Country Profile: LIBERIA

Scientific basis for zoonosis education program (as of January 2023)

In situ project partner: Libassa Wildlife Sanctuary (sole wildlife rescue centre in Liberia)

Location: Gbono Town, 46 km from Monrovia

☑ **urban** ☑ **rural**

Outreach to (area): Montserrado, Grand Cape Mount, Nimba, Grand Bassa, Gbarpolu, Sino, Bomi

Structure

1. National characteristics

- With 28 ethnic groups and languages, Liberia is one of the most ethnically diverse countries in the world (World Factbook 2022) - with a wide variety of tribal, cultural, and religious practices, where the majority of the population depend on the forest and its resources for their livelihood (Machalaba 2022).
- Liberia is not listed in the Global Food Security Index but ranks at 113 (of 121 countries) in the Global Hunger Index (Welthungerhilfe 2022 & Concern Worldwide).
- **Urban population**: 53.1% of total population, with approximately one-third living within an 80-km radius of Monrovia (World Factbook 2022). Liberia has the highest urban primacy, with the capital Monrovia (1.2 million inhabitants) more than 21 times larger than the second agglomeration Buchanan (58 000 inhabitants) (OECD/SWAC 2020). ⇨ see also 5.2.3.
- **Increasing demand by urban citizens?** A study of 2004 noted "that the majority of urban respondents (52%) reported no bushmeat consumption at all in the previous week", while consumption in rural areas of Liberia was reported to be higher (ODI 2004).

1.1. National legislation

- **Act adopting the National Wildlife conservation and Protected Area Management Law of Liberia (2016)**. The species protected under this law are not listed but they include: All pangolins, all hornbills, all crocodiles, all turacos, all pythons, red river hogs, forest elephants, giant forest hog, all monkeys, leopards, Western chimpanzees, all parrots, Liberian mongoose, all sea turtles, pygmy hippo, all birds of prey, all sharks and rays, west African manatee, golden cat, water chevrotain, bongo, most duikers. This makes it illegal to hunt, buy, sell, capture, have as a pet or eat any protected animals. http://wri-sites.s3.amazonaws.com/forest-atlas.org/lbr.forest-atlas.org/resources/Documents/National%20Wildlife%20Law%20of%20Liberia.pdf
- Several primates fully protected (e.g. *Cercocebus atys, Caercopithecus campbelli, C. petaurista, C. diana*) – in contrary, *Procolobus verus* not listed (Bené *et al.* 2013b)
- **Community rights law (2009)**: https://faolex.fao.org/docs/pdf/lbr143892.pdf
- **Environmental and protection management law of Liberia** (2003): http://extwprlegs1.fao.org/docs/pdf/lbr53038.pdf
- **National forest reform law** (2006): https://www.fao.org/forestry/16151-05fd47b845599b5d3a594a9b0240dacff.pdf

1.2. Human population

~ 5.36 Mio people (2022 est.; World Factbook 2022)

Population growth rate: 2.73% (2022 est.; World Factbook 2022)

Religion (2008 est.; World Factbook 2022):

- Christianity: 85.1%
- Islam: 12.2 %
- traditional religious groups: 0.6%
- other groups: 0.2 %

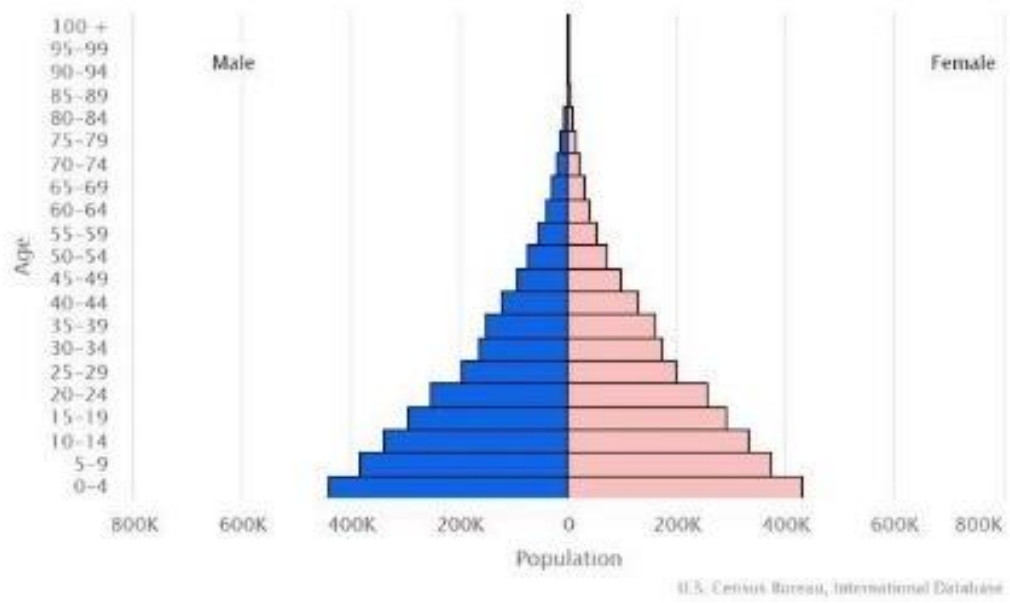
Ethnic groups:

Percentage estimation of the main tribes by 2008 (World Factbook 2022):

Kpelle 20.3%, Bassa 13.4%, Grebo 10%, Gio 8%, Mano 7.9%, Kru 6%, Lorma 5.1%, Kissi 4.8%, Gola 4.4%, Krahn 4%, Vai 4%, Mandingo 3.2%, Gbandi 3%, Mende 1.3%, Sapo 1.3%, other Liberian 1.7%, other African 1.4%, non-African 0.1%

Age structure (2020 est.; World Factbook 2022):

- 0-14 years: 43.35% (male 1,111,479/female 1,087,871)
- 15-24 years: 20.35% (male 516,136/female 516,137)
- 25-54 years: 30.01% (male 747,983/female 774,615)
- 55-64 years: 3.46% (male 89,150/female 86,231)
- 65 years and over: 2.83% (male 70,252/female 73,442)



2. Relevant zoonotic diseases

2.1. Key points on zoonotic diseases

Some zoonotic diseases (such as yellow-fever and trypanosomiasis) are transferred to humans by insect bites. Those "vector-borne" diseases are not covered by this country profile, as this project aims raising awareness for consumption-linked spillover risks (e.g. via bushmeat, keeping of wildlife as pets), which are easier to avoid than insect bites.

In a nutshell:

- **About 75% of all novel infectious diseases are zoonoses** (i.e. diseases transmitted from animals to humans).
- **More than 70% of zoonoses originate from wild animals**.
- Legal AND illegal wildlife trade promote zoonotic spillover events.
- While zoonotic diseases have their origin in animals, human-to-human transmission may become the dominant pathway (e.g. COVID-19, AIDS). Nevertheless, the original source has been in animals (mostly wildlife) and **risks for new spillover events should be reduced to a minimum…**
- **… especially as new zoonotic diseases are expected to come**, with deforestation, increased human encroachment into natural habitat and commercialization of bushmeat trade being driving forces.
- **Viruses** present the greatest zoonotic disease threat to humans because their fast rates of evolution will allow them to easily adapt to new hosts. However, other zoonotic diseases are caused by **bacteria or parasites**.
- During a workshop in December 2018, **ECOWAS agreed upon a list of seven priority zoonotic diseases for the region** – Anthrax, Rabies, Ebola and other viral hemorrhagic fevers (for example, Marburg fever, Lassa fever…), zoonotic influenzas, zoonotic tuberculosis, Trypanosomiasis* and Yellow fever*.
- **Liberia has been struck by outbreaks of several zoonotic diseases**, e.g. Ebola in 2014, Mpox (formerly "monkey pox") in 2017 and Lassa fever in 2018.
- **Liberia was one of three countries heavily impacted by the Ebola epidemic** in West Africa from 2014-2016.
- **80% of Liberia is estimated as Lassa fever risk area.** Lassa Fever is endemic in the West African countries and causes 300,000 to 500,000 cases annually with about 5,000 deaths. A first outbreak was in 2018.
- According to WHO the **number of zoonotic outbreaks in the African region increased by 63% in the decade from 2012-2022**, compared to the decade before.
- **Reptile-associated salmonellosis** globally increases in countries. In some of the most poverty-afflicted regions of Africa, the burden of this neglected disease may be alarming.

** Vector-borne diseases, not relevant for this project (see below)*

2.2. Table: Zoonotic health risks relevant for Liberia

Zoonotic disease	Type of pathogen (group)	Symptoms	Means of trans-mission	Outbreak (when?)	Extent (how many felt ill / died)	Measures by Government	References
Ebola	Virus (Filovirus)	**Incubation time**: 2-21 days **Symptoms**: e.g. life-threatening **haemorrhagic fever**, malaise, fatigue, aching limbs, pain in abdomen, nausea, diarrhoea, internal and external bleeding (haemorrhages), delirium, shortness of breath	**Spillover from wildlife to humans**: bushmeat and contact to bats (primary hosts) as well as primates, rodents & duikers (secondary hosts) **Human to human**: Direct contact, blood, body liquids, faeces, vomit	2014-2016	average case fatality rate is approximately 50% 10,678 ill / 4,808 died in Liberia >> 45% mortality	**Priority for Government in Liberia** Ban of hunting and bushmeat sale (since July 2014). Cremation of bodies and state-enforced quarantine	Arthur *et al.* 2022 CDC 2022a Samuels et al. 2022 WHO 2021a Fall 2019 Pellecchia *et al.* 2015; Judson *et al.* 2016
Lassa Fever	Virus (Arenavirus)	**Incubation period**: 6-21 days, highly virulent **Symptoms**: **haemorrhagic fever**, general weakness, and malaise. After a few days, headache, sore throat, muscle pain, chest pain, nausea, vomiting, diarrhoea, cough, abdominal pain. In severe cases facial swelling, general bleeding tendency (mucosal bleeding), pleural and pericardial effusions, neurological symptoms, slowed heartbeat, low blood pressure. Death approx. 12 days after onset of disease in irreversible shock with organ failure, hypovolaemia and anuria.	**Spillover from wildlife to humans**: Contamination with excrement/secretions of rodents; consumption of uncooked rodent meat **Human to human**: direct contact with blood, tissues, secretions and urine of infected persons, sexual contact	2020 2019 Feb 2018	**80% of Liberia estimated as Lassa Fever risk area**; In Liberia, the magnitude of LF mortality and morbidity is underreported case fatality ratio is 1-15% among hospitalized patients About 80% of people who become infected with Lassa virus have no symptoms	**Priority for Government in Liberia** Children are implicated as the high-risk group for Lassa spillover.	WHO undated a,b WHO 2021c Woyessa *et al.* 2019 Mylne *et al.* 2015 Douno *et al.* 2021

Zoonotic disease	Type of pathogen (group)	Symptoms	Means of trans-mission	Outbreak (when?)	Extent (how many felt ill / died)	Measures by Government	References
Marburg Disease	Virus (Filovirus)	**Incubation time**: 2-21 days **Symptoms**: bleeding from nose and mouth, high fever, severe headache, severe malaise, muscle aches and pain, diarrhoea, abdominal pain and cramping, nausea, and vomiting	**Spillover from wildlife (e.g. bats) to humans**: spread by body fluids, such as blood and saliva **Human to human**: direct contact with blood or body fluids of sick persons	No outbreak yet in Liberia, but 2022 in neighbouring Ghana	average case fatality rate is approximately 50% 2005-outbreak in Angola: > 200 people died 2 of 3 ill persons in Ghana died	**Priority for Government in Liberia**	Sah et al. 2022 WHO 2022f Jipoh 2022 WHO 2021b Markotter et al. 2020
Mpox (=Monkey pox)	Virus (orthopox-virus)	**Incubation time**: 3-17 days **Symptoms**: e.g. fever, headache, muscle pain, skin lessons, pustules, lymphadenopathy, back pain, myalgia, weakness	**Spillover from wildlife to humans**: bushmeat (blood and secretions of infected primates, duikers & rodents) **Human to human**: Direct contact with infected persons, saliva droplets, sexual contact	2022 2018 2017 1970	Only few confirmed (but more suspected) cases in Liberia (24 cases in 1970 outbreak) neglected disease, but with high prevalence reported for Liberia	case management, awareness in the community, early reporting	CDC 2022b WHO 2022d Milbank & Vira 2022 Larway *et al.* 2021 Gweh *et al.* 2021
T-cell leukemia	Virus (Simian retroviruses: STLV-1 / HTLV-1 and STLV-2 / HTLV-2)	**Incubation time**: 6 months – 20 years **Symptoms**: Often without symptoms; however, 5% of infected persons suffer from adult T-cell leukaemia / lymphoma and HTLV-1 associated myelopathy; higher risk for tuberculosis	**Spillover from wildlife to humans**: bushmeat, bites by non-human primates; blood, saliva **Human to human:** Blood, sexual contact, breast-feeding		High HTLV-1 prevalence given for Liberia 50,000-100,000 infected people (HTLV-1 prevalence 1-1.6%)		Anyanwu *et al.* 2018 Fillippone et al. 2015 Gessain & Cassar 2012; ECDC 2015
Avian bird flu	Virus (Influenca virus: H5N1,	**Incubation time**: up to 21 days **Symptoms**: pneumonia; stomach and intestinal complaints; increase in liver enzymes; severe reduction of	**Spillover from wildlife:** wild aquatic birds as primary host, poultry as secondary host, direct contact	first cases in animals in Africa in 2006 (in Nigeria),	case fatality rate is approximately 60%	Priority for Government in Liberia?	Spiegel 2023 FAO 2015

Zoonotic disease	Type of pathogen (group)	Symptoms	Means of trans-mission	Outbreak (when?)	Extent (how many felt ill / died)	Measures by Government	References
	H5N8 & H7N9)	leukocytes (leukopenia), erythrocytes (anaemia) and thrombocytes (thrombocytopenia), in severe cases renal failure, lung failure, multiorgan failure	with infected birds (blood, faeces, feathers)	spreading within Africa	Zoonotic spillover in East Asia, spreading by migrating wild birds and poultry. (so far no human-to-human infections known, but first possible mammal-to-mammal infection noted among minks in a fur farm in Spain in October 2022)		Wertheim et al. 2012 Gaidet *et al.* 2010 Cattoli *et al.* 2009 Seck et al. 2007 WHO 2006
Rift Valley Fever	Virus (Bunyavirus)	**Incubation period**: 2-6 days **Symptoms**: feverish syndrome with sudden onset of flu-like fever, muscle pain, joint pain and headache. In severe cases retinal lesions, decreased vision or even blindness ("ocular form"), **haemorrhagic fever**, Meningoencephalitis (loss of memory, hallucinations, confusion, disorientation, vertigo, convulsions, lethargy and coma)	**Spillover from livestock to humans**: direct or indirect contact with the blood or organs of infected animals (cattle, sheep, goats – in southern Africa also from wildlife) - **Human to human**: not documented	No outbreak yet in Liberia, but spreading in Africa (2003: Egypt, 2006: East Africa, 2007 Sudan, 2012 Mauritania, 2016 Niger)	Case-fatality rate in patients with haemorrhagic fever up to 50%	Priority for Government in Liberia	WHO 2021d
Rabies	Virus (Lyssa virus)	**Incubation time**: 1-3 months **Symptoms**: Fever, headache, vomiting, agitation, confusion, hyperactivity, excessive salivation, hallucinations, insomnia, partial paralysis	Bites or scratches mainly from dogs, but also from wild animals (e.g. bats, monkeys)		Liberia considered a high-risk country;	**Priority for Government in Liberia**	Public Health England 2020 Markotter et al. 2020
Corona / COVID-19	Virus (Corona virus: SARS-CoV-2)	**Incubation time**: 2-14 days **Symptoms**: fever or chills, cough, shortness of breath or difficulty breathing, fatigue, muscle or body aches, headache, loss of taste or smell,	**Spillover from wildlife**: bats as primary host, wildlife (e.g. civets, bamboo rats, primates) sold at wet markets	2020-2023	Zoonotic spillover in China, but pandemic spreading by humans Corona viruses also found in wild bats in Cameroon and other African countries	**Priority for Government in Liberia**	Worobey *et al.* 2022 Xiao *et al.* 2022

Zoonotic disease	Type of pathogen (group)	Symptoms	Means of trans-mission	Outbreak (when?)	Extent (how many felt ill / died)	Measures by Government	References
		sore throat, congestion or runny nose, nausea or vomiting, diarrhoea	discussed as secondary host; **human to human**: respiratory uptake of virus-containing particles (aerosols)				Fischhoff *et al.* 2021 Markotter et al. 2020
Hendra Virus Disease	Virus (Henipavirus-group)	**Incubation period**: 9-16 days **Symptoms** range from mild influenza-like illness to fatal respiratory or neurological disease.	Direct contact with infected bats (natural hosts) or other species (as secondary host, including livestock), contact with body fluids (blood, urine, saliva); consumption of contaminated food products; contact with infected persons		Although infection with Hendra virus is rare, the case fatality is high: 57%		WHO undated c Weiss *et al.* 2012 Mbu'u *et al.* 2019
Nipah Virus Disease	Virus (Henipavirus-group)	**Incubation period**: 4-14 days **Symptoms** range from asymptomatic infection (subclinical) to acute respiratory infection, pneumonia and acute encephalitis; in severe cases progressing to coma within 24 to 48 hours and death. considered one of the world's deadliest viruses with the heaviest mortality rates in some instances	Direct contact with infected bats (natural hosts) or other species (as secondary host, including livestock), contact with body fluids (blood, urine, saliva); consumption of contaminated food products; contact with infected persons	Not yet, but to be expected	case fatality rate is estimated at 40% to 75%; 20% of patients are left with neurological disorders		WHO 2018 Weiss *et al.* 2012 Soman Pillai *et al.* 2020 Skowron *et al.* 2022 Yob *et al.* 2001 Mbu'u *et al.* 2019

Zoonotic disease	Type of pathogen (group)	Symptoms	Means of trans-mission	Outbreak (when?)	Extent (how many felt ill / died)	Measures by Government	References
Crimean-Congo haemo-rrhagic fever	Virus (Arbovirus: CCHFV)	**Incubation period**: 1-9 days **Symptoms**: fever, muscle ache, dizziness, neck pain, backache, headache, sore eyes and photophobia (sensitivity to light), nausea, vomiting, diarrhoea, abdominal pain, confusion, depression lassitude, **haemorrhagic fever**. In severe cases hepatitis, rapid kidney deterioration, sudden liver failure or pulmonary failure	**Spillover from wildlife:** transmitted from ticks or by contact to blood and tissues from infected animals **Human to human**: close contact with the blood, secretions, organs or other bodily fluids of infected persons	recent spreading, with nine African countries reporting first cases since 2000	case fatality rate of 10 to 40% Yet no reported cases in Liberia and neighbouring countries, but serological evidence;	**Priority for Government in Liberia**	WHO 2022h Temur et al. 2021
Anthrax	Bacteria (*Bacillus anthracis*)	**Incubation period**: 1 day – 2 months **Symptoms (3 forms of Anthrax):** a) **skin anthrax** (most common form): itchy blisters and bumps, ulcers, black sore; headache, muscle aches, fever and vomiting b) **inhalation anthrax**: fever, chest pain, confusion, shortness of breath, extreme tiredness c) **gastrointestinal anthrax**: diarrhoea (evtl. with blood), abdominal pains, vomiting of blood, severe diarrhoea	**Spillover from wildlife:** Direct contact with herbivorous wildlife & livestock, consumption, handling of hides **Human to human**: no transfers yet documented		Highly toxic (used as military weapon) Skin infections represent more than 95% of cases Without treatment the risk of death from skin anthrax is 23.7%, for intestinal infection 25-75%, respiratory anthrax: 50-80%	**Priority for Government in Liberia**	WHO 2016 Katani et al. 2021
Brucellosis	Bacteria (*Brucella* sp.)	**Incubation period**: 1 week – 2 months **Symptoms:** flu-like symptoms, including fever, weakness, malaise and weight loss	**Spillover from wildlife:** Contact with infected herbivorous wildlife & livestock, consumption, floodwaters >> **Human to human**: rare transmission			**Priority for Government in Liberia** surveillance and control of brucellosis rarely implemented	Simpson et a. 2021 Katani et al. 2021

Zoonotic disease	Type of pathogen (group)	Symptoms	Means of trans-mission	Outbreak (when?)	Extent (how many felt ill / died)	Measures by Government	References
Leptospirosis	Bacteria (*Leptospira borgpetersenii, L. Interrogans, L. kirschneri*)	**Incubation period:** 2-10 days **Symptoms:** Weil's syndrome characterized by jaundice, renal failure, haemorrhage and myocarditis with arrhythmias; meningitis/meningoencephalitis; pulmonary haemorrhage with respiratory failure (often lethal).	**Spillover from animals:** Mainly contact with infected livestock, but also rodents and other wildlife, consumption of bushmeat **Human to human**: rare (via body fluids)	One of the most widespread zoonosis worldwide	Neglected but widespread: 2.3-19.8% of hospital patients with fever in Africa Case-fatality rates of 5 – 70%	**Priority for Government in Liberia**	Allan et al. 2015 Jobbins et al. 2014
Reptile-associated Salmonellosis	Bacteria (*Salmonella enterica* and *Salmonella typhimurium*)	**Incubation period**: 12-72 h **Symptoms:** diarrhoea, abdominal cramps, fever, occasionally nausea and vomiting. Bloodstream infections can be life threatening, especially in children under 5 yrs, the elderly, or in persons with weakened immune systems.	**Spillover from animals:** direct or indirect contact with faecal material from reptiles; handling of reptiles; touching surfaces/objects that were in contact with a reptile	(No systematic records)	Remains often undiagnosed >> underestimated		Zajac et al. 2021 Pulford et al. 2019 Pawlak 2014 Gumpenberger 2000
Human visceral pentastomiasis (caused by *Armillifer armillatus*)	Endoparasite (worm) endemic to West Africa	**Symptoms**: Most human infections are asymptomatic (sometimes even over decades), but serious or even fatal infections are described. Calcifications, caused by died and calcified parasites, can accumulate in liver, lung, pleura or abdomen, causing pain.	Contact with snake secretions (e.g. as bushmeat), consumption of uncooked bushmeat Rodents and small primates as secondary host	(No systematic records)	Outbreak in neighbouring Ivory Coast in 2022 infection rate in West Africa may be as high as 23%; numbers of infections increasing. In DRC, ~ 90% of snakes sold as bushmeat were infected with *A. armillatus*	greatly underestimated public health relevance; Pictured brochures on risks and hygienic measures are recommended	Milbank & Vira 2022 Blundell *et al.* 2020 Hardi *et al.* 2017 Tappe *et al.* 2016

2.3. Scientific background

2.3.1. General information

- **About 75% of all novel infectious diseases are zoonoses** (i.e. diseases transmitted from animals to humans) (WOAH 2022).
- **More than 70% of zoonoses originate from wild animals** (Jones *et al.* 2008).
- Legal AND illegal wildlife trade promote spreading of pathogens and zoonotic spillover events (IPBES 2020; Nijman 2021; Travis 2011).
- **New zoonotic diseases to come**: Probability for the emergence and spread of new diseases increases (Warren et al. 2022). According to WHO there has been a 63% increase in the number of zoonotic outbreaks in the African region in the decade from 2012-2022 compared to 2001-2011, e.g. Ebola, Mpox and corona viruses (UN Africa Renewal 2022).
- During a One Health Zoonotic Disease Prioritization workshop in December 2018, Economic Community of West African States (**ECOWAS**), including Liberia, **agreed upon a list of seven priority zoonotic diseases for the region** – Anthrax, Rabies, Ebola and other viral haemorrhagic fevers (for example, Marburg fever, Lassa fever), zoonotic influenzas, zoonotic tuberculosis, Trypanosomiasis* and Yellow fever* (**Vector-borne diseases, not relevant for this project (see below);* Goryoka et al. 2021).
- "*Infections originating in animals and then jumping to humans have been happening for centuries, but the risk of mass infections and deaths had been relatively limited in Africa. Poor transport infrastructure acted as a natural barrier*," said Dr. Matshidiso Moeti WHO Regional Director for Africa (UN Africa Renewal 2022).
- Human zoonotic disease risk can be defined as a function of several factors, including transmission of infection and transition to disease. These components of disease risk rely on several factors (e.g. extrinsic factors, such as urbanization, agriculture, socioeconomic standing and intrinsic factors, such as life history, behavior, and rapid evolutionary changes in animal hosts and pathogens) that are external to the host–pathogen system (Han *et al.* 2016).
- **Reptile-associated salmonellosis** has become a globally important epidemiological problem, in many countries caused by the boom of exotic pets (Waltenburg *et al*. 2022; Pawlak 2014). In Africa, reptiles are also consumed as bushmeat or for traditional medicine.
- *Leptospira* infection was reported in a wide range of domestic and wild animal species from across Africa. **Leptospirosis** is a substantial cause of human illness in Africa, representing 2.3-19.8% of hospital patients with fever (Allan *et al.* 2015).

2.3.2. Country-specific information

- "National Technical Guidelines for Integrated Disease Surveillance and Response": *The zoonotic diseases which could transfer to humans mentioned in the plan include rabies through dogs biting humans and viral haemorrhagic fevers (including Ebola) through consumption of bushmeat or other transmission events, Lassa fever etc. These address the surveillance and control of Ebola Virus Disease, Lassa Fever, Marburg Virus Disease and human rabies*." (GHS Index 2021c)

- **Lassa Fever** is endemic in the West African countries and causes 300,000 to 500,000 cases annually with about 5,000 deaths. In some areas of Sierra Leone and Liberia, 10–16% of annual hospital admissions are due to Lassa Fever (Woyessa *et al.* 2019).
- 80% of Liberia is estimated as **Lassa Fever** risk area (Woyessa *et al*. 2019). Liberia has the largest reported per capita incidence of Lassa Fever patients in the West African region. Cases of the disease increased unprecedentedly in 2019 and 2020, had a high case fatality rate and spread to new counties that had not previously reported Lassa Fever (Jetoh *et al*. 2022).
- Liberia was one of three countries heavily impacted by the **Ebola epidemic** in West Africa from 2014-2016 (Guinea and Sierra Leone were the other two) (Fall 2019). A greater long-fingered bat sampled in the northern territory of Liberia tested positive for Zaire ebolavirus. This was the first evidence of Ebola virus detected in a bat in West Africa (US AID 2020a).
- **Marburg** outbreak was recorded in 2022 in neighbouring Ghana, with two deaths and quarantine of nearly 100 (Jipoh 2022).

3. Relevant wildlife species

(e.g.; bats, which primate species? …):

3.1. Key points on relevant wildlife species

In a nutshell:

- **Relative risk of disease emergence is highest for bats, followed closely by primates, then ungulates and rodents – all of them heavily exploited for wildlife trade**. They host 132 (58%) of 226 known zoonotic viruses in present wildlife trade.
- At the same time duikers, primates, bats and pangolin were identified as the most frequently mentioned bushmeat species.
- The relative risk of disease emergence was found highest for bats, followed closely by primates, then ungulates and rodents.
- **Primates** represent the largest group of species hunted for bushmeat. **As the closest relatives of humans, primates pose a particularly high risk of zoonotic transmission to humans**. For example, the origin of AIDS and Ebola is linked to the consumption of primate meat.
- **A minimum of 9,500 primates are traded annually at a single bushmeat market in Konobo, in eastern Liberia.**
- Viruses, found in **bats**, are causing e.g. Marburg disease, SARS and COVID-19, while pathogens in **rodents** are responsible for outbreaks of e.g. Mpox or Lassa fever.
- In mammals and birds alone, the number of undetected viruses is estimated at 1.7 million, of which 540,000 to 850,000 may have the potential to infect humans.
- **Reptiles**: With the vast majority showing no symptoms, 12-85% of tortoises and freshwater turtles, 16-92% of snakes and 36-77% of lizards are carrying **Salmonella** pathogens.
- **Theoretically any wildlife species harvested for bushmeat could be a potential source of zoonotic disease.** While bats have been identified as major primary hosts for many pathogens, primates, racoon dogs, civets and other wildlife are potential secondary hosts.

3.2. Table: Relevant wildlife species traded in Liberia

Species	IUCN Red List	Taxonomic group	Relevance in trade	Related zoonotic disease risks	References
Western chimpanzee *Pan troglodytes verus*	**CR** decreasing	Primates	Hunted for bushmeat, live trade, traditional medicine	Ebola STLV-1 / HTVL-1 AIDS Anthrax	Jones *et al.* 2019; Mossoun *et al.* 2017 Humle et al. 2016 Judson *et al.* 2016 Greengrass 2015

Species	IUCN Red List	Taxonomic group	Relevance in trade	Related zoonotic disease risks	References
					Rouquet *et al.* 2005 Leroy *et al.* 2004a Leendertz et al. 2004 Hahn *et al.* 2000
Sooty mangabey *Cercocebus atys*	**VU** decreasing	Primates	Heavily hunted for bushmeat (most hunted primate in West-Liberia); offspring often kept as pet	Ebola AIDS STLV-1 / HTVL-1	Jones *et al.* 2019; Koné et al. 2019 Covey & McGraw 2014; Mossoun *et al.* 2017 Greengrass 2015 Hahn *et al.* 2000 Marx et al. 1991
King colobus *Colobus polykomos*	**EN** decreasing	Primates	Intensely hunted for bushmeat (at border to Cote d'Ivoire: 11.4% of primate carcasses for sale) skins are also marketed	Ebola STLV-1 / HTVL-1 (?)	Gonedelé et al. 2019 Jones *et al.* 2019; Mossoun *et al.* 2017; Covey & McGraw 2014 Jeffrey 1977
Western red colobus *Piliocolobus badius*	**EN** decreasing	Primates	heavily hunted for bushmeat; skins are also marketed	STLV-1 / HTVL-1	McGraw et al. 2020 Mossoun *et al.* 2017 Greengrass 2015 Jeffrey 1977
Olive colobus *Procolobus verus*	**VU** decreasing	Primates	Uncontrolled and heavy hunting for bushmeat Also used in Traditional Medicine (e.g. in Togo)	…	D'Cruze et al. 2020 Oates et al. 2020 Covey & McGraw 2014 Jeffrey 1977
Diana monkey *Cercopithecus diana* **Spot-nosed monkey** *Cercopithecus petaurista*	**EN** decreasing NT decreasing	Primates	All three species among the most hunted primates for bushmeat, in Liberia also trade in skins *C. petaurista* also used in Traditional	Ebola Marburg	Sah *et al.* 2022 D'Cruze et al. 2020 Matsuda Goodwin et al. 2020a, b Jones *et al.* 2019 Konè et al. 2019 Greengrass 2015

Species	IUCN Red List	Taxonomic group	Relevance in trade	Related zoonotic disease risks	References
Campbelli monkey *Cercopithecus campbelli*	NT decreasing		Medicine (e.g. in Togo)		Covey & McGraw 2014 Bené et al. 2013a,c Jeffrey 1977
West African Potto *Perodicticus potto*	NT decreasing	Primates	Intensely hunted for bushmeat (subsistence & commercial), also traded as pet and for traditional medicine & practices	…	Svensson *et al.* 2015 Bené et al. 2013a Conservation International (undated)
Duikers **Bay duiker** *Cephalophus dorsalis* **Black duiker** *Cephalophus niger* **Zebra duiker** *Cephalophus zebra* **Jentink's duiker** *Cephalophus jentinki (et al.)* **Maxwell's duiker** *Philantomba maxwelli*	 NT decreasing LC decreasing **EN** Decreasing **EN** Decreasing LC decreasing	Ungulates	Among the most hunted taxa for bushmeat (hunting pressure increasing) In East-Liberia, 41% of animals hunted as bushmeat are duikers *C. dorsalis* also used in Traditional Medicine in Togo	Ebola Anthrax (?) Brucellosis (?) Anthrax and Brucella was proven in herbivorous wildlife in Tanzania (e.g. wildebeest, zebra with Anthrax; Brucella in Dik-dik and wildebeest)	Katani et al. 2021 D'Cruze et al. 2020 IUCN SSC Antelope SG 2020, 2016a,b,c Jones *et al.* 2019; Judson *et al.* 2016 Covey & McGraw 2014 Bené et al. 2013a,c Rouquet *et al.* 2005 Leroy *et al.* 2004a Jeffrey 1977
Bushbuck *Tragelaphus scriptus*	LC stable	Ungulates	Hunted as bushmeat, hunting pressure increasing in some parts	…	IUCN SSC Antelope Specialist Group 2016d Bené et al. 2013a Munang'andu et al. 2012
Red river hog *Potamochoerus porcus*	LC decreasing	Ungulates	One of the primary species hunted for commercial bushmeat trade Used in Traditional Medicine, e.g. in Togo	Anthrax (?) Brucellosis (?) Anthrax and Brucella was proven in herbivorous wildlife in Tanzania (e.g. wildebeest, zebra with Anthrax; Brucella	Katani et al. 2021 D'Cruze et al. 2020 Reyna et al. 2016 Greengrass 2015 Jeffrey 1977

Species	IUCN Red List	Taxonomic group	Relevance in trade	Related zoonotic disease risks	References
				in Dik-dik and wildebeest)	
Bats	--	Bats	Bushmeat hunting of bats (especially fruit bats, having larger bodies) common in West Africa Several species also used in Traditional Medicine (e.g. in Togo), increasing persecution in reaction to Ebola	COVID 19 SARS MERS Rabies / Lyssa Marburg Ebola **more than 60 different viruses were identified in bats**	Amman *et al.* 2021 WHO 2021a WHO 2021b D'Cruze et al. 2020 Markotter *et al.* 2020 Judson *et al.* 2016 Mildenstein et al. 2016 Luis *et al.* 2013 Quan *et al.* 2013 Towner *et al.* 2007 Wang & Eaton 2007
Straw-coloured fruit bat *Eidolon helvum*	NT decreasing	Bats	Seriously over-harvested: The most heavily hunted bat for bushmeat and traditional medicine in West & Central Africa (low price item)	Nipah Virus Disease Hendra Virus Disease Ebola Rabies (Lyssa virus)	Peros et al. 2021 Cooper-Bohannon et al. 2020 Markotter et al. 2020 Mildenstein et al. 2016 Weiss *et al.* 2012 Kamins *et al.* 2011 Mickleburgh *et al.* 2009
Hammer-headed fruit bat *Hypsignathus monstrosus*	LC unknown trend	Bats	Hunted as bushmeat across its range (largest bat species)	**Ebola** **Henipavirus** detected in this species in West and Central Africa **Marburg-virus** found in DRC, Gabon and easertn & southern African countries	Markotter et al. 2020 Tanshi 2016 Bené et al. 2013a
Egyptian Fruit Bat *Rousettus aegyptiacus*	LC stable	Bats	?	Henipavirus detected in this species in West and Central Africa	Markotter et al. 2020 Korine 2016
Greater long-fingered bat *Miniopterus inflatus*	LC unknown trend	Bats	No data on hunting and consumption	Ebola (first-time discovery of an Ebolavirus in January 2019 in this species!)	US AID 2020a Samuels *et al.* 2022 Monadjem & Schlitter 2017

Species	IUCN Red List	Taxonomic group	Relevance in trade	Related zoonotic disease risks	References
Nimba long-fingered bat *Miniopterus nimbae*	not evaluated	Bats	?	Ebola	US AID *et al.* 2021
African brush-tailed porcupine *Atherurus africanus*	LC unknown trend	Rodents	Intensely hunted as bushmeat in Liberia also used in Traditional Medicine in Togo	Salmonella	Peros et al. 2021 Jones *et al.* 2019 Hoffmann & Cox 2016 Bené et al. 2013a,c
Crested porcupine *Hystrix cristata*	LC unknown trend	Rodents	Hunted for food in West Africa		Amori & De Smet 2016
Giant pouched rats **Gambian pouched rat** *Cricetomys gambianus* **Emin's giant pouched rat** *Cricetomys emini*	LC Stable LC stable	Rodents	hunted and locally consumed in West Africa, mainly by children, meat only rarely sold at markets	Lassa Fever Mpox	Dono *et al.* 2021 Kennerley 2019 Doty et al. 2017 Bené et al. 2013a, c Subramanian 2012 Jeffrey 1977
Mastomys sp.		Rodents	*Mastomys* species are hunted and consumed in West Africa, mainly by children also used in Traditional Medicine in Togo	Lassa Fever (*Mastomys natalensis* is the primary reservoir species) Mpox ?	WHO undated a,b Mylne *et al.* 2015 Alders & Kock 2017 Douno *et al.* 2021 D'Cruze et al. 2020
African cane rat *Thryonomys swinderianus*	LC Trend unknown	Rodents	Intensely hunted for bushmeat, often hunted by children	Lassa Fever Mpox?	Douno *et al.* 2021 Child 2016 Greengrass 2015 Bené et al. 2013a,c Amori & Gippoliti 2002
Squirrels **Striped ground squirrel** *Euxerus erythropus* **African giant squirrel** *Protoxerus stangeri* **Red-legged sun Squirrel** *Heliosciurus rufobrachium*	LC Trend unknown LC Trend unknown	Rodents	Intensely hunted for bushmeat hunted for food and medical purpose; also used as pet	Lassa Fever Mpox	Bené et al. 2013a Cassola 2016a,b Doty et al. 2017

Species	IUCN Red List	Taxonomic group	Relevance in trade	Related zoonotic disease risks	References
African palm civet *Nandinia binotata*	LC Trend unknown	Carnivores	commonly trapped or hunted for bushmeat and for traditional medicine	… SARS and COVID related to Asian palm civets	Hooper 2022 Gaubert et al. 2015 Bené et al. 2013a Wang & Eaton 2007
African civet *Civettictis civetta*	LC Trend unknown	Carnivores	Commonly found for sale as bushmeat; males used for perfume production	… SARS and COVID related to Asian palm civets	Do Linh San et al. 2019 Bené et al. 2013a Wang & Eaton 2007
Common cusimanse *Crossarchus obscurus*	LC Trend unknown	Carnivores	Hunted as bushmeat, in some regions the most commonly trapped small carnivore	…	Angelici & Do Linh San 2015 Bené et al. 2013a
Slender mongoose *Herpestes sanguineus*	LC stable	Carnivores	Hunted as bushmeat	Leptospirosis (?) (found in mongooses in southern Africa)	Do Linh San & Maddock 2016 Jobbins et al. 2014 Bené et al. 2013a
tree pangolins **White-bellied pangolin** *Phataginus tricuspis* **Black-bellied pangolin** *Phataginus tetradactyla*	 **EN** Decreasing **VU** Decreasing	Pangolins	Both species heavily hunted for local bushmeat, already popular in 1970s used in traditional folk medicine (at least in neighboring Sierra Leone, also in Ghana, Togo) and increasingly traded on international level	Asian pangolins discussed as intermediate host for SARS-CoV2	Ingram et al. 2019 Jones *et al.* 2019 Pietersen et al. 2019 ODI 2004 Gupta *et al.* 2022 Jeffrey 1977 D'Cruze et al. 2020 Bené et al. 2013a
Giant ground pangolin *Smutsia gigantea*	**EN** Decreasing	Pangolins	Intensely exploited for bushmeat markets; used in traditional folk medicine (at least in neighboring Ghana & Sierra Leone)	Asian pangolins discussed as intermediate host for SARS-CoV2	Nixon et al. 2019 Boakye *et al.* 2015 2014
Pythons **African rock python** *Python sebae* **Ball python** *Python regius*	 NT Decreasing NT Decreasing	Reptiles	among the most harvested reptile species sold at Central and West African bushmeat markets; proportion of snakes in bushmeat markets is increasing;	visceral pentastomiasis Salmonellosis	D'Cruze *et al.* 2022, 2020 Alexander et al. 2019 Pulford *et al.* 2019 Hardi *et al.* 2017 Bené et al. 2013a

Species	IUCN Red List	Taxonomic group	Relevance in trade	Related zoonotic disease risks	References
			also used in traditional folk medicine as well as in skin and pet trade		
Venomous snakes ***Gabon viper*** *Bitis gabonica* **Rhinoceros viper** *Bitis nasicornis*	 **VU** Decreasing **VU** Decreasing	Reptiles	among the most harvested reptile species sold at Central & West African bushmeat markets; proportion bushmeat markets is increasing; also used in traditional folk medicine as well as in skin and pet trade	visceral pentastomiasis Salmonellosis	Luiselli et al. 2021 Penner et al. 2021 Tappe et al. 2016

3.3. Scientific Background

- Although research has focused largely on mammals and, to a lesser extent, birds, theoretically any wildlife species harvested for bushmeat could be a potential source of zoonotic disease that can spillover during the hunting, butchering, and preparation process (Kurpiers et al. 2016; Karesh & Noble 2009).
- **Mammals and birds alone are thought to host an estimated 1.7 million undiscovered viruses and, of these, 540,000–850,000 viruses could have the ability to infect humans** (Shivaprakash *et al.* 2021; Carroll *et al.* 2018).
- In their assessment of the risk of disease emergence by taxa, Cleaveland *et al.* (2007) found that the relative risk of disease emergence was highest for bats, followed closely by primates, then ungulates and rodents – all of them heavily exploited for wildlife trade. Primates, ungulates, carnivores, and bats pose a high zoonotic risk, harbouring 132 (58%) of the 226 known zoonotic viruses in the current wildlife trade. Bats, rodents, and marsupials pose a significant zoonotic risk in future wildlife trade (Shivaprakash *et al.* 2021).
- Duikers, primates and pangolin were identified as the most frequently mentioned bushmeat species (Ordaz-Németh *et al.* 2017; Jeffrey 1977). Sooty mangabeys (being a carrier for the AIDS virus) ranked only at No. 13 of taste preference of urban consumers (ODI 2004; Hahn *et al.* 2000).

3.3.1. Primates

- Primates represent the largest group of species hunted for bushmeat (Kurpiers et al. 2016). As the closest relatives of humans, they pose a particularly high risk of zoonotic transmission to humans (Mossoun et al. 2017). Nevertheless, parasite sampling is still too low, especially for arboreal and nocturnal species (Cooper & Nunn 2013).

- Researchers recently discovered a family of viruses that can cause fatal hemorrhagic fever in African primate populations. Since humans have a similar form of the receptor responsible, the researchers concluded that transmission of this disease to humans is very likely (Mactilda Mbenywe 2022; Warren *et al.* 2022).
- Due to population decline of larger primates now even smaller species, such as *Cercopithecus petaurista* are now hunted for commercial bushmeat markets, despite high costs for ammunition (Matsuda Goodwin et al. 2020a, b; Svensson et al. 2020).
- **Covey & McGraw (2014) estimate that a minimum of 9,500 primates are traded annually at a single bushmeat market in Konobo** (near the border to Ivory Coast).
- Availability of alternatives to bushmeat, e.g. fish as protein source, is correlated with reduced hunting of e.g. chimpanzees (Junker et al. 2015).

3.3.2. Bats

- **Bats** are heavily over-exploited since at least three decades; hunting is particularly prevalent among the large-bodied fruit bats (Mildenstein et al. 2016).
- Bats are identified as the most likely primary host for outbreaks of SARS, MERS and COVID-19 outbreaks, with other mammals, such as civets, racoon dogs etc. as secondary host, causing spillover events to humans via wildlife markets (Worobey *et al.* 2022; Markotter *et al.* 2020; Banerjee *et al.* 2019). Bats are also hosts for Marburg, Ebola and many other viruses (Kia *et al.* 2021; Kajihara *et al.* 2019; Hayman *et al.* 2012; Leroy *et al.* 2009).
- **Fruit bats are heavily consumed in West Africa: In southern Ghana only, about 128,000 *Eidolon helvum* are sold each year as bushmeat** (Kamins *et al.* 2011; Mickleburgh *et al.* 2009). Hunting of bats is often underrepresented in surveys, due to separate commodity chains, and therefore underestimated (Kamins et al. 2011).

3.3.3. Others

- **Reptiles**: With the vast majority showing no symptoms, 12-85% of tortoises and freshwater turtles, 16-92% of snakes and 36-77% of lizards are carrying *Salmonella* pathogens. Under stressful unhygienic conditions risk of spillover to humans increases (Zajac et al 2021; Gumpenberger 2000). Pulford *et al*. (2019) examined wild-caught snakes originating from eight African countries and found 91% of them carrying *Salmonella*.

4. Relevant potential spillover pathways

4.1. Key findings on spillover pathways

In a nutshell:

- **Legal AND illegal wildlife trade are contributing to the spreading of zoonotic diseases.**
- **Bushmeat**-related activities (hunting, butchering, cooking, consumption) have been linked to numerous EID outbreaks, such as Ebola, HIV, and SARS.
- Of 58 species of bushmeat globally investigated, 48 species were found to host one or more pathogens.
- Bushmeat is often smoked, dried or salted. But medical experts estimate that these processes are insufficient to kill viruses and other pathogens in the meat.
- **Increasing demand and commercialization of bushmeat is exposing more people to pathogens and facilitating the geographic spread of diseases**.
- Larger species, such as chimpanzees or duikers, are mainly destined for urban markets, while smaller species (guineafowls, greater cane-rats) are consumed locally.
- **Wildlife as pets:** Bites, scratches and contact with urine, saliva and feces pose a risk for disease transmission from e.g. pet monkeys to keepers.
- **Wildlife use in Traditional Medicine and religious rituals is common in West African countries**: 281 different wildlife species were recorded at a traditional medicine market in Togo, of which 140 were mammals, 33 were reptiles, 59 were bird species and 49 amphibians.
- At least 25 primate species are used in traditional folk medicine in Africa, in Nigeria for example *Pan troglodytes*. Use of pangolins in TM is reported from Ghana, Togo and Sierra Leone.
- **Be a model in your communication** (including social media): Don't post pictures holding wildlife, keep distance, wear masks and gloves)

4.2. Scientific background

- **Legal AND illegal wildlife trade are contributing to the spreading of zoonotic diseases.** Since the outbreak of COVID-19 wildlife markets are often seen as synonymous with illegal wildlife trade, but Nijman (2021) stresses that most of the wildlife offered at Wuhan wet market was legally offered. Stressful, unhygienic conditions during wildlife trade are fueling pathogen levels in the animals.

4.2.1. Bushmeat

- A review of global bushmeat studies (with a focus on Africa) found that of the 58 species of bushmeat investigated, 48 species were found to host one or more pathogens (Peros et al. 2021).

- Bushmeat (e.g. from duikers and monkeys) is generally cheaper than domestic meat, such as beef and pork (Jeffrey 1997). However, domestic meat (goats and chicken) is not widespread and bushmeat is seen as a cultural bondage (Libassa 2023, own data).
- Bushmeat-related activities (hunting, butchering, cooking, consumption) have been linked to numerous emerging infectious disease (EID) outbreaks, such as Ebola, HIV, and SARS. Increasing demand and commercialization of bushmeat is exposing more people to pathogens and facilitating the geographic spread of diseases (Kurpiers *et al.* 2016).
- Subramanian (2012) found that 38 % of respondents processing bushmeat carcasses cut themselves on a regular basis during butchering.
- Highest spillover risk when handling carcasses of non-human primates.
- Ebola-outbreak among chimpanzees after hunting and shared consumption of a red colobus monkey is proven; seropositive chimpanzees were found broadly throughout forested regions of Central Africa (Alexander *et al.* 2015).
- Household interviews during two surveys across Liberia shows that there was an overall decrease in bushmeat consumption during the recent Ebola crisis. However, the consumption of bushmeat in wealthier households decreased less than in poorer households (Ordaz-Németh *et al.* 2017).
- During a survey in two commercial hunting camps (1 month each) on the boundary of the Sapo National Park in SE Liberia 82 dead chimpanzees were recorded. Most of the bushmeat harvested was destined for Monrovia and other major towns (Greengrass 2015).
- Bushmeat is often smoked, dried or salted. However, medical experts estimate that these processes are insufficient to kill viruses and other pathogens in meat. For example, wildlife biltong may pose special challenges, given that the virus can survive over 50 days when dried and kept at 4°C (Alexander *et al.* 2015). Fresh bushmeat is available from roadside vendors (Jeffrey 1977).
- Larger species, such as chimpanzees or duikers, are mainly destined for urban markets, while smaller species (guineafowls, greater cane-rats) are consumed locally (Jones *et al.* 2019).

4.2.2. Wildlife as pets

- In many parts of the primate distribution range, the practice of keeping primates as pets is common. However, keeping them as pets may result in close spatial proximity and to physical contact, thereby creating opportunities for zoonosis (Lappan et al. 2020; Muehlenbein 2017).
- Primate infants, often survivors of bushmeat hunting, are sold as pets or to private and public zoos, providing additional income for the hunter (Marx et al. 1991).
- 8 alive chimp infants were found during two 1-month surveys in commercial hunting camps located close to Sapo National Park in SE Liberia, selling bushmeat to Monrovia and other major towns (Greengrass 2015).
- **!! Model safe and appropriate practices with primates in field settings, outreach, and social media materials:** Conservationists must follow safe distance and masking protocols when being observed or photographed. They should not be photographed holding primates (even in captive care settings) and should avoid sharing images showing close human–primate spacing in outreach materials, on social media accounts, or in public presentations. **Such images may create public perceptions that primates are appealing and tame, increasing the risks of inappropriate behaviour toward wild primates, and increasing demand for primates as pets** (Lappan et al. 2020).

4.2.3. Traditional medicine & magic-religious rituals

- According to Alves *et al*. (2010) 25 primate species are used in traditional folk medicine and magic-religious rituals in Africa: In Liberia, ***Pan troglodytes*** is claimed to help against male impotency and epilepsy and is used for amulets and as concoction for ailments ("regarded as a sacred totem and a reincarnation of ancestors, considered sacred, piece of the dried bone of chimpanzees is tied around the waist or wrist of infants in the belief that it makes them stronger as they grow into adulthood, chimpanzee's central incisors procured to be worn as amulet around the waist of infants to protect them and give them power over others in their cohort").
- **Pangolins** are used in several West African countries in traditional folk medicine, a widespread practice e.g., in neighbouring Ghana, where scales and bones are used for the treatment of spiritual protection, rheumatism, financial rituals and convulsions; meat is used to heal infertility, menstrual pains and coughing (Boakye *et al*. 2015).
- **Traditional hunting management**: Some wildlife species are considered totems to a specific individual or family and, thus, cannot be consumed. Among the Mano people of Nimba County, several species are considered totems: the leopard, the **chimpanzee and duiker** species such as the **bushbuck**. The bushbuck, for example, is a totem for the Akan group of Côte d'Ivoire, who believe that it houses the souls of the dead and that human beings can take on its appearance (Béibro, 1995). In Nimba County, the chimpanzee and leopard are more often than other species considered totem animals and therefore experience reduced hunting pressure. According to legend, a young girl who eats a yellow-backed duiker won't be able to carry a child. **Traditional medicines** are also derived from body parts (skulls, feet, skin, tails and bones) of many forest and savannah species and are sold in marketplaces throughout the Guinean forest zone. Among the Agni people of Côte d'Ivoire, the paws of the West African Potto, if dried and attached to the arm of a child, allegedly creates a protective force; its skin is also used by Mano people to treat burns (Conservation International undated).

5. Information relevant for awareness campaigns & programs

5.1. Key points for awareness campaigns

In a nutshell:

- **Longstanding cultural beliefs, livelihood, and food security challenges** mean that research findings alone would not have been successful in changing practices.
- **3 building blocks are needed for successful awareness campaigns**: 1) trust building – 2) awareness raising – 3) evidence through research.
- **Skepticism /opposition against information on zoonotic diseases and related measures to reduce risk for spillover events (after Ebola outbreak 2014-2016):** Traders and consumers argued that wildlife was eaten for generations without ever having caused, or been associated with, an epidemic in humans.
- **Possible counterarguments must be collected and debunked to best persuade.**
- **Urban consumers see bushmeat as a local, natural, and healthy food compared to livestock ⇨ need to be refuted in awareness campaigns.**
- **Promotion of the One Health approach:** Interconnection between humans, wildlife, and environment. In the long-term human health can only been assured together in a healthy environmental and with healthy animals.
- **Wildlife must not be blamed for zoonotic diseases**, instead highlighting a species' ecological role is needed. Living with wildlife, not destroying them, and wildlife conservation (including habitat conservation) as part of the solution!
- **Explain probabilities and statistical incidents!** Most events of eating bushmeat or contact with wildlife will not lead to zoonotic diseases, but risks are significantly rising with deforestation & intrusion into remote habitats, commercialization of bushmeat trade (incl. long transport routes to cities). Increased human density in cities and increased mobility support outbreaks and spreading of diseases as soon as a spillover event has occurred.
- **Communication of human health risks, combined with demystification of bushmeat (e.g. primate is no more nutritious than other meat) caused strongest demand reduction**
- **Best arguments:** In demand reduction campaigns on wildlife as pets the aspects of illegality and human health risks have been proven more efficient than species conservation or animal welfare issues.
- **Messaging**: Positive messages are easier acceptable than negative; involve influential and credible actors; present appropriate alternatives
- **Food alternatives: Urban bushmeat consumers have a key role, as they can create a deadly suction effect for wildlife up to distant areas – but have a better choice.**
- **Enforcement AND persuasion are key to ensure long-term change of behaviour**
- **Urban citizens are a major consumer group and should be prioritized in awareness campaigns.**

5.2. Scientific background

- **3 building blocks are needed for successful awareness campaigns**: 1) trust building – 2) awareness raising – 3) evidence through research (for details see Machalaba 2022)
- **Ideal-reality gap**: Although many people are concerned about a problem (a stated preference, which can be triggered by education), this does not always translate into taking practical steps to perform an environmental behaviour (revealed preferences).

5.2.1. Awareness & Skepticism

- In Liberia, widely spread beliefs that traditionalists, witches, wizards, and even spirits have the ability to cast diseases upon people continue to hamper the prevention, diagnosis, treatment, and control of many diseases. Many people interact with wildlife and domestic animals in Liberia, but overall awareness about zoonotic disease risks is low (Machalaba 2022).
- Thirty-three percent of bushmeat consumers in a Ghanaian market were not aware that zoonotic diseases could be transmitted from bushmeat to humans. Those who were aware gave Ebola (48 %) and anthrax (16 %) as examples of zoonotic diseases (Kuukyi *et al*. 2014).
- Given the lack of awareness and precautionary measures taken among people who come into contact with bushmeat, the opportunity for new zoonotic pathogens to spillover into humans remains high. This is especially true, since the current rate of hunting wild animals will likely continue — at least until domestic animal production increases and can support the protein needs of the local people (Kurpiers *et al.* 2016; LeBreton *et al*. 2006).
- The Liberian Government banned hunting and sale of bushmeat in July 2014, but 1 year later the fear for Ebola was gone and customers and vendors were defying the law, as the reward of profits from selling (and buying cheaper) bush meat outweighed the risk (The New Humanitarian 2015). Interviewed woman stated: "I *am not afraid of bush meat giving me Ebola. This is something our parents ate and they never got Ebola. Why now are people stopping us from eating it? For me, I just can't do without eating bush meat*."
- Trust of international non-governmental organizations (iNGOs) during 2014-16 Ebola epidemic was consistently higher than trust in the Liberian government (Arthur *et al.* 2022).
- Abramowitz *et al.* (2017) noted reports of "resistance" in Monrovia during the Ebola response were overstated and based on a limited number of incidents. However, they also found that as Ebola spread through human-to-human contact, rather than animal-to-human transmission, fewer respondents referenced "playing with monkeys and bats" as a risk factor for contracting Ebola.
- Bonwitt *et al.* (2018) underline that the **epistemic dissonance** between health risks in the context of Ebola and long-term experiences consuming bushmeat without personal incident would radically undercut the effectiveness of the bushmeat ban, which merely served to proliferate informal networks of wild animal trade and sale— hampering the development of acceptable, evidence-based surveillance and mitigation strategies for zoonotic spillovers. "*People simply refused to believe that wild meat could pose any health risk. Informants argued that wild animals were hunted and eaten for generations without ever having caused, or been associated with, an epidemic in humans. The same argument was commonly heard in rural areas of Guinea*." Other argument for suspicion was the government would try to consolidate power and weaken villages in areas supporting opposition party (as wild meat is considered an important source of physical

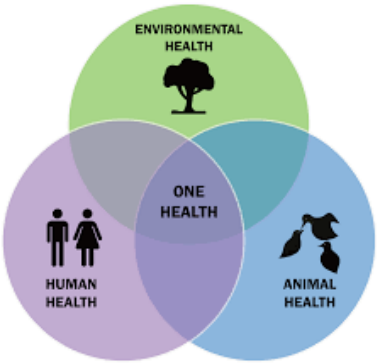
strength and energy) – or the rumour that conservationist introduced the ban to prevent poaching.

- Gaubert et al. (in print) interviewed bushmeat vendors in three west African countries and found that vendors generally did not believe that pangolins were involved in the pandemic, as people have always been eating pangolins and have never been sick. The authors recommend that future awareness campaigns through television and social networks also include education on microbial evolution and host shift.
- Machabala (2022) of the Society for the Conservation of Nature of Liberia noted that "*during the Ebola virus crisis in Liberia, health authorities told Liberians not to eat bats, monkeys, and other animals that could potentially play a role as a reservoir or host of the virus. Some Liberians still believed that Ebola didn't come from bats or other animals, reinforced by their own historical experience eating bats without recognized disease consequences. There are strong cultural beliefs about the source of illness, linked to superstition. Thus, it was difficult for people to listen to the health authorities during the epidemic, and the bat hunting, killing, and consumption of bats has continued. When visiting communities at the start of the project, the field team was initially met with scepticism…*". She also underlined that "*under the PREDICT-2 project, Liberian One Health experts trained in health, conservation, and social sciences conducted biological and behavioural surveys, followed by community outreach that improved awareness and acceptance of zoonotic disease risk reduction practices. Using the 'Living Safely with Bats' book [adapted to the Liberian context], this outreach also reinforced biodiversity protection and animal welfare. Its success was enabled by trust, awareness, and a strong evidence base*."

5.2.2. Ecology and One Health Approach

- Major reasons behind the emergence and spread of zoonotic pandemics are related to activities such as habitat fragmentation, deforestation, biodiversity loss, intensive agriculture and livestock farming, uncontrolled urbanization, pollution, climate change and wildlife trade, including wild meat markets (Mishra et al. 2021; Dobson et al. 2020).
- People **need to understand the role of different wildlife species in the ecosystems** and that deforestation, agricultural and infrastructure expansion even into formerly remote habitats, biodiversity loss bring people and livestock into closer contact with wildlife which significantly increases the risk of spillover events (Machalaba 2022; Keesing & Ostfeld 2021; Everard 2020; IPBES 2020).
- For example, bats comprise the highest risk among all wildlife for harboring emerging diseases; increased human encroachment in recent decades has driven some bat species to become peri-domestic, which increases the risk of zoonotic spillovers (Kurpiers *et al.* 2016).
- In Liberia, the finding of Ebola virus antibodies in a bat provided evidence that Ebola is circulating in wildlife in the West Africa region and signalled that there are ongoing spillover risks requiring public health attention (Machalaba 2022).
- However, the **ecological benefit of bats is immense:** In their natural ecological roles they perform valuable ecosystem services beneficial to humans, seed dispersal maintaining local watersheds, all of which are reduced when bats are hunted. Reductions in bat populations as a result of hunting could have expensive ramifications on local communities' water supplies, agriculture, and eco-tourism industries (Mildenstein et al. 2016).

- Furthermore, persecution of bats, including the destruction of their roosts and culling of whole colonies, has led not only to declines of protected bat species, but also to an increase in virus prevalence in some of these populations. Educational efforts are needed in order to prevent future spillovers and to further protect bats from unnecessary and counterproductive culling (Schneeberger & Voigt 2015).
- 5 years after the Ebola outbreak in 2014, the Liberian Government, in cooperation with the project PREDICT, revisited affected communities, and promoted the One Health strategy. PREDICT developed and utilized an **illustrated risk reduction and behaviour change communication resource "Living Safely with Bats"** for community education that would help reduce risk of exposure to Ebola virus without creating fear of bats (https://www.ecohealthalliance.org/wp-content/uploads/2018/10/Living-Safely-with-Bats_download.pdf) and provided the resource to the Ministry of Health to become part of their public risk communication toolkit (US AID *et al.* 2021).
- The **One Health approach** - considering the health of people, animals and the environment – has been already promoted since the 2010s (Karesh & Vora 2010; Travis *et al.* 2011; Mackenzie *et al.* 2014). Since COVID-19, this approach received much more attention (Zowalaty & Järhult 2020, Everard *et al.* 2020; Mishra *et al.* 2021; Berthe *et al.* 2022, Schwensow *et al.* 2022).



- ODI 2004: "*While many people are unaware of which animals are being protected by Liberian law, most (61%) recognised that bushmeat should not be purchased if it is protected. Few respondents (24%) knew of any unique animals in West Africa, and the majority (65%) did not believe that species can become extinct. Respondents recognised that Liberia has protected species and felt that not enough was being done to conserve Liberia's wildlife. Most (63%) believe they have a role to play in conserving Liberia's forests and wildlife. However, of the top 15 most preferred bushmeat species, five are protected under Liberian law. Variations in ranked preferences from different locations were likely to be related to availability of the species in the local markets. Only one primate species, the sooty mangabey, appeared in the top 15 taste preferences. Public awareness efforts, focused on selected species and habitats, could therefore be effective*."

5.2.3. Role of urban consumers / food alternatives

- Africa has the fastest urban growth in the world. The continent's population is projected to double between 2020 and 2050; with 2/3 will be living in urban areas (OECD/SWAC 2020).
- Urban citizens are a main consumer group in Liberia (Jones *et al.* 2019): Most of rural bushmeat hunters' catch was sold to traders (85% of harvested biomass) and subsequently transported to urban markets (65% of all harvested biomass).
- Most common destination for meat was Liberia's capital, Monrovia, followed by markets in Sierra Leone and neighbouring Liberian counties (Jones *et al.* 2019).
- During a survey in Nigeria, Togo, Burkina Faso, and Niger the proportion of persons not consuming any bushmeat was highest in urban areas, especially among young people. Nevertheless, existing demand from a large urban population can create an immense pull and support very long-distance wild meat trade (Luiselli et al. 2019).

- In Kisangani (Democratic Republic of the Congo), for example, more than 1.5 million people get a large proportion of their protein from wild meat, which has led to terrestrial and aquatic wildlife populations becoming severely depleted within several hundred kilometres of the city (van Vliet et al. 2017a).
- Urban consumption is now considered a key intervention point; urban citizens have a choice in their consumption behaviour (many other food items, such as fish and domestic meat, are available and may be even cheaper), which can contribute to demand reduction (Ingram et al. 2021).

Understanding motives and barriers:

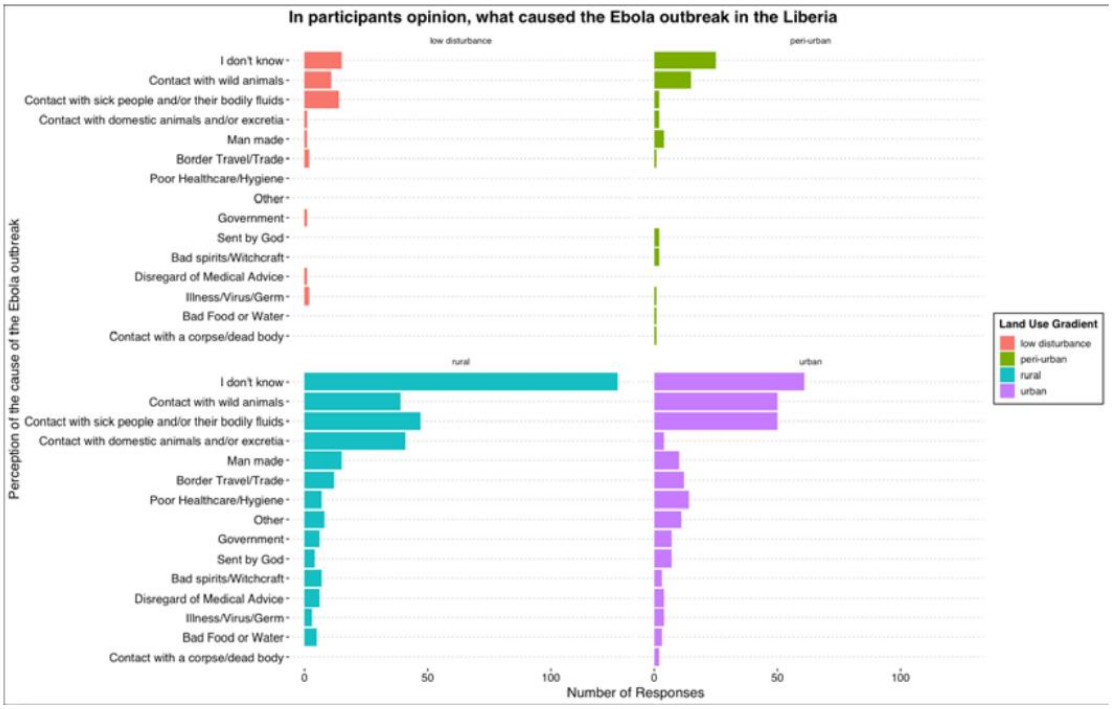
- Ingram et al. (2021) underline: "*City dwellers may consume wildlife for many reasons, including a desire for traditional cuisines and to maintain a cultural connection to a rural heritage, or a perception of wild meat as fresh, healthy, tasty, exotic, and/or as a marker of status. Therefore, reducing demand in metropolitan areas is rarely a question of providing affordable and accessible substitutes, as these already exist. Instead, it is about changing consumer attitudes and practices*."
- Chausson et al. (2019) found that "*the perception of bushmeat as natural, tasty and healthy, and a rare luxury product functioning as a symbol of social status, underpins social norms to provide bushmeat. The main barriers to purchasing were cost and availability. Locally produced fish, meat, and poultry were positively perceived as organic and healthy, whereas frozen imported animal proteins were perceived negatively as transformed, of poor quality and taste, and unhealthy*."
- A survey by WCS found that "traditional" conservation campaigns and messages may be counterproductive and even reinforce negative perceptions of conservation, because perceptions held by urban African bushmeat consumers and those held by actors in the conservation sector are often incongruent: "*For example, in Pointe Noire (Kongo Brazzaville), bushmeat consumers associated bushmeat with their culture, status, and hospitality – and they don't want to give this part of their social life up. They were suspicious of conservation as a foreign preoccupation, putting more importance on animals than humans and imposed by outsiders who do not appreciate Congolese life and culture. They felt they were helping rural people and hunters make a living by buying bushmeat. … In Kinshasa (DRC), eating bushmeat was considered expression of status and cultural identity. … The limited supply, long transport and maintaining the bushmeat quality make it expensive and more desirable. …They resisted being told what to do by international conservation organizations. They had more immediate urban problems such as pollution, the pandemic, and the social and economic pressures of their daily lives*" (Yocum et al. 2022).
- WCS recognized that **to reduce bushmeat consumption to be accepted by consumers, behaviour change strategies (e.g. communication campaigns) needed to be oriented to how the intended audiences perceive conservation issues and bushmeat consumption** (Yocum et al. 2022).**:**
    - In Pointe Noire's pilot campaign, the new frame aimed to reorient audiences from resistance to acceptance and a sense of ownership about conservation. The campaign shared "good news" instead of bad news that denies the consumers' interests and pleasures and gave reasons for optimism and pride to positively reorient perceptions about conservation and reducing bushmeat consumption.
    - In Kinshasa, the new frame aimed to shift indifference to interest in conservation that has a closer connection to urban life. Small, feasible actions, and moments of success were offered as chances to make daily life better and at the same time be part of a conservation

initiative… Reducing bushmeat consumption was offered as a way to enhance social life and feel more successful.

5.2.4. Demand reduction strategies

- **Arguments for demand reduction:** According to Moorhouse et al. (2017) human health risks (via zoonotic diseases) and legal aspects (protection status of a species and potential legal consequences) were more convincing for potential clients not to buy, compared to conservation (rarity of a species) or animal welfare aspects.
- The need for education programs to include understanding of the risks of zoonotic diseases, and to stimulate behaviour change is obvious (MacFarlane et al. 2022; Veríssimo et al. 2018; Moorhouse et al. 2017).
- **Food preferences and habits are formed in large part through childhood experiences and actually persist throughout the course of an individual's life**, helping to maintain memories and strengthen connections with traditional origins and territory (van Vliet et al. 2015).
- Van Vliet (2018) warns that stigmatization of bushmeat may foster a "cultural backlash", accusing protectionist behaviours of "cultural imperialism" and recommends to analyse and consider the complex cultural dimension. Cawthorn & Hoffman (2015) also underline potential ethical collisions and the need to provide alternative sources for food and income.
- Campbell et al. (2021) from TRAFFIC highlight main factors for the success of demand reduction strategies, e.g.:
  - "*In general, target audiences respond better to **positive social messages** than to negative environmental messages. This is in line with the experience from communications targeting climate change deniers, which have proved more effective when focusing on the social welfare improvements of mitigating climate change, rather than the risks and realities of climate change."*
  - ***"The perceived credibility and pick-up of behaviour change messaging are influenced by who presents the message.** Locally influential actors and institutions should be engaged as messengers to change perceptions and bring about effective behaviour change. These messengers can have a strong voice in promoting alternative products or forms of consumption. In the Republic of Congo, for example, Protestant Christian groups are growing in influence, and have significant social and political influence to connect with target audiences" (see also https://changewildlifeconsumers.org/toolkit/choosing-the-right-messenger/).*
  - *"**Proposing suitable alternative options** is important for any behaviour change intervention, and the right alternative product for wildlife consumers will vary based on local preferences and local availability. In the Republic of the Congo, imported frozen meats are seen as poor quality and unsafe, often making consumers sick. Local organic poultry and livestock and locally caught fish are seen as fresh, tasty, and healthy, satisfying the main motivators for why people consume wild meat in this area. Fresh fish may be a good alternative protein source in similar urban coastal areas if fish can be sustainably sourced.*
- For the WWF, Nicolas (2021) also noted that "demand reduction campaigns that focus on diminishing the purchase of specific wildlife products work best when they target consumers and develop messaging based on research of consumer motivations. This allows campaigns to target consumers more effectively and develop appropriate messaging."

- US AID *et al.* (2021): "*When asked about the etiology of Ebola, the majority of respondents acknowledged that they did not know what caused the Ebola outbreak in their country. However, many respondents did attribute the origins of Ebola to wild animals, sick people, their bodily fluids, and domestic animal excreta (Figure 7). With regard to concerns over disease outbreaks in local live animal markets, respondents across all geographies noted a stark rise in their concern during the Ebola outbreak. In the period following the crisis, however, reported concern diminished.*"



FIGURES 7. Interviewer responses on perceived cause of the 2014 West African Ebola epidemic.

- MacFarlane *et al.* (2022) highlight: "*In light of the devastation caused by the current coronavirus pandemic, and the aforementioned associated risks, there may be a* ***moral responsibility for conservationists to incorporate factual health-risk warnings into communications that concern many wildlife trade activities…*** *Thus, by communicating that consuming primate meat is both high in risk (e.g., of contracting disease) and low in benefit (no more nutritious than other forms of protein) we can use both elements combined to reduce people's perception of its value.* ***Indeed, a recent experiment found that while the perceived value of an ineffective health remedy could be reduced by communicating either its lack of benefits (by 23%) or its potential health risks (by 30%), communicating both produced the greatest reduction in perceived value (by 50%).***

6. Relevant stakeholders & potential partners

(e.g., religious leaders / government / authorities / celebrities…):

- Society for the Conservation of Nature of Liberia / PREDICT Liberia Team (Machalaba 2022)
- Local leaders, such as Paramount Chiefs, play a crucial role in their communities and are vital partners in trust building (Machalaba 2022)
- FDA
- Ministry of Internal Affairs
- Environment protection Agency
- Ministry of Agriculture
- The Nature Campact
- National Traditional Council of Liberia
- Bishop of the United Methodist Church
- Bishop of the Lutherian Church of Liberia
- National Muslim Council of Liberia, Monrovia
- African Methodist Episcopal Church

6.1. Role of stakeholders

- Religious leaders in Africa can have a central role in awareness campaign (e.g. vaccination, prevention of diseases, climate change), but also have the potential to undermine awareness or vaccination campaigns (Nche & Agbo 2022; Jegede 2007). Therefore, they need to be convinced first before becoming an active helpful player (Agbo & Nche 2022; Nche 2020; Remes et al. 2012).
- In northern Nigeria, a **coalition campaign involving imams, Islamic school teachers, traditional rulers, doctors, journalists, and polio survivors** was gradually turning the tide against polio vaccine rejection (Nasir *et al.* 2014).
- During the COVID-19 pandemic religious leaders (Christians and Muslims) in several African countries were involved in Governments' public health education campaigns – including spots on TV and speaking on radio (WHO Africa 2020).

6.2. Health Alliance partners

Who: **GIZ Liberia**
What: eventually helpful for networking with authorities
Contacts: GIZ regional office Sierra Leone – Liberia – Guinea
Country Director: Christian Widmann, giz-sierra-leone@giz.de; +232 78 700 887
32d Wilkinson Rd., Freetown, Sierra Leone
Linked Programmes:
„Support pandemic prevention in the ECOWAS region"
- Country focus on Burkina Faso, Guinea, Liberia, Mali, Sierra Leone, Togo, Nigeria and Ghana
- Contact: Damien Bishop (damien.bishop@giz.de)

Link: https://www.giz.de/en/worldwide/325.html

7. Studies on national use of (social) media tools

7.1. Key findings on media tools

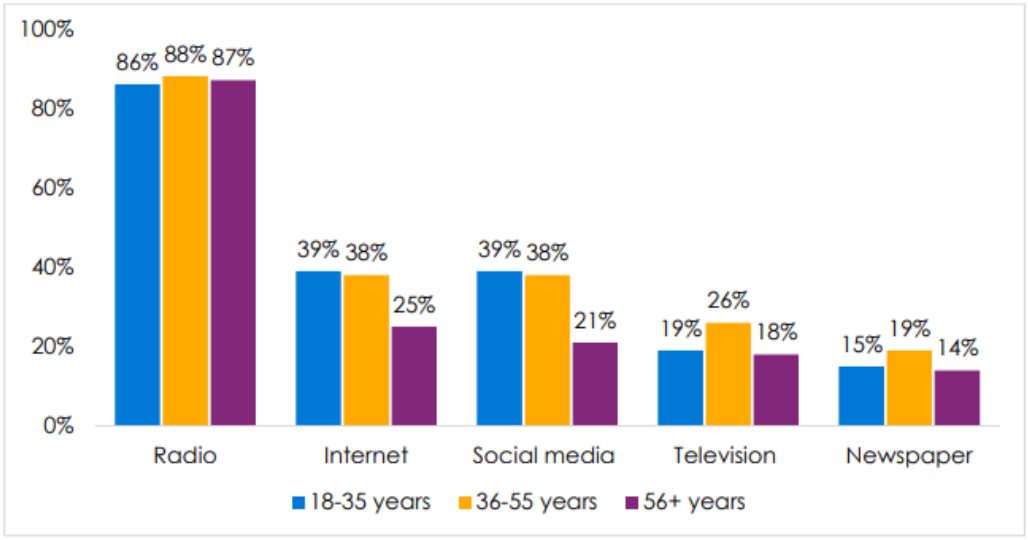
In a nutshell:

- **Radio is the dominant news source in Liberia, tuned in "every day" or "a few times a week" by 87% of adults and being equally popular as a news source across all age groups.** Digital media channels follow radio in popularity: Almost four in 10 citizens (38%) say they regularly get news from the Internet and social media. Far fewer regularly use television (21%) and newspapers (16%) as sources of news.
- There were 1.15 million **internet users** and 748.2 thousand **social media** users in Liberia in January 2022. Facebook is by far the most popular social media channel, followed by LinkedIn, Facebook Messengers, Instagram and – with a much lower range – Twitter.
- Social media have been proven to help spread the word in public health campaigns.
- During the Ebola outbreak in Liberia, **most relevant mass media were newspapers, radio public service announcements, billboards, social media campaigns through text messages**, education activities, and direct education initiatives sponsored by Government of Liberia (GOL) and UNICEF social mobilization teams.
- **Problem for several media tools is the difficult evaluation of impact**, of e.g. radio spots or billboards. While social media may reach only some target groups, evaluation is much easier, as outreach data are provided by the channels.

7.2. Scientific background

- **Radio remains the most used mass-communication medium in Africa**. It has the widest geographical reach and the greatest audiences compared with the Internet, television and newspapers - reaching millions who have no access to the internet (UN 2022).
- According to Afrobarometer (2021) **Radio is the dominant news source in Liberia, tuned in "every day" or "a few times a week" by 87% of adults and being equally popular as a news source across all age groups.** Digital media channels follow radio in popularity: Almost four in 10 citizens (38%) say they regularly get news from the Internet and social media. Far fewer regularly use television (21%) and newspapers (16%) as sources of news. For more details see: https://www.afrobarometer.org/wp-content/uploads/2022/02/ad483-liberians_want_free_media-within_limits-afrobarometer_dispatch-20oct21.pdf

Figure 2: Regular media consumption | by age group | Liberia | 2020



Respondents were asked: *How often do you get news from the following sources? (% who say "every day" or "a few times a week")*

- Almost four in 10 citizens in Liberia (38%) say they regularly get news from the Internet and social media, while only about one in five are regular consumers of news via television (21%) and newspapers (16%).
- Radio is proving to be invaluable during the current Covid-19 Pandemic. Learners around the world are tuning into radio stations to receive academic tuition via the airwaves. Messages on how to prevent the spread of infection have saved countless lives already.
- 22-26% of Liberian citizens were using **internet** in 2020, which is significantly lower than in neighboring countries (Statista 2022; World Bank Group 2023).
- There were 1.15 million **internet users** in Liberia in January 2022. Kepios analysis indicates that internet users in Liberia increased by 27, 000 (+2.4 percent) between 2021 and 2022. For perspective, these user figures reveal that 4.09 million people in Liberia did not use the internet at the start of 2022, meaning that 78.0 percent of the population remained offline at the beginning of the year (Kepios 2023).
- There were 748.2 thousand **social media** users in Liberia in January 2022.The number of social media users in Liberia at the start of 2022 was equivalent to 14.3 percent of the total population, but it's important to note that social media users may not represent unique individuals. According to Kepios (2023), **Facebook** had 709,700 users in Liberia in early 2022, **Facebook Messengers** 105,600 users, **Instagram** 92,100 users, **Twitter** 17,300 users and **LinkedIn** 120,000 users.)(see https://datareportal.com/reports/digital-2022-liberia#:~:text=Social%20media%20statistics%20for%20Liberia,in%20Liberia%20in%20January%202022.
- In 2019, the government enforced a social media shutdown, including WhatsApp, Instagram, and Facebook to subdue public protests (Business & Human Rights Resource Centre 2019).
- **On COVID-19**: Adanlawo (2020) revealed that media, especially social media play critically role in curbing the spread of Coronavirus. The study concluded that crisis risk communication is an

important step contributing to changing individual behaviour and control of Coronavirus. The study recommends the need for every stakeholder to indulge in the use of social media in communicating Coronavirus crisis to the public to achieve behavioural epidemiology control.

- In the context of COVID-19, Porat et al. (2020) highlight an **infodemic — an over-abundance of information, of which some is accurate, and some is not, making it hard for people to find trustworthy and reliable guidance to make informed decisions**. The authors propose five practical guidelines for public health and risk communication that will cut through the infodemic and support well-being and sustainable behaviour change: (1) create an autonomy-supportive health care climate; (2) provide choice; (3) apply a bottom-up approach to communication; (4) create solidarity; (5) be transparent and acknowledge uncertainty.
- **On Ebola emergency**: Mass media that helped to spread the word were newspapers, radio public service announcements, billboards, social media campaigns through text messages, education activities, and direct education initiatives sponsored by Government of Liberia (GOL) and UNICEF social mobilization teams (Abramowitz *et al.* 2017). In Nigeria, social media, including Facebook and Twitter, obviously helped to curtail the outbreak during the Ebola-outbreak of 2014 by disseminating accurate information about the disease and correcting hoax messaging (Fayoyin 2016; Carter 2014).
- **Role of social media campaigns**: A study by Duong et al. (2021) underscored the need to leverage the power of social media and interpersonal communication in public health campaigns to prevent infectious outbreaks. They found that interpersonal communication mediated the effect of social media campaign exposure on risk-reducing behaviour.
- **Impact of radio features:** In Tanzania, a series of 15-min features aimed to reduce demand for bushmeat has been aired on radio. However, according to interviews there was no evidence of the intervention achieving its initial goals. One possible reason was the low audience penetration rate. Fewer than 40% of respondents listened to the show and among those who did, only about 20% listened to five of more episodes (Veríssimo *et al*. 2018).

8. Other relevant information

Cultural and social taboos

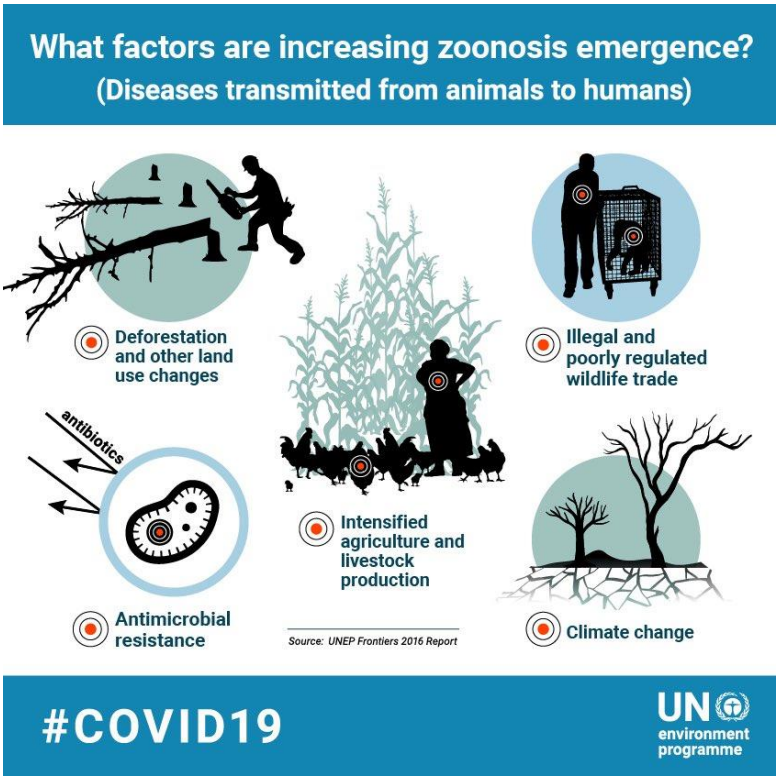
- **A critical explication of the functions and limits of taboos and customary practices attached to wildlife harvesting is needed to see what the society stands to gain from various taboos and how these taboos can be constructively repositioned to achieve ultimate wildlife conservation**, according to a study in Nigeria (Obioha et al. 2012). For example, the endangered sclater's monkey, endemic to Nigeria, is locally protected in a community complex by long-standing social taboos, which remained largely intact until nowadays (Baker et al. 2017).
- The Islam's prescribed method of slaughter for halal means de facto that all bushmeat species are prohibited for strict Muslims (van Vliet & Mbazza 2011), including the eating of primate meat. However, Nyanganji et al. (2010) note that, while eating of great ape meat is restricted by certain taboos, those traditional taboos are increasingly breaking down because of an influx of immigrants from non-Muslim areas, and because of a commercialization of the bushmeat trade.
- Bachmann et al. (2020) found that Muslims in Côte D'Ivoire consumed 86% less primate meat, 90.6% less duiker meat and 94.1% less rodents than Animists.
- Hunting pressure is unsustainable due (in part) to non-selective guns and traps placed around farms and forests. At present, hunters only avoid killing **totemic animals**. For instance, Nimba hunters, avoid killing of chimpanzees and some other primates, leopard, some species of mongoose and the yellow-backed duiker. These avoided species serve as totems, are considered dangerous, have mystical value (especially chimpanzees and leopards), are of known conservation value or are known to be rare (Conservation International undated).
- In central Ghana, two primate species (the ursine black and white colobus and the Campbell's monkey) are locally protected by a **hunting taboo**, thought to date back to the 1830s (Saj et al. 2013). The authors conclude from their research that the monkeys serve as a totemic mechanism to preserve the villagers' social world.
- According to a second study in Ghana, hunters are often more aware of existing **taboos and myths** than of legal aspects, such as closed hunting season and license requirements. However, existing rituals as a remedy for the violation, serving as an antidote against the intrigue, are undermining efficiency of taboos. Rather than integration of the myths and taboos into biodiversity management, increased efforts for enforcement of laws are needed (Emieaboe et al. 2014).
- **Local hunting practices, often accompanied by several taboos, were practiced for centuries, but this does not apply to commercial bushmeat trade into urban markets**, where new consumption aspects have been developed (Zhou et al. 2022).
- State-enforced quarantine, with a mandatory prohibition of movement, raised condemnation, strengthened stigmatization, created a climate of fear, mistrust and denial that did not help people to understand the causes, ways of transmission, and prevention strategies. An understanding of the drivers of fear and mistrust in the affected communities which ultimately result in behaviour that may increase disease transmission, appear to be a crucial and substantial part of an outbreak control (Arthur *et al.* 2022; Pellecchia *et al.* 2015).

9. Examples for Visualizations & Graphics (for internal use only)

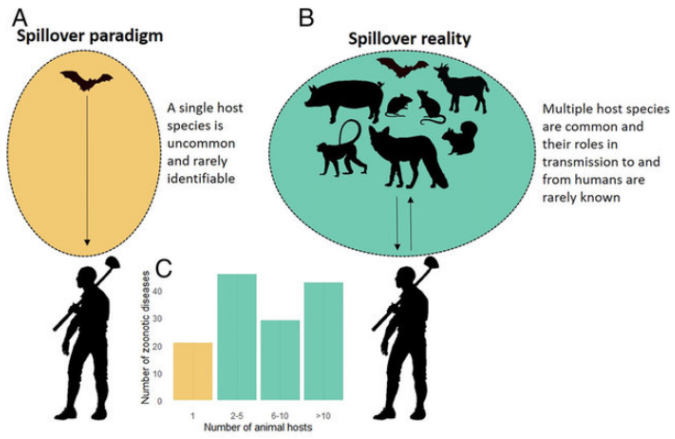
One Health concept

>> GIZ: https://www.giz.de/en/worldwide/95590.html

Biodiversity loss & zoonosis emergence
(https://twitter.com/GlobalGoalsUN/status/1251562406624374784/photo/1)



Complexity of hosts
(https://www.researchgate.net/publication/350665803_Impacts_of_biodiversity_and_biodiversity_loss_on_zoonotic_diseases/figures?lo=1)



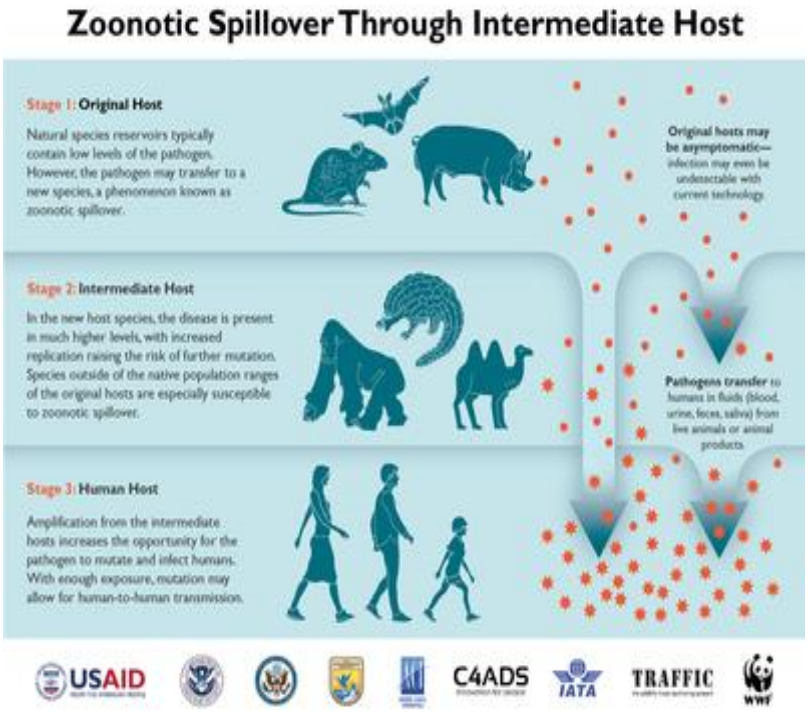
Figure

Caption

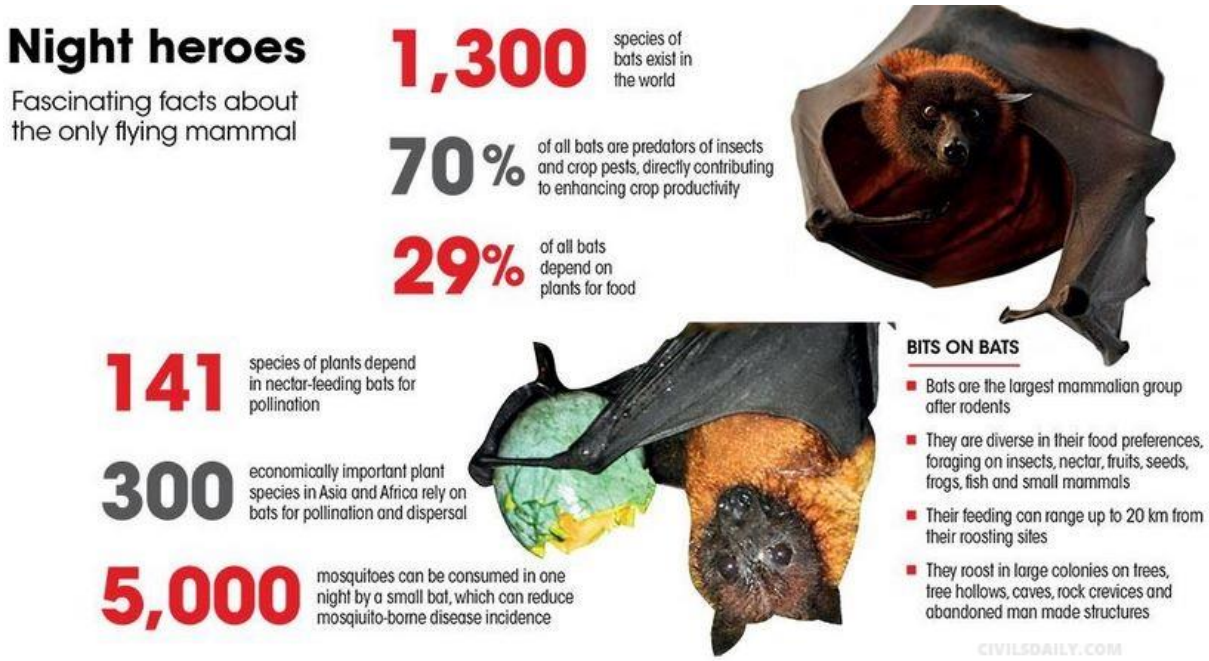
Fig. 4. The paradigm and the reality for research on spillover of zoonotic pathogens into humans. (A) The paradigm emphasizes a single animal host species for a zoonotic pathogen and an original spillover event, though the event and the species are rarely identified. (B) In reality, most zoonotic pathogens have multiple host species whose specific roles in transmission to and from humans are rarely known. (C) The number of viral zoonotic diseases that have 1, 2 to 5, 6 to 10, or 11+ known animal host species other than humans. Plotted from data made available in supplementary materials from Johnson et al. (21); see caveats about these and similar data in SI Appendix.

Zoonotic spillover through intermediate hosts

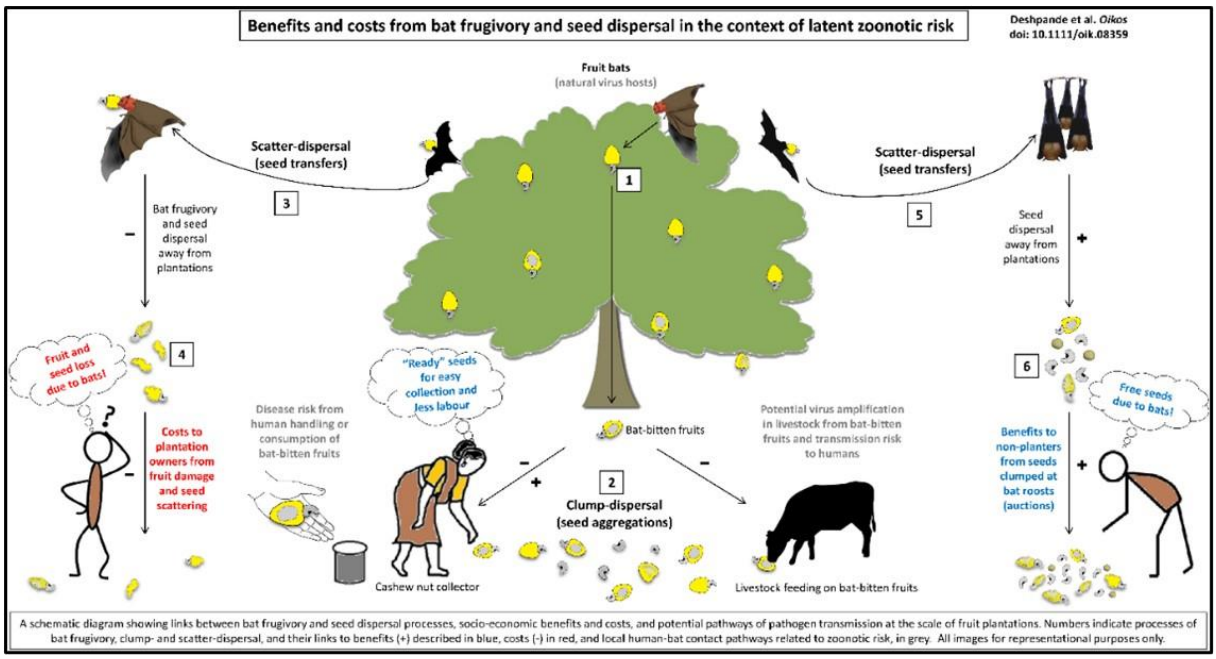
(https://routespartnership.org/news-room/covid-19-underscores-global-need-to-combat-animal-smuggling-in-aviation)



Ecological role of bats: https://www.civilsdaily.com/news/bats-and-their-ecological-significance/



https://www.oikosjournal.org/blog/fruit-bat-people-interactions



Helpful initiative: PREDICT-2 project, 'Living Safely with Bats' and ‘What’s the Fever’ (see https://panorama.solutions/en/solution/integrating-biodiversity-and-health-messaging-and-tackling-superstition-communities-liberiaproject

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