Brazil and was totally blocked, similarly causing retailers (2 out of 2) to halt their market activities.

Even in cases where retailers were able to stay open, many reported selling lower volumes of wild meat. In Guyana, retailers explained that the species and prices of the wild meat sold did not change significantly during the pandemic; however, the volume of wild meat being sold was half what it was pre-pandemic. This was due to supply shortages, as restrictions in movements made it difficult for traders to transport wild meat from rural hunting grounds to urban areas. In Cameroon, restrictions on movement and a lack of access to ammunition decreased the level of commercial hunting, leaving traders with little supply for urban centres. Of the 60 retailers interviewed in Dja South, 65% considered that supply in wild meat decreased or considerably decreased while the prices they paid for wild meat increased. About 40% of the retailers closed business for several months and temporarily engaged in other activities to make ends meet, such as agriculture and the sale of crops.

Retailers were also affected by shifts in the behaviours and preferences of consumers during the pandemic. In Leticia, consumers barely left their homes during the early days of the pandemic, meaning demand was far lower than usual. In Dja South, retailers (61%) reported a decrease in demand, with less demand for pangolin and monkeys from consumers. One market trader attribute this decrease in sales to "the media [which] accused pangolin and monkey of transmitting the COVID-19 virus" (Dja South, October 2021). In contrast, none of the interviewed retailers in Yangambi were concerned about the links between COVID-19 and wild meat, explaining "COVID has nothing to do with wild meat" (Yangambi, May 2021) and "my clients pay no attention to that because that disease, we don't have it here" (Yangambi, May 2021).

5.3. Hunters and subsistence users

As a general trend, shocks triggered by COVID-19 reduced the incentive for hunters to engage in commercial hunting. In some cases, restrictions on movement made it hard for hunters to access supplies needed to hunt for commercial purposes. As one hunter in Ngazi, near Kisangani, DRC, explained, "I changed the frequency of hunting. There were not many ammunitions available because people circulated less during that period. I went hunting 2–3 times per month instead of 5–6 times" (Ngazi, May 2021). In other cases, there were fewer opportunities for hunters to generate income through hunting because retailers were closed and consumers were buying less than before the pandemic. In Cameroon, 49% of hunters reported hunting less during the pandemic due to market closures, decreased demand and lower prices. In Guyana, concerns of becoming ill with COVID-19 also discouraged hunters from joining hunting parties during the first few months of the pandemic. There were also reports of increased scrutiny from forest and wildlife services in Cameroon, which discouraged hunters from harvesting wild animals for commercial purposes during the pandemic.

In contrast, the incentive to hunt for subsistence purposes slightly increased during the pandemic. In Cameroon, people reported that access to processed foods arriving in rural villages from urban areas slowed during the first months of the pandemic due to restrictions on travel and transport. Despite this decrease in food availability, most rural households (96%) did not worry about having enough food during this time. Instead, food was secured by turning to subsistence activities, such as hunting, fishing, gathering forest products, and agriculture. As one hunter explained, "During COVID-19, I hunted only to feed myself" (Meyomessala, September 2021) and as another said, "I went hunting a bit more during COVID-19 crisis to ensure the survival of my family, as other type of foodstuffs had become rare due to restrictions in transports" (Mintom, September 2021).

Similar trends were seen in rural parts of DRC where hunting was common, with hunters explaining that although foods like Maggi cubes and salt became expensive, there was always enough food due to hunting. In rural areas around Yangambi, 20% of the hunters mentioned increasing their crop production during the pandemic and 11% of them mentioned eating more wild meat than usual. As one hunter explained: "We observed the closure of schools and church, so we moved with all the kids to the camp inside the forest. I cultivated some crops there. We could go fishing and hunting all the time" (Weko, May 2021). In response to restrictions that prevented people from convening, socializing and engaging in income-generating opportunities, families temporarily moved to the forest, where they "started putting more traps for wildlife" and also fishing, gathering, and cultivating more small crops (e.g. cassava, plantain, yam, and fruits) (Weko, May 2021).

In most cases, the incentive to hunt for commercial purposes decreased far more than the incentive to hunt for subsistence purposes, which may suggest that less wild meat was harvested during the pandemic; however, in the absence of data on the volume of meat harvested by individual hunters before and during the pandemic, we cannot know for certain.

Alongside greater reliance on subsistence hunting by existing hunters, there was also a return to subsistence hunting by other actors in wild meat trade networks during the pandemic. Many urban dwellers were forced to return back to their home villages due to the closure of schools and universities and the loss of employment in urban centers. In Cameroon, people described how there was "more bushmeat in the village [during this time] as many people were hunting, even students who came from the city after closure of schools" (Meyomessi, August 2021). Even those that did not lose jobs sometimes elected to return to their villages during the pandemic "due to fear of contamination" (Dja South, October 2021), similarly reverting to hunting to secure food and earn income while back home.

These same trends were seen in the interior of Guyana, where people reported an increase in subsistence hunting during the pandemic. They explained that many urban households that migrated to rural areas and un-employed rural households had more time available and less purchasing power because of the loss of jobs and income. As such, men invested more time in subsistence fishing and hunting – both as a pastime and as a source of food. Out of 188 hunters, 25 (13%) increased hunting for subsistence during the pandemic, while 100% of men that migrated temporarily from urban to rural areas engaged in hunting and fishing as a pastime. Interestingly, Indigenous leaders described renewed reliance on wild meat as having the potential to have a positive impact on the land, explaining: "The pandemic became the engine to inspire the younger generation in learning our traditional knowledge and skills, something for which we have worked hard for decades" (Indigenous leader, Aishalton/Guyana, October 2020). Indeed, the pandemic showed the limitations of having food systems that were too dependent on the global economy and on transborder trade.

Similarly, in rural areas around Leticia, Indigenous communities that usually rely on incomes from tourism, turned to subsistence farming, fishing, and hunting during the first months of the pandemic. As people were left without jobs or income, many reactivated their *chagras* and started growing vegetables around their homes. All hunters (46 out of 46) increased hunting for subsistence. Only Indigenous leaders were allowed to travel to the city to procure necessities, such as grains, salt, and sugar, for the community. One community member stated that "Those who knew how to hunt or fish were advantaged" (San Pedro community, October 2020), as a new economy arose at the community level, whereby people went fishing or hunting to trade for crops at the local community market instead of being transported to Leticia. Since movement to Leticia was forbidden, communities became new consumption hubs for all food products coming from the forest and farms. Much like in the interior of Guyana, this return to subsistence activities revived interest in caring for the territory and Indigenous land. Hunters and fishermen went fishing in areas that had been disused for decades. In some communities near Leticia, Indigenous leaders regulated where community members were fishing and hunting, controlled access for outsiders, and engaged in new conservation efforts, such as the protection of special salt licks.

6. Discussion

Departing from early predictions that the COVID-19 crisis would result in less wild meat in the food system overall, our findings suggest that the pandemic reduced access to wild meat in urban areas while increasing reliance on wild meat for subsistence purposes in rural areas. This aligns with recent work by McNamara et al. (2020) and Kamogne Tagne et al. (2022), who report decreases in the commercial incentive to hunt for wild meat alongside increases in the incentive to hunt for subsistence purposes in sub-Saharan African countries during the pandemic. We present this finding cautiously, as we recognise that the response of wild meat markets to the COVID-19 crisis needs to be contextualised: The same shocks may have led to different outcomes in places with different ecological, political-economic and socio-cultural conditions. Nonetheless, our findings provide a useful insight into how shocks to global food systems – which can be caused by disease outbreaks, like COVID-19, or other crises, such as political upheaval or natural disasters – may impact on wild meat markets, peoples' food security and biodiversity conservation outcomes.

In terms of the causes of changing incentives to hunt and trade wild meat during the COVID-19 pandemic, some of our findings slightly diverge from other work, such as that by McNamara et al. (2020) and Kamogne Tagne et al. (2022). By and large, we did not find evidence of commercial hunting decreasing as a result of wild meat being stigmatized at the national level unambiguously as hypothesized in McNamara et al. (2020). Instead, we saw marginalization of particular species in places where local behaviour change campaigns were put in place to reduce consumption for health related reasons, such as pangolin in Cameroon. McNamara et al. (2020) also hypothesised that falling government revenue because of declines in oil prices and international tourism would lead to less hunting regulation and law enforcement in national parks and, consequently, greater incentive to hunt. However, we found no evidence of this causal pathway across our cases. On the contrary, hunters in Cameroon reported more checks by enforcement officers, and hunters in Guyana and Colombia reported more restrictions on movement in and out of hunting grounds. Similar trends were seen by van Vliet et al. (2022) in other parts of Latin America where national and local authorities were stricter in controlling access to hunting and fishing grounds to avoid disease transmission. Such measures decreased peoples' incentive and ability to transport wild meat from hunting areas to urban areas during the pandemic, further contributing to reduced access to wild meat in urban centers.

We also identified additional impact pathways through our study. First, the reduction in international travel and decline in visitors resulted in employment loss and declining incomes in some rural areas, increasing the incentive to hunt for subsistence purposes. Second, restrictions that reduced the availability of transport to and from town and increased transport costs decreased the supply and diversity of wild meat available in urban markets and increased wild meat prices in urban areas. Third, as unemployed urban dwellers migrated to rural areas, they engaged in hunting both as a subsistence activity and as a spare time activity. Fourth, as international markets collapsed, access to ammunition became an issue for hunters, who gave up on commercial hunting. Lastly, since church and school were closed, we also observed temporary migration of rural families to forest camps where they had easier access to food.

Relatedly, we identified feedback loops which were absent from the McNamara model (orange arrows in Figure 2). First, as the incentive to hunt for commercial purposes decreased, the supply of wild meat in urban food systems decreased and the price increased. Also, as the borders closed and national markets collapsed due to COVID-19 related measures, trade networks collapsed. We have added these impact pathways to McNamara et al.'s (2020) and Kamogne Tagne et al.'s (2022) model (Figure 2). Our adapted model only depicts the causal pathways illuminated through our research. Importantly, this is not to say that the other

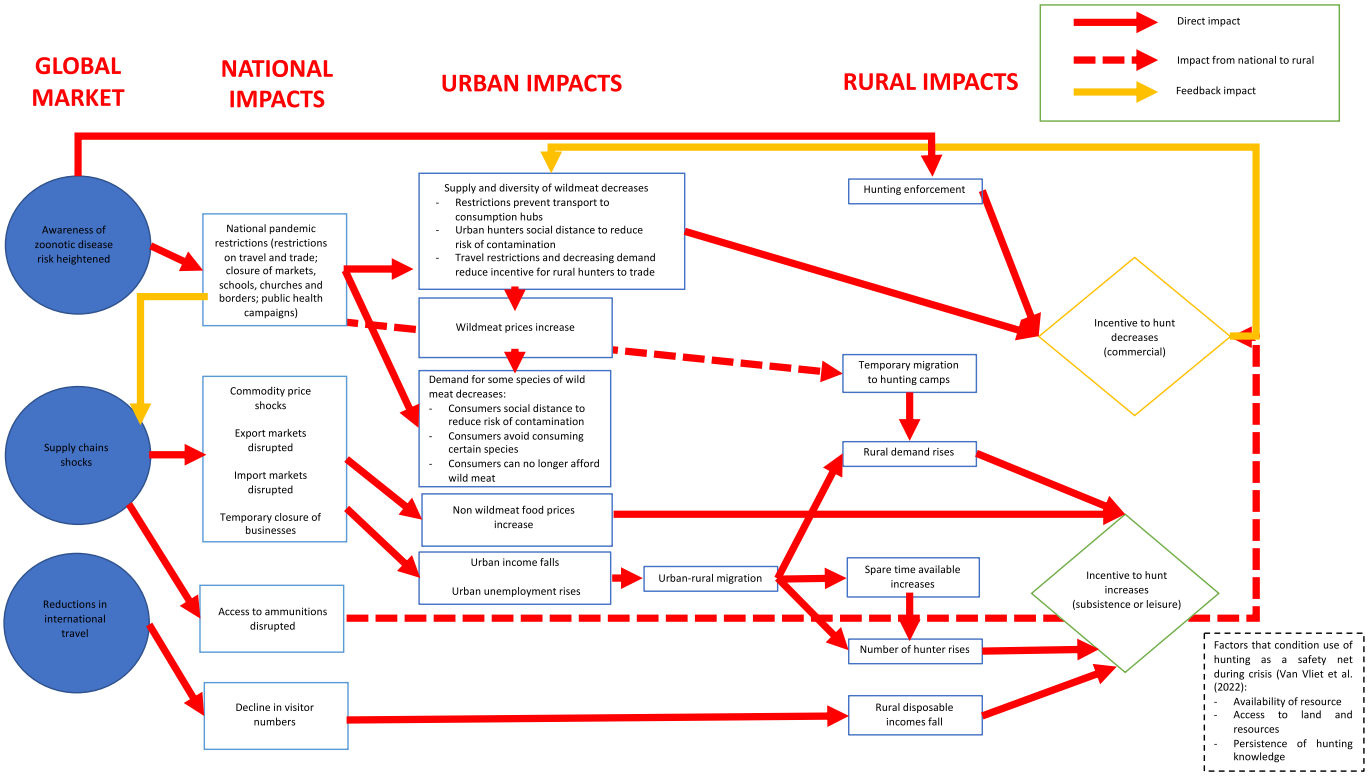

Figure 2. Revision of McNamara et al.'s (2020) and Kamogne Tagne et al.'s (2022) causal model describing key linkages between global COVID-linked shocks and wild meat market dynamics, featuring casual pathways at work in our cases and with additional pathways identified through our study.

causal pathways identified by McNamara et al. (2020) and Kamogne Tagne et al. (2022) – such as the link between an increased incentive to hunt and reduction of government revenue – are unimportant in other settings.

In addition to testing and revising this causal model, our study identifies patterns and trends in how different wild meat trade network actors experienced the impacts of the pandemic. By and large, trade network actors in urban spaces were more acutely affected by COVID-19 than those in rural areas. These effects were most pronounced in regions where wild meat networks are complex, including multiple intermediaries or spanning long distances, as national restrictions on transport and trade prevented meat from reaching urban markets for a period of time (see Table 2). For example, urban retailers in Kisangani were affected by supply shortages and market closures whereas retailers outside of the urban centre in Yangambi reported far less severe impacts on their trade (see Table 3). This supports recent work by Rudolph et al. (2022), who found that the disruptions caused by the pandemic were most notable in urban centres where the wild meat market provides retailers an important cash-generating opportunity in otherwise challenging economic landscape. Urban consumers were also more affected by COVID-19 related shocks than rural consumers. This was particularly true of urban consumers who rely on wild meat for food security and lack access to affordable alternative protein sources (see Table 2). For example, urban consumers in Kisangani were far more concerned about their food security than rural consumers in nearby Yangambi, who were often still able to access meat or hunt for subsistence purposes (see Table 3).

Unlike in urban settings where reliance on wild meat was often to the detriment of trade network actors, wild meat served as a safety net and means of coping with shocks and stressors for many rural trade network actors. Even in cases where urban market closures decreased demand for commercial hunting, rural hunters did not tend to associate this with significant adverse impacts on their overall food security or livelihoods. They were instead able to meet their needs by increasing subsistence activities during this period, such as hunting, fishing, gathering forest products, and farming. Like McNamara et al. (2020) and Kamogne Tagne et al. (2022), we found increased dependence on subsistence hunting in rural settings across our case studies, especially during the early months of the pandemic when the socioeconomic effects of lockdowns were most acute. The importance of hunting as a coping strategy is further evidenced by the fact that hunting increased as processed food in rural spaces became less accessible and more expensive, and as people returned home to rural areas from towns and cities to hunt following income loss and food insecurity.

These findings parallel an existing body of research that suggests that wild meat can serve as an environmental coping strategy that rural populations turn to as a safety net during hazard exposure. For example, some research has found higher levels of wild meat consumption and trade during seasonal dry spells and droughts (Alves et al. 2009; Mendonça et al., 2016; Schulte-Herbrüggen et al. 2017). Even in places where hunting does not tend to be a major contributor to income, wild meat can be turned to as a safety net when agricultural livelihoods are temporarily unavailable or fail because of idiosyncratic shocks (Jambiya et al. 2007; Ordaz-Németh et al. 2017; Schulte-Herbrüggen et al. 2017). Similarly, van Vliet et al. (2017; 2018) found that the trade and consumption of wild meat increased in parts of DRC in response to high levels of political and economic instability and conflict, loss of employment, and a lack of production and supply of other protein sources.

Importantly, we found that the turn to subsistence hunting experienced during the COVID-19 pandemic was not necessarily a last resort. In the past, some have argued that environmental coping strategies, like hunting, are an option of last resort, "which people only select as their primary safety net response when shocks are particularly severe and when, due to adverse household

Table 2
Summary of wild meat trade characteristics across case studies.

	Coast of Guyana, Guyana	Dja South, Cameroon	DRC		Leticia, Colombia
			Yangambi	Kisangani	
Type of trade network[i]	Subsistence and commercial Subsistence hunting in rural areas; hunting to supply more distant urban, coastal markets	Subsistence and commercial Subsistence hunting in rural areas; hunting to supply nearby or urban towns or more distant urban markets	Subsistence and commercial Subsistence hunting in rural areas; hunting to supply nearby urban markets	Commercial Wild meat is supplied to urban markets by rural hunters	Commercial Subsistence hunting in *peri*-urban areas; hunting to supply nearby urban markets; wild meat is also supplied to urban markets by international traders
Structure of trade network[ii]	Restricted resource access Resource access at source is restricted by hunting access and, therefore, limited set of hunters	Complex Widespread participation as a result of few barriers to participation in harvest and/or ease of access to market	Complex Widespread participation as a result of few barriers to participation in harvest and/or ease of access to market	Complex Widespread participation as a result of few barriers to participation in harvest and/or ease of access to market	Gatekeeper Few traders control much of the business due to its illegality
Importance for income of hunters	High	High	High	–	Moderate
Importance as source of food	Low	High	High	High	Low
Cost	Less than other meat	More than other meat	Less than other meat	Less than other meat	More than most other meat
Accessibility	Accessible	Moderately accessible	Highly accessible	Highly accessible	Difficult to access
National pandemic restrictions	Market closures; social distancing advice; restrictions on movement and travel	Market closures; social distancing advice; restrictions on movement and travel; public health campaigns to discourage wild meat consumption	Market closures; social distancing advice; restrictions on movement and travel	Market closures; social distancing advice; restrictions on movement and travel	Market closures; social distancing advice; restrictions on movement and travel

[i] The distinction between subsistence and commercial use of wild meat is often blurred (see Ingram et al., 2021; Ndibalema & Songorwa, 2008).
[ii] Trade networks can also be blurry and vary by type of wildlife product being traded; however, the typology by Phelps (2016) is useful in capturing broad trends in wildlife trade.

and village conditioning factors, they do not have any easier way out" (Wunder et al. 2014, S39). On the contrary, in our study, participants reported increasing reliance on subsistence hunting during the pandemic as a spare time activity that could reconnect them to their roots and culture. They also described how they enjoyed being able to hunt more during the pandemic, associating wild meat and hunting with health and happiness.

A growing body of research on the drivers of wild meat consumption finds that consumption of wild meat is often associated with emotional wellbeing and collective happiness (Dounias and Ichikawa 2017; van Vliet et al. 2015; van Vliet 2018) and promotes groundedness, security, and identity (Jepson and Canney 2003). Such insights help explain why returning to wild meat hunting and consumption during the COVID-19 pandemic, even among more urban dwellers, was often readily accepted as a coping strategy rather than being seen as a measure of last resort. Food insecurity and income loss may cause people to seek out coping strategies during times of crises; however, the specific strategies they turn to are also associated with affective motivators, such as attachment to place, culture and identity, and belonging, as well as contextual understandings of health and wellbeing. People often choose to eat wild meat as it strengthens their connection to culture, home, and territory (van Vliet et al. 2015; van Vliet 2018). It is therefore not surprising that rural, and even urban, populations may turn to subsistence hunting during severe hazard exposure instead of relying on other coping strategies, such as seeking support from relatives or finding informal work.

Ultimately, although hunting for wild meat can provide a safety net when incomes fall or food insecurity is experienced, not all wild meat trade network actors have the same access to this coping strategy. As Pritchard et al. (2020) explain, the environmental coping strategies available and preferred will depend on the type of hazards encountered, the resources available and the larger socio-political and environmental contexts. In the case of hunting for wild meat, there are a number of conditions that need to be met before hunting can be used as a safety net. These include: availability of wildlife (i.e. in depleted areas, the scarcity of wildlife is a constraint from an adaptation point of view); secure access to land and resources (i.e. in areas where communities have no granted access rights, vulnerability increases); and persistence of hunting knowledge (where hunting skills are lost, the capacity to rely on hunting in time of crises decreases) (van Vliet et al. 2022). This is well-illustrated by a case like Guyana with restricted resource access (see Table 2), as the right to hunt is largely limited to Indigenous peoples on their own territories (van Vliet 2019). While a hunter in this trade network may be able to turn to subsistence hunting to cope with shocks, someone reselling wild meat in an urban market is less likely to have this option. These factors that condition a turn to hunting as a coping strategy have been added to our revised causal model (Figure 2).

Finally, our study reinforces a growing body of research that shows how the indirect effects of the COVID-19 pandemic, including the socio-economic impacts, had particularly adverse impacts on peoples' welfare and wellbeing in the global South (Carmody and McCann 2020). Across these studies, sudden food costs hikes, alongside supply chain disruptions, closures of markets and other public spaces, and lockdowns made it difficult for many people in the global South to earn income and afford and access food

Table 3
Impacts of COVID-19 across wild meat trade chains.

Trade chain actor	Coastal towns, Guyana	Dja South, Cameroon	DRC		Leticia and tri-frontier region, Colombia
			Yangambi	Kisangani	
Consumers	12% of the households were more concerned about the links between zoonotic diseases (e.g. COVID) and wild meat	26% of the households were more concerned about the links between zoonotic diseases (e.g. COVID) and wild meat	0% of the households were more concerned about the links between zoonotic diseases (e.g. COVID) and wild meat	0% of the households were more concerned about the links between zoonotic diseases (e.g. COVID) and wild meat	N/A
	5% of consumers worried about their food security as a result of supply chain shocks and food prices increases	4% of rural consumers worried about their food security as a result of supply chain shocks and food prices increases	5% of rural consumers worried about their food security as a result of supply chain shocks and food prices increases	58% of urban consumers worried about their food security as a result of supply chain shocks and food prices increases	11% of consumers worried about their food security as a result of supply chain shocks and food prices increases
Retailers and Traders	60% of retailers were more concerned/aware about the links between zoonotic diseases and wild meat	47% of retailers were more concerned/aware about the links between zoonotic diseases and wild meat	0% of retailers were more concerned/aware about the links between zoonotic diseases and wild meat	0% of retailers were more concerned/aware about the links between zoonotic diseases and wild meat	0% of retailers were more concerned/aware about the links between zoonotic diseases and wild meat
	43.7% of retailers perceived a decrease or sharp decrease in consumer demand	61% of retailers perceived a decrease or sharp decrease in consumer demand	18% of retailers perceived a decrease or sharp decrease in consumer demand	92.5% of retailers perceived a decrease or sharp decrease in consumer demand	0% of retailers perceived a decrease or sharp decrease in consumer demand
	100% of retailers perceived a decrease or sharp decrease in supply	65% of retailers perceived a decrease or sharp decrease in supply	18% of retailers perceived a decrease or sharp decrease in supply	57.5% of retailers perceived a decrease or sharp decrease in supply	100% of retailers perceived a decrease or sharp decrease in supply
	75.4% of retailers stopped trading for a period of time	40% of retailers stopped trading for a period of time	0.9% of retailers stopped trading for a period of time	100% of retailers stopped trading for a period of time	100% of retailers stopped trading for a period of time
	3% of retailers increased prices of wildmeat	63% of retailers increased prices	0% of households reported increased prices of wildmeat	27.5% of retailers increased prices	0% of retailers increased prices
Hunters		49% of hunters decreased hunting for commercial purposes	26.8% of hunters decreased hunting for commercial purposes		
			13% of hunters increased hunting for subsistence purposes		
	13% of hunters increased hunting for subsistence purposes	5% of hunters increased hunting for subsistence purposes			100% of the hunters increased hunting for subsistence purposes

(Crush and Si 2020; Krauss et al. 2022; Kansiime et al. 2021; Makombe, 2021). This research has also found examples where national and international restrictions related to COVID-19 infringed on peoples' social and cultural rights and increased social stigmatisation of vulnerable groups in the global South (for example, see Uddin et al. 2022). Our research adds to this research further examples of tensions between public health interventions and socio-cultural rights, such as the Indigenous peoples' right to engage in subsistence hunting on their territories and exercise food sovereignty.

However, there have been some positive findings in this research, which are similarly reflected by our study. The pandemic highlighted the risks of over-reliance on global trade networks. Producers in the global South who focus on growing specialized crops for export proved to be particularly vulnerable. As global buyers cancelled contracts and movement ceased, producers were often left holding perishable products they could not sell (Clapp and Moseley 2020). In contrast, those less integrated in global trade networks – such as small-scale fisheries and local wild meat trade – were not as vulnerable to COVID-19 outbreaks (Bassett et al. 2021; Moseley and Battersby 2020). Over time, many local trade networks proved able to adapt their distribution models to keep their production stable (Bennett et al 2020). In some cases, this shift generated environmental benefits. For example, there was a resurgence of local food networks and community-supported fisheries during the pandemic alongside less industrial fishing, which may have provided some relief to marine ecosystems and possibly benefits for small-scale fisheries too (Bennett et al 2020). The increased reliance on hunting for subsistence purposes discussed in this article reflects a similar trend of (re)turning to local, decentralised solutions for managing food security in the global South during time of crisis – a trend that could usher in 'a new chapter in the field of global food security' (Fennell, n.d.).

7. Conclusion

The global COVID-19 pandemic thrust the wild meat trade into the international spotlight. Amidst rising fear and speculation the trade could lead to further zoonotic disease outbreaks, the sector came under greater pressure and scrutiny for posing public health

risks. For this reason, one of the "immediate responses to COVID-19 has been a call to ban wildlife trade given the suspected origin of the pandemic in a Chinese market selling and butchering wild animals" (Roe 2020, 1). Animal rights groups and conservation organisations have been at the forefront of these calls, but major development actors have also made similar calls, including the European Union, United Nations Environment Programme, and the United States Agency for International Development.

There is undeniably an urgent need to tackle wildlife trade that is illegal or unsustainable, or that carries risks to human health or animal welfare. However, attempts to mitigate public health risks by amending wild meat policy and management have often outpaced evidence about what does and does not work. For example, wildlife trade bans and market closures during past outbreaks and epidemics have pushed trade underground, making wild meat use more difficult for authorities to monitor, which is problematic when safety and public health concerns are at play (Weber et al. 2015; Bonwitt et al. 2018). As Ingram (2020) writes, there is a need for action to manage wildlife use "to consider far more than risks of disease transmission alone, but also the wider implications of management strategies aimed at reducing wildlife use, taking into account the vast differences in the needs of different sectors of society to hunt and consume wild meat" (2020, 118). In other words, policies and interventions for the wild meat sector need to be informed by evidence to prevent unintended social, economic, and environmental outcomes, especially for more vulnerable segments of society.

Our study responds to this point by revealing differences in how shocks affect the vulnerability and coping strategies of different segments of society involved in the hunting, trade, sale and consumption of wild meat. We show that for urban consumers living in places where wild meat provides a key source of protein – with complex supply chains that are particularly sensitive to external shocks – shocks that impede on the availability and accessibility of wild meat in markets threaten food security. For urban traders and vendors, such shocks remove an important cash-generating option from peoples' livelihood portfolios. Rural hunters and consumers appear better able to cope when wild meat becomes less available and accessible in markets, as they can turn to hunting as a coping strategy during times of crises. Our research suggests that protecting the right to participate in legal and sustainable hunting is essential to ensuring that rural actors can use wild meat as a safety net during times of crisis.

Based on this research, we conclude that shocks that disrupt wild meat hunting and trade risk adversely impacting on peoples' livelihoods and food security. Thus, efforts to improve the safety, sustainability and resiliency of the wild meat sector have greater potential to contribute to development outcomes than policies and interventions that initiate shocks in the wild meat sector, such as banning wild meat use altogether. This requires wild meat consumers, retailers, hunters, health officials and law enforcement to work together to understand where exposure to zoonotic risk occurs within wild meat networks and to implement practices that decrease this risk (van Vliet et al. 2022).

Our study raises important questions about the possible environmental benefits of the (re)turn to subsistence hunting – and local, decentralised food systems more broadly – as a coping strategy during times of crisis. In some of our case studies, reliance on hunting during the COVID-19 crisis appeared to make positive contributions to biodiversity and biocultural conservation outcomes, such as reinvigorating traditional knowledge and customary systems of land and resource management to prevent overharvesting of wild resources. There is existing evidence to suggest that sustainable wildlife use and trade can have conservation benefits by motivating people to actively protect species, habitats, and biodiversity (Roe et al. 2020). Future research should explore whether the shifts towards local food systems that happened during COVID-19 were long-lasting and, if so, how such shifts are interacting with development and conservation outcomes.

CRediT authorship contribution statement

Charis Enns: Conceptualization, Methodology, Data curation, Formal analysis, Writing – original draft, Writing – review & editing, Project administration, Funding acquisition. **Nathalie van Vliet:** Conceptualization, Methodology, Data curation, Formal analysis, Conceptualization, Writing – original draft, Writing – review & editing, Project administration. **Joseph Mbane:** Methodology, Investigation, Data curation, Writing – review & editing. **Jonas Muhindo:** Methodology, Investigation, Data curation. **Jonas Nyumu:** Methodology, Investigation, Data curation. **Brock Bersaglio:** Conceptualization, Methodology, Writing – review & editing, Project administration, Funding acquisition. **Francis Massé:** Conceptualization, Methodology, Writing – review & editing, Project administration, Funding acquisition. **Paolo Cerutti:** Conceptualization, Methodology, Conceptualization, Writing – review & editing, Project administration. **Robert Nasi:** Conceptualization, Methodology, Conceptualization, Writing – review & editing, Project administration.

Data availability

The authors do not have permission to share data.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This work was supported by the United Kingdom's Global Challenges Research Fund and Newton Fund (GCRF_NF94); the European Union's Development Fund (FED/2016/381-145); and the SWM Programme, an Initiative of the Organisation of African, Caribbean, and the Pacific States, which is funded by the European Union with co-funding from the French Facility for Global Environment and the French Development Agency. We are grateful to the reviewers for their constructive feedback and for helping us improve the manuscript.

References

Alves, R., MendonÓa, L. E., Confessor, M. V., Vieira, W. L., & Lopez, L. (2009). Hunting strategies used in the semi-arid region of northeastern Brazil. *Journal of Ethnobiology and Ethnomedicine, 5*(1), 1–16.

Alves, R. R. N., & van Vliet, N. (2018). Wild fauna on the menu. In *Ethnozoology* (pp. 167-194). Academic Press.

êvila, E., Tagg, N., Willie, J., Mbohli, D., FarfÃn, M. ê., Vargas, J. M., et al. (2019). Interpreting long-term trends in bushmeat harvest in southeast Cameroon. *Acta Oecologica, 94*, 57–65.

Bartlett, L., & Vavrus, F. (2016). *Rethinking case study research: A comparative approach*. Routledge.

Bassett, H. R., Lau, J., Giordano, C., Suri, S. K., Advani, S., & Sharan, S. (2021). Preliminary lessons from COVID-19 disruptions of small-scale fishery supply chains. *World Development, 143* 105473.

Belton, B., Leah, R., Lucinda, M., Saadiah, G., Abdullah-Al, M., Jacqueline, S., et al. (2021). COVID-19 impacts and adaptations in Asia and Africas aquatic food value chains. *Marine Policy, 129* 104523.

Bennett, N. J., Finkbeiner, E. M., Ban, N. C., Belhabib, D., Jupiter, S. D., Kittinger, J. N., et al. (2020). The COVID-19 pandemic, small-scale fisheries and coastal fishing communities. *Coastal Management, 48*(4), 336–347.

Bobo, K. S., Aghomo, F. F. M., & Ntumwel, B. C. (2015). Wildlife use and the role of taboos in the conservation of wildlife around the Nkwende Hills Forest Reserve; South-west Cameroon. *Journal of Ethnobiology and Ethnomedicine, 11*(1), 1–24.

Booth, H., Clark, M., Milner-Gulland, E. J., Amponsah-Mensah, K., Antunes, A. P., Brittain, S., et al. (2021). Investigating the risks of removing wild meat from global food systems. *Current Biology, 31*(8), 1788–1797.
Bonwitt, J., Dawson, M., Kandeh, M., Ansumana, R., Sahr, F., Brown, H., et al. (2018). Unintended consequences of the bushmeat banin West Africa during the 2013 2016 Ebola virus disease epidemic. *Social Science & Medicine, 200*, 166–173.
Brashares, B. J. S., Abrahms, B., Fiorella, K. J., Christopher, D., Hojnowski, C. E., Marsh, R., et al. (2014). Wildife decline and social conflict. *Science, 345*, 376–378.
Brinkmann, S. (2014). Unstructured and semi-structured interviewing. *The Oxford handbook of qualitative research, 2*, 277–299.
Cardoso, P., Amponsah-Mensah, K., Barreiros, J. P., Bouhuys, J., Cheung, H., Davies, A., et al. (2021). Scientists' warning to humanity on illegal or unsustainable wildlife trade. *Biological Conservation, 263* 109341.
Carmody, P., & McCann, G. (2020). COVID-19 in the Global South Impacts and Responses Introduction. *Covid-19 in the Global South. Impacts and Responses*, 1–4.
Cawthorn, D. M., & Hoffman, L. C. (2015). The bushmeat and food security nexus: A global account of the contributions, conundrums and ethical collisions. *Food Research International, 76*, 906–925.
Challender, D. W., Brockington, D., Hinsley, A., Hoffmann, M., Kolby, J. E., MassÕ, F., ... & MilnerGulland, E. J. (2022). Accurate characterization of wildlife trade and policy instruments: Reply to D'Cruze et al.(2022) and Frank and Wilcove (2022). *Conservation Letters*.
Clapp, J., & Moseley, W. G. (2020). This food crisis is different: COVID-19 and the fragility of the neoliberal food security order. *The Journal of Peasant Studies, 47*(7), 1393–1417.
Coad, L., Schleicher, J., MILNERGULLAND, E. J., Marthews, T. R., Starkey, M., Manica, A., & Abernethy, K. A. (2013). Social and ecological change over a decade in a village hunting system, central Gabon. *Conservation Biology*, *27*(2), 270-280.
Coad, L., Fa, J. E., Abernethy, K., Van Vliet, N., Santamaria, C., Wilkie, D., et al. (2019). Towards a sustainable, participatory and inclusive wild meat sector. *CIFOR.*.
Cowlishaw, G. U. Y., Mendelson, S., & Rowcliffe, J. M. (2005). Evidence for post-depletion sustainability in a mature bushmeat market. *Journal of Applied Ecology, 42*(3), 460–468.
Crush, J., & Si, Z. (2020). COVID-19 containment and food security in the Global South. *Journal of Agriculture, Food Systems, and Community Development, 9*(4), 149–151.
De Merode, E., Homewood, K., & Cowlishaw, G. (2004). The value of bushmeat and other wild foods to rural households living in extreme poverty in Democratic Republic of Congo. *Biological conservation, 118*(5), 573–581.
Dirzo, R., Young, H. S., Galetti, M., Ceballos, G., Isaac, N. J., & Collen, B. (2014). Defaunation in the Anthropocene. *Science, 345*(6195), 401–406.
Dounias, E., & Ichikawa, M. (2017). Seasonal bushmeat hunger in the Congo Basin. *EcoHealth, 14*(3), 575–590.
Dutta, A., & Fischer, H. W. (2021). The local governance of COVID-19: Disease prevention and social security in rural India. *World Development, 138* 105234.
Fargeot, C., Drouet-Hoguet, N., & Le Bel, S. (2017). The role of bushmeat in urban household consumption: Insights from Bangui, the capital city of the Central African Republic. *BOIS & FORETS DES TROPIQUES, 332*, 31–42.
Fennell, S., n.d. Local food solutions during the coronavirus crisis could have lasting benefits. University of Cambridge. https://www.cam.ac.uk/stories/globaltolocal.
Funk, S. M., Fa, J. E., Ajong, S. N., Eniang, E. A., Dendi, D., Nasi, R., et al. (2021). *Impact of COVID-19 on wild meat trade in Nigerian markets*. Conservation Science and Practice.
Gill, D. J., Fa, J. E., Rowcliffe, J. M., & K≈mpel, N. F. (2012). Drivers of change in hunter offtake and hunting strategies in Sendje, Equatorial Guinea. *Conservation Biology, 26*(6), 1052–1060.
Gluszek, S., Viollaz, J., Mwinyihali, R., Wieland, M., & Gore, M. L. (2021). Using conservation criminology to understand the role of restaurants in the urban wild meat trade. *Conservation Science and Practice, 3*(5), e368.
Gore, M. L., Escouflaire, L., & Wieland, M. (2021). Sanction avoidance and the illegal wildlife trade: A case study of an Urban Wild Meat Trade network. *Journal of Illicit Economies and Development, 3*(1).
Harvey-Carroll, J., Simo, F. T., Sonn-Juul, T., Tsafack, J. P., Aka'a, S. J., Tarla, F. N., et al. (2022). Continued availability and sale of pangolins in a major urban bushmeat market in Cameroon despite national bans and the COVID-19 outbreak. *African Journal of Ecology*.
Ibarra, J. T., Barreau, A., Campo, C. D., Camacho, C. I., Martin, G. J., & McCandless, S. R. (2011). When formal and market-based conservation mechanisms disrupt food sovereignty: Impacts of community conservation and payments for environmental services on an indigenous community of Oaxaca, Mexico. *International Forestry Review, 13*(3), 318–337.
Ingram, D. J. (2020). Wild meat in changing times. *Journal of Ethnobiology, 40*(2), 117–130.
Ingram, D. J., Coad, L., Milner-Gulland, E. J., Parry, L., Wilkie, D., Bakarr, M. I., et al. (2021). Wild meat is still on the menu: Progress in wild meat research, policy, and practice from 2002 to 2020. *Annual Review of Environment and Resources, 46*, 221–254.
Jambiya, G., Milledge, S., & Mtango, N. (2007). 'Night time spinach': conservation and livelihood implications of wild meat use in refugee situations in north-western Tanzania.
Jepson, P., & Canney, S. (2003). Values-led conservation. *Global Ecology and Biogeography, 12*(4), 271–274.
Kamogne Tagne, C. T., Brittain, S., Booker, F., Challender, D., Maddison, N., Milner-Gulland, E. J., et al. (2022). Impacts of the COVID-19 pandemic on livelihoods and wild meat use in communities surrounding the Dja Faunal Reserve, South-East Cameroon. *African Journal of Ecology*..
Kansiime, M. K., Tambo, J. A., Mugambi, I., Bundi, M., Kara, A., & Owuor, C. (2021). COVID-19 implications on household income and food security in Kenya and Uganda: Findings from a rapid assessment. *World Development, 137* 105199.
Krauss, J. E., Artur, L., Brockington, D., Castro, E., Jr, Fernando, J., Jr, Fisher, J., et al. (2022). To prevent this disease, we have to stay at home, but if we stay at home, we die of hungerlivelihoods, vulnerability and coping with Covid-19 in rural Mozambique. *World Development, 151* 105757.
Lai, John, Stephen, Morgan, Bachir, Kassas, Kropp, Jaclyn, & Zhifeng, Gao (2020). Spending of economic stimulus payments and changes in food purchasing during the COVID-19 pandemic. *Choices, 35*(3), 1–8.
Leach, M., MacGregor, H., Scoones, I., & Wilkinson, A. (2021). Post-pandemic transformations: How and why COVID-19 requires us to rethink development. *World Development, 138* 105233.
Lescuyer, G., & Nasi, R. (2016). Financial and economic values of bushmeat in rural and urban livelihoods in Cameroon: Inputs to the development of public policy. *International Forestry Review, 18*(1), 93–107.
Lindsey, P. A., Balme, G., Becker, M., Begg, C., Bento, C., Bocchino, C., et al. (2013). The bushmeat trade in African savannas: Impacts, drivers, and possible solutions. *Biological Conservation, 160*, 80–96.
Luiselli, L., Hema, E. M., Segniagbeto, G. H., Ouattara, V. A. L. Y., Eniang, E. A., Parfait, G., et al. (2020). Bushmeat consumption in large urban centres in West Africa. *Oryx, 54*(5), 731–734.
Makombe, E. K. (2021). Between a rock and a hard place: The coronavirus, livelihoods, and socioeconomic upheaval in Harares high-density areas of Zimbabwe. *Journal of Developing Societies, 37*(3), 275–301.
Mansour, S., Abulibdeh, A., Alahmadi, M., & Ramadan, E. (2022). Spatial Assessment of COVID-19 First-Wave Mortality Risk in the Global South. *The Professional Geographer, 74*(3), 440–458.
MendonÓa, L. E., Vasconcellos, A., Souto, C. M., Oliveira, T. P., & Alves, R. (2016). Bushmeat consumption and its implications for wildlife conservation in the semi-arid region of Brazil. *Regional Environmental Change, 16*(6), 1649–1657.
McNamara, J., Robinson, E. J., Abernethy, K., Midoko Iponga, D., Sackey, H. N., Wright, J. H., et al. (2020). COVID-19, systemic crisis, and possible implications for the wild meat trade in Sub-Saharan Africa. *Environmental and Resource Economics, 76*(4), 1045–1066.
Morrison, D. (2020). Reflections and realities: expressions of food sovereignty in the Fourth World. *Indigenous Food Systems: Concepts, Cases, and Conversations*, 17-38.
Morsello, C., Yag≈e, B., Beltreschi, L., Van Vliet, N., Adams, C., Schor, T., et al. (2015). Cultural attitudes are stronger predictors of bushmeat consumption and preference than economic factors among urban Amazonians from Brazil and Colombia. *Ecology and Society, 20*(4).
Moseley, W. G., & Battersby, J. (2020). The vulnerability and resilience of African food systems, food security, and nutrition in the context of the COVID-19 pandemic. *African Studies Review, 63*(3), 449–461.
Nielsen, M. R., Meilby, H., Smith-Hall, C., Pouliot, M., & Treue, T. (2018). The importance of wild meat in the global south. *Ecological Economics, 146*, 696–705.
Nowak, A., Rosenstock, T. S., Hammond, J., Degrande, A., & Smith, E. (2019). Livelihoods of Households Living Near Yangambi Biosphere Reserve, Democratic Republic of Congo.
Nguyen, L. B., Fossung, E. E., Affana Nkoa, C., & Humle, T. (2021). Understanding consumer demand for bushmeat in urban centers of Cameroon with a focus on pangolin species. *Conservation Science and Practice, 3*(6), e419.
Ordaz-NÕmeth, I., Arandjelovic, M., Boesch, L., Gatiso, T., Grimes, T., Kuehl, H. S., et al. (2017). The socio-economic drivers of bushmeat consumption during the West African Ebola crisis. *PLoS Neglected Tropical Diseases, 11*(3), e0005450.
Pattiselanno, F., Lloyd, J. K., Sayer, J., Boedhihartono, A. K., & Arobaya, A. Y. (2020). Wild Meat Trade Network on the Bird's Head Peninsula of West Papua Province, Indonesia. *Journal of Ethnobiology, 40*(2), 202–217.
Phelps, J., Biggs, D., & Webb, E. L. (2016). Tools and terms for understanding illegal wildlife trade. *Frontiers in Ecology and the Environment, 14*(9), 479–489.
Pritchard, R., Grundy, I. M., van der Horst, D., Dzobo, N., & Ryan, C. M. (2020). Environmental resources as last resortcoping strategies following harvest failures in Zimbabwe. *World Development, 127* 104741.
Quinn, C. H., Ziervogel, G., Taylor, A., Takama, T., & Thomalla, F. (2011). Coping with multiple stresses in rural South Africa. *Ecology and Society, 16*(3).
Republique Democratique du Congo, (RDC). (2015). Annuairre Statistique 2015. Kinshasa: Ministere du Plan.
Ripple, W. J., Wolf, C., Newsome, T. M., Betts, M. G., Ceballos, G., Courchamp, F., et al. (2019). Are we eating the world's megafauna to extinction?. *Conservation Letters, 12*(3), e12627.
Roe, D., Dickman, A., Kock, R., Milner-Gulland, E. J., & Rihoy, E. (2020). Beyond banning wildlife trade: COVID-19, conservation and development. *World Development, 136* 105121.
Sakanashi, K. (2011). Land use patterns for cacao agroforestry in southern Cameroon. *African Study Monographs, 32*(4), 135–155.
Saylors, K. E., Mouiche, M. M., Lucas, A., McIver, D. J., Matsida, A., Clary, C., et al. (2021). Market characteristics and zoonotic disease risk perception in Cameroon bushmeat markets. *Social Science & Medicine, 268* 113358.
Schulte-Herbr≈ggen, B., Cowlishaw, G., Homewood, K., & Rowcliffe, J. M. (2017). Rural protein insufficiency in a wildlife-depleted West African farm-forest landscape. *PLoS One1, 12*(12), e0188109.
Turner, N. J., Davidson-Hunt, I. J., & O'flaherty, M. (2003). Living on the edge: ecological and cultural edges as sources of diversity for socialecological resilience. *Human Ecology*, *31*(3), 439-461.

Uddin, M. K., Chy, M. T., & Ahmmed, H. U. (2022). COVID-19 responses, human rights and the cultural context of Global South. *International Journal of Human Rights in Healthcare, 15*(4), 399–411.

van Vliet, N., Nebesse, C. A. S. I. M. I. R., Gambalemoke, S., Akaibe, D., & Nasi, R. (2012). The bushmeat market in Kisangani, Democratic Republic of Congo: Implications for conservation and food security. *Oryx, 46*(2), 196–203.

van Vliet, N., Mesa, M. P. Q., Cruz-Antia, D., de Aquino, L. J. N., Moreno, J., & Nasi, R. (2014). *The uncovered volumes of bushmeat commercialized in the Amazonian trifrontier between Colombia* (p. 3). Ethnobiology and Conservation: Peru & Brazil.

van Vliet, N., Quiceno, M. P., Cruz, D., de Aquino, L. J. N., Yag≈e, B., Schor, T., et al. (2015a). Bushmeat networks link the forest to urban areas in the trifrontier region between Brazil, Colombia, and Peru. *Ecology and Society, 20*, 21. https://doi.org/10.5751/ES-07782-200321.

van Vliet, N., Nebesse, C., & Nasi, R. (2015). Bushmeat consumption among rural and urban children from Province Orientale. *Democratic Republic of Congo. Oryx, 49*(1), 165–174.

van Vliet, N., Quiceno, M. P., Cruz, D., de Aquino, L. J. N., Yag≈e, B., Schor, T., et al. (2015b). Bushmeat networks link the forest to urban areas in the trifrontier region between Brazil, Colombia, and Peru. *Ecology and Society, 20*(3).

van Vliet, N., Moreno Calderœn, J. L., Gomez, J., Zhou, W., Fa, J. E., Golden, C., ... & Nasi, R. (2017). Bushmeat and human health: assessing the evidence in tropical and sub-tropical forests.

van Vliet, N. (2018). Bushmeat crisis and cultural imperialism in wildlife management? Taking value orientations into account for a more sustainable and culturally acceptable wild meat sector. *Frontiers in Ecology and Evolution, 6*, 112.

van Vliet, N., Lharidon, L., Gomez, J., Vanegas, L., Sandrin, F., & Nasi, R. (2018). The use of traditional ecological knowledge in the context of participatory wildlife management: Examples from indigenous communities in Puerto Nariþo, Amazonas-Colombia. In *Ethnozoology* (pp. 497-512). Academic Press.

van Vliet, N., Muhindo, J., Nyumu, J. K., & Nasi, R. (2019). From the forest to the dish: A comprehensive study of the wild meat value network in Yangambi, Democratic Republic of Congo. *Frontiers in Ecology and Evolution, 7*, 132.

van Vliet, N., Nyumu, J. K., Nziavake, S., Muhindo, J., Paemelaere, E. A., & Nasi, R. (2022). How Do Local Folks Value Wild Meat, and Why It Matters? A Study in the Democratic Republic of Congo. *Human Ecology, 50*(1), 195–203.

van Vliet, N., Muhindo, J., Nyumu, J., Enns, C., Masse, F., Bersaglio, B., et al. (2022). Understanding factors that shape exposure to zoonotic and food-borne diseases across wild meat trade networks. *Human Ecology, online first.*.

van Vliet, N., Puran, A., David, O., & Nasi, R. (2022). From the forest to the coast: The wild meat trade network on the Coast of Guyana. *Ethnobiology and Conservation, 11*.

Weber, D. S., Mandler, T., Dyck, M., De Groot, P. J. V. C., Lee, D. S., & Clark, D. A. (2015). Unexpected and undesired conservation outcomes of wildlife trade bans An emerging problem for stakeholders?. *Global Ecology and Conservation, 3*, 389–400.

Wenner, M. and Johnny, T. (2015). *Tourism and ecotourism development in Guyana: Issues and challenges and the critical path forward.* Washington: Inter-American Development Bank.

WildAid. "Don't eat, buy, or trade in risky bushmeat". 9 December 2020. San Francisco, USA. https://wildaid.org/dont-eat-buy-or-trade-in-risky-bushmeat/.

Wildlife Conservation Society (WCS). "Summary of WCS Policy and Messaging on COVID-19". 28 March 2020. New York. https://c532f75abb9c1c021b8c-e46e473f8aadb72cf2a8ea564b4e6a76.ssl.cf5.rackcdn.com/2020/04/01/8294efiuzg_COVID_19_Summary_of_WCS_Policies_and_Messaging_March29.2.pdf.

Willis, J., Ingram, D. J., Abernethy, K., Kemalasari, D., Muchlish, U., Sampurna, Y., et al. (2022). WILDMEAT interventions database: A new database of interventions addressing unsustainable wild meat hunting, consumption and trade. *African Journal of Ecology, 60*(2), 205–211.

Wilkie, D. S., Wieland, M., Boulet, H., Le Bel, S., van Vliet, N., Cornelis, D., et al. (2016). Eating and conserving bushmeat in Africa. *African Journal of Ecology, 54*(4), 402–414.

Wunder, S., B—rner, J., Shively, G., & Wyman, M. (2014). Safety nets, gap filling and forests: A global-comparative perspective. *World Development, 64*, S29–S42.

Zhou, P., Yang, X. L., Wang, X. G., Hu, B., Zhang, L., Zhang, W., et al. (2020). A pneumonia outbreak associated with a new coronavirus of probable bat origin. *Nature, 579*(7798), 270–273.

Further reading

Bennett, N. J., Blythe, J., Tyler, S., & Ban, N. C. (2016). Communities and change in the anthropocene: Understanding social-ecological vulnerability and planning adaptations to multiple interacting exposures. *Regional Environmental Change, 16*(4), 907–926.