One Health Zoonotic Disease Prioritization for Multisectoral Engagement in the Economic Community of West African States (ECOWAS) Region

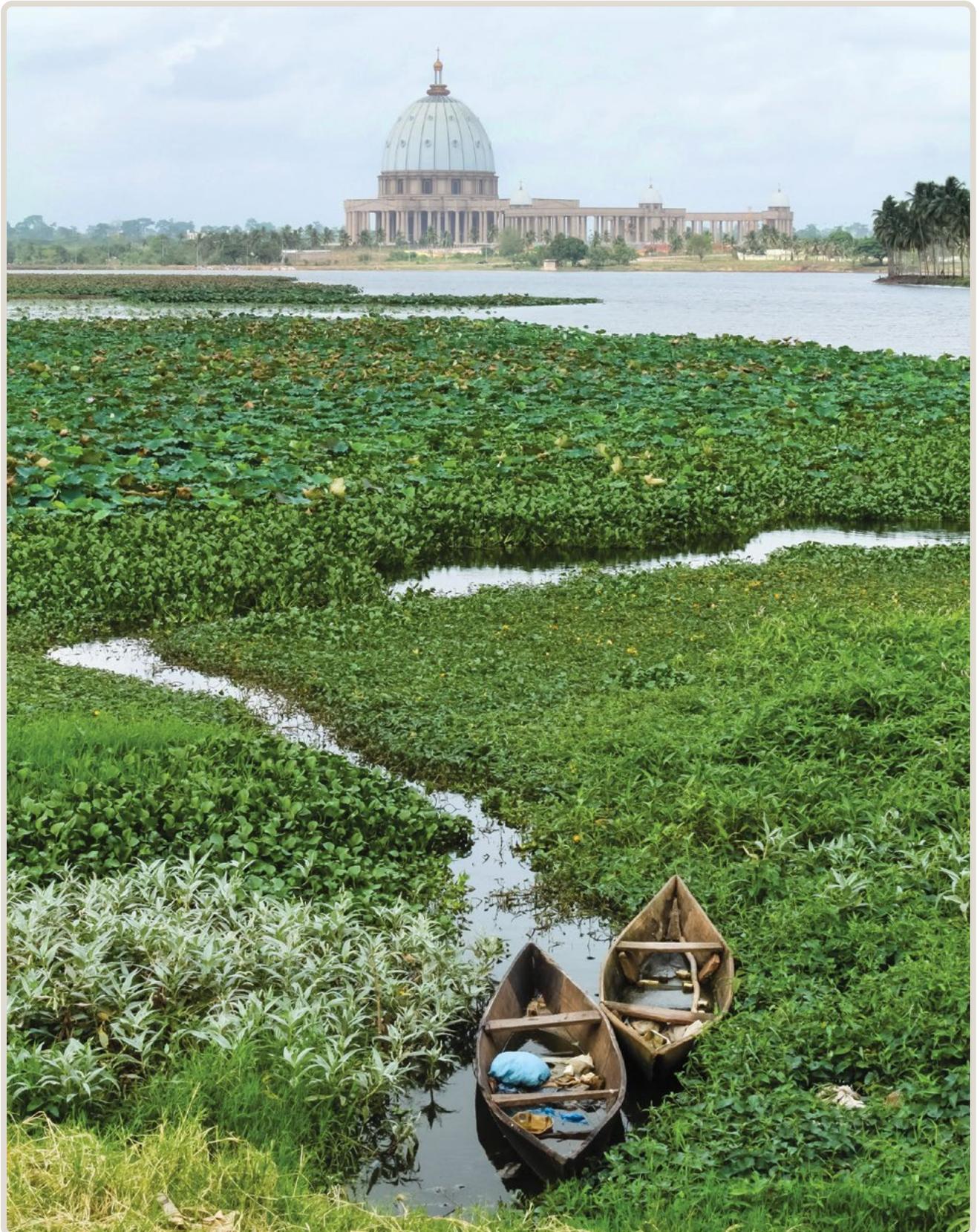**Food and Agriculture Organization of the United Nations**

Photo 1. The Basilica of Our Lady of Peace, Yamoussoukro, Côte d'Ivoire.

TABLE OF CONTENTS

PARTICIPATING ECONOMIC COMMUNITY OF WEST AFRICAN STATES (ECOWAS) MEMBER STATES

Republic of Benin

Burkina Faso

Republic of Cape Verde

Republic of Côte d'Ivoire

Republic of the Gambia

Republic of Ghana

Republic of Guinea

Republic of Guinea Bissau

Republic of Liberia

Republic of Mali

Republic of Niger

Federal Republic of Nigeria

Republic of Senegal

Republic of Sierra Leone

Republic of Togo

PARTICIPATING ORGANIZATIONS

Economic Community of West African States, Regional Animal Health Centre (RAHC)

Food and Agriculture Organization (FAO)

Inter-State School for Sciences and Veterinary Medicine (EISMV)

National Laboratory for Veterinary Studies and Research (LNERV)

Nigeria Centre for Disease Control (NCDC)

United States Agency for International Development (USAID)

United States Centers for Disease Control and Prevention (CDC)

United States Defense Threat Reduction Agency (DTRA)

United States Department of Agriculture (USDA)

West Africa Livestock and Innovation Center (WALIC)

World Health Organization (WHO)

EXECUTIVE SUMMARY

A One Health Zoonotic Disease Prioritization (OHZDP) Workshop for the Economic Community of West African States (ECOWAS), to begin addressing zoonotic disease challenges within the ECOWAS region, was held from December 3–7, 2018, in Dakar, Senegal. Trained U.S. Centers for Disease Control and Prevention (CDC) facilitators and regional Food and Agriculture Organization (FAO) facilitators facilitated the 5-day OHZDP Workshop for ECOWAS.

The purpose of the workshop was to use a multisectoral, One Health approach to identify zoonotic diseases of greatest regional concern for ECOWAS. The specific goals of the prioritization process were:

1. To use a multisectoral, One Health approach to prioritize endemic and emerging zoonotic diseases of greatest regional concern that should be jointly addressed by human, animal, and environmental health ministries and other partners using a One Health approach.

2. To develop next steps and action plans for addressing the prioritized zoonotic diseases through a multisectoral, One Health approach.

CDC's OHZDP process was used to prioritize zoonotic diseases within the region (Appendix A).[1–3] The OHZDP process allows for equal representation amongst the various One Health sectors and uses a transparent and locally adaptable process. Workshop participants represented human, animal, and environmental health ministries from all 15 ECOWAS Member States. Observers from regional and international organizations were also present to observe the workshop proceedings and support future activities for the priority zoonotic diseases.

During the workshop, representatives identified a list of zoonotic diseases relevant for the ECOWAS region, defined criteria for prioritization, and determined questions and weights relevant to each criterion using previously described methods.[1–3]

Seven zoonotic diseases were prioritized for the ECOWAS region (Table 1):

1. **Anthrax**
2. **Rabies**
3. **Ebola and other viral hemorrhagic fevers (for example, Marburg fever, Lassa fever, Rift Valley fever, Crimean-Congo Hemorrhagic fever)**
4. **Zoonotic influenzas**
5. **Zoonotic tuberculosis**
6. **Trypanosomiasis**
7. **Yellow fever**

The final results of the OHZDP process and the normalized weights for all zoonotic diseases discussed at the regional OHZDP workshop are shown in Appendix C.

After finalizing the list of priority zoonotic diseases, the workshop participants discussed recommendations and further actions that could be taken using a regional approach to address them. Participants made recommendations for how to approach the priority zoonotic diseases in thematic areas including One Health coordination, surveillance and laboratory capacity, response and preparedness, prevention and control, workforce development, and research needs.

This report describes the process used to prioritize the top zoonotic diseases of concern for ECOWAS and the key themes surrounding next steps to address these zoonotic diseases using a multisectoral, One Health approach that includes human, animal, and environmental health sectors and other relevant partners. The OHZDP workshop effort was supported by ECOWAS, FAO, US CDC, and USAID.

Table 1. Description of priority zoonotic diseases in the One Health Zoonotic Disease Prioritization Workshop for multisectoral engagement in the ECOWAS region

Zoonotic Disease	Causative Agent	Human Disease Burden	Animal Disease Burden	Diagnostics, Treatment, and Prevention
Anthrax	*Bacillus anthracis*	Anthrax is considered hyperendemic in West Africa. Exact human case burden is unknown, but both cutaneous (skin) and gastrointestinal forms are frequently reported in most countries in the ECOWAS region.[4]	Anthrax is considered hyperendemic in West Africa, and outbreaks have been reported in livestock and/or wildlife in most countries in the ECOWAS region.[4,5]	Effective vaccination and treatment exist for both animals and humans. While the anthrax vaccine for humans is not available in the ECOWAS region, an anthrax vaccine is available for animals within ECOWAS Member States.
Rabies	Rabies virus	Globally, an estimated 59,000 people die from rabies every year, 40% of whom are children living in Asia and Africa.[6] Africa and Asia have the highest rabies burden in humans and account for 95% of rabies deaths worldwid. [7]	It is estimated that >99% of human rabies deaths come from a dog bite exposure. [6] Rabies has been reported by 11 countries within the ECOWAS region over the last decade.[8] Available data suggest there is significant under-reporting of rabies cases in Africa. [9]	Human rabies vaccines exist for pre-exposure immunization. Vaccinating dogs is the most cost-effective strategy for preventing rabies in people.[7] Post-exposure prophylaxis is the immediate treatment for people after rabies exposure. Effective treatment soon after exposure to rabies can prevent the onset of symptoms and death. [7]

Zoonotic Disease	Causative Agent	Human Disease Burden	Animal Disease Burden	Diagnostics, Treatment, and Prevention
Ebola and other viral hemorrhagic fevers (Lassa fever, Marburg virus, Rift Valley fever, Crimean Congo hemorrhagic fever)	Ebola virus and other viral hemorrhagic fevers (Lassa virus, Marburg virus, Rift Valley fever virus, Crimean-Congo hemorrhagic fever virus)	During the 2014–2016 Ebola outbreak in West Africa, there were a total of 28,616 cases and 11,325 deaths. In Guinea, Liberia, and Sierra Leone, 11,310 deaths were reported.[10] Case fatality rates of Ebola have varied from 25% to 90% in past outbreaks, with an average around 50%.[8]	Fruit bats are thought to be the natural Ebola virus hosts. Ebola virus is introduced into the human population through close contact with infected animals such as fruit bats, chimpanzees, gorillas, monkeys, forest antelope, or porcupines found ill or dead in the rainforest.[11] Little information is known about how domestic animals respond to Ebola virus.[12]	Currently, there are no animal vaccines. Human vaccines are available for some viral hemorrhagic fevers. Supportive care is the only treatment for humans.[11]
Zoonotic influenza	Influenza A viruses	Avian: One fatal H5N1 case in Nigeria was reported to WHO from 2003–2018. No other cases were reported from West African countries. Swine: Excluding the 2009 pandemic, 7 of 73 cases reported worldwide from 1958 to 2010 have been fatal.[13] 2009 H1N1 Pandemic: 168 laboratory confirmed fatal cases were reported across Africa. However, some estimate there may have been up to 65,600 respiratory and cardiovascular deaths associated with H1N1 infection in Africa.[14]	In 2016, H5N1 caused continued outbreaks and was detected in poultry and wild birds. In 2016, large outbreaks of H5N8 affecting poultry and captured and wild birds were reported throughout the ECOWAS region.[15]	Avian influenza vaccines exist and are mostly produced for poultry. H5N1 vaccines for humans have been developed in the event of an epidemic but are not in routine use.[16] Influenza antiviral drugs can be used to treat influenza infections in humans.[16]
Zoonotic tuberculosis	*Mycobacterium bovis*	In 2016, there were an estimated 147,000 new human cases of zoonotic tuberculosis globally, and 12,500 deaths. African countries carry the heaviest burden with an estimated 72,700 new cases in 2016. Of all TB cases in Africa, 0–37% can be attributed to *M. bovis*.[17] Between 2005–2015, multiple countries within the ECOWAS region reported outbreaks of bovine tuberculosis.[8]	The prevalence of *M. bovis* in animals in the region is unknown. However, between 2005–2015, multiple countries within the ECOWAS region reported outbreaks of bovine tuberculosis.[8]	Effective treatment exists for people. Vaccination is not widely used in animals, but candidate vaccines are under development.[18]

Zoonotic Disease	Causative Agent	Human Disease Burden	Animal Disease Burden	Diagnostics, Treatment, and Prevention
Trypanosomiasis (Sleeping sickness)	*Trypanosoma spp.*	Sleeping sickness threatens millions of people, many of whom live in remote rural areas. In 2014, 3,796 cases were reported and there were less than estimated 15,000 cases in Africa.[19] Due to increased coverage by surveillance and control programs, it is believed that many cases go undiagnosed and unreported.[20–22] Trypanosomiasis is considered endemic in Central and West Africa, with highest prevalence likely in West Africa. It is highly endemic in Guinea, with an estimated prevalence of 0.16% in the coastal region.[23] Another study found a prevalence of 0.3% in the coastal region of Guinea, with an active population (20–45 years old) comprising 70% of the cases detected. Their literature review suggested infection rates are generally 0.5–1% in coastal villages, but can go up to 5%.[24]	The prevalence of trypanosomiasis in the ECOWAS region is 10% based on parasitological tests.[8] Trypanosomiasis in domestic animals is a major obstacle to the economic development of affected rural areas.[19] Trypanosomiasis is present across Sub-Saharan Africa, killing an estimated 3 million livestock each year and reducing productivity of sick animals. About 50 million animals are at risk for animal trypanosomiasis.[25]	No vaccines are available for people or animals. Effective prophylactic and curative treatments are available for animals. Effective treatment is available for humans.[26]
Yellow fever	Yellow fever virus	The annual burden of yellow fever in Africa is estimated at 84,000–170,000 severe cases and 29,000–60,000 deaths.[27] Many countries within the ECOWAS region are at high risk, with large non-immune populations.[28]	Monkeys are the primary reservoir of yellow fever virus. In tropical rainforests, sylvatic transmission between monkeys can occur via mosquitoes. There can also be transmission between monkeys and humans via a semi-domestic method where mosquitoes breed in both the wild and around households.[29] In Africa, monkeys are resistant to the yellow fever virus and do not die of yellow fever if they become sick or infected, but rather become immune.[30]	Vaccination is available for people. Through the Eliminate Yellow Fever Epidemics in Africa strategy, nearly one billion people will be vaccinated against yellow fever in 27 high-risk African countries by 2026.[31] There is no treatment or cure once infected. To prevent getting sick, use insect repellent, wear long-sleeved shirts and long pants, and get vaccinated.[32]

BACKGROUND

Zoonotic diseases are diseases spread between animals and people. Most known human infectious diseases and about three-quarters of newly emerging infections originate from animals.[33] Some zoonotic diseases pose a significant threat to human public health, while others may have tremendous agricultural, social, or economic impacts. The multisectoral nature of zoonotic diseases has historically been a challenge in preparing for and responding to zoonotic disease threats at the human-animal-environment interface, highlighting the critical need for a multisectoral and interdisciplinary One Health approach to address these emerging health threats.

Zoonotic diseases that occur in large numbers of people or animals can impact society in various ways:

- Threaten the health of animals resulting in illness, loss of productivity, and/or death.
- Threaten the livelihood of a large segment of the population dependent on livestock as a major source of income.

- Threaten the health of people with the ability to cause a large number of illnesses and deaths, which is also associated with significant social and economic losses.

The threat of zoonotic diseases is perpetuated by factors such as expanding human populations, increased industrialization and deforestation, and an increase in international travel and trade. Cumulatively, these factors contribute to increased opportunities for contact and disease transmission between humans, animals, and the environment.[34] Given the expected population growth in many Member States, the goal of free trade between Member States, and the number of countries in this region that rely on the production of livestock both for local use and for export to other regions, ECOWAS Member States are particularly vulnerable to the effects of zoonotic diseases.

Photo 2. Children walking with wood, The Gambia.

ECONOMIC COMMUNITY OF WEST AFRICAN STATES (ECOWAS)

On May 28, 1975, ECOWAS was established with the signing of the Treaty of Lagos by the Heads of State and Governments of the Member States. The treaty has been revised twice, in 1993 and 2006, to strengthen the operations of ECOWAS institutions including the ECOWAS Commission, ECOWAS Parliament, and the ECOWAS Community Court. The ECOWAS Community consists of 15 Member States in West Africa: Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, The Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Sierra Leone, Senegal, and Togo. ECOWAS is an economic and integration community aimed at fostering relations among its Member States, maintaining and enhancing economic growth, raising the standard of living, and contributing to the progress and development of the African continent. The ECOWAS Community has the vision of a peaceful, borderless, and integrated region where citizens enjoy free movement and access to shared resources in accordance with the principles of democracy, the rule of law, and good governance. The 2017 estimated ECOWAS population was 367,145,245.

Photo 3. Western red colobus in a tree in Cantanhez National Forest, Guinea Bissau.

In many ECOWAS Member States, over half the population is involved in agricultural pursuits and agriculture is a major component of the overall economy of all states. Seventy percent of the population of the ECOWAS region earn more than 50% of their income from livestock rearing, and the livestock sector contributes 23–35% to the agriculture gross domestic product (GDP) in the region.[35] The ECOWAS Commission has the mandate for coordinating and harmonizing all aspects of the development of agriculture in the region. This mandate is achieved through the ECOWAS agriculture policy (ECOWAP). The ECOWAS Commission is further mandated to provide efficient education and health systems in a peaceful and secure environment. The Regional Animal Health Center (RAHC) is the ECOWAS technical agency on animal health and collaborates with the West Africa Health Organization (WAHO), the ECOWAS institution on human health, in delivering the One Health approach for disease control in the region.

The goal of the One Health in West Africa (OHWA) project, funded by USAID, is to promote a One Health approach in the ECOWAS region. This includes addressing existing and emerging zoonotic threats in West Africa by promoting regional capacities on One Health policy formation, disease surveillance, rapid response and support for intersectoral collaboration and coordination. The OHWA project is coordinated by the Regional Animal Health Center based in Bamako, Mali.

As the mission of ECOWAS is to promote integration of all aspects of economic activity between member states, an OHZDP Workshop in the ECOWAS region was needed to strengthen One Health. With the vision of free movement of people throughout the region, it is also quite possible for diseases to move just as freely. The health of humans, animals, and the environment are fundamental to the livelihood and productivity of all people, livestock, and wildlife. By extension, it also contributes to the overall health of the region, economic and otherwise. Major

Photo 4. Boats in Cape Coast, Ghana.

outbreaks threaten the stability of the region, and thus it is important to coordinate prevention and control activities across all ECOWAS Member States.

A major example of this can be seen in outbreaks of Ebola. In the 2014–2016 Ebola outbreak, three of the ECOWAS Member States—Guinea, Liberia, and Sierra Leone—were heavily impacted by the outbreak. However, confirmed cases of Ebola were also identified in other ECOWAS Member States including Mali, Nigeria, and Senegal. Additionally, areas outside of the region such as Italy, Spain, the United Kingdom, and the United States were also impacted. The outbreak resulted in 28,652 cases, with 15,261 of these being laboratory confirmed, and over 11,000 deaths.[10] Although surveillance and outbreak control measures across the region have been strengthened since this outbreak, it is important to continue to be prepared for infectious disease threats. Additionally, outbreaks of Lassa fever have been seen across the ECOWAS region. An outbreak of Lassa fever affected Nigeria from January 1–10, 2019. As of February 14, 2019, the outbreak was responsible for 327 cases of Lassa fever and 72 deaths.[36] Lassa fever is endemic to Nigeria and this outbreak represented an increase in the incidence of cases. In previous years, there have been cases of the disease in Benin and Togo that potentially originated in Nigeria, showing a need for close surveillance in neighboring

countries. Middle East Respiratory Syndrome (MERS) may also be a potential zoonotic disease threat to the ECOWAS region. Although cases have not been reported in humans in the region, strains of the virus have been detected in dromedary camels.[37] These cases in dromedary camels reinforce the continued surveillance needs for emerging zoonotic disease threats.

Additional One Health challenges can arise around the movement of animals and animal products across countries within the region, which can lead to an increased risk of infectious disease transmission. Transhuman pastoralism, or pastoralism organized around the migration of livestock between mountain pastures in warm seasons, plays a major role in livestock production systems in Sahel and West Africa. It is estimated that 70–90% of cattle and 30–40% of small ruminants are involved in this system. Routes in West Africa exist for the export of live cattle and small ruminants across many of the countries within the ECOWAS region. The movement of animals can lead to an increased risk of transboundary animal diseases.[38] Establishing and strengthening One Health networks and surveillance across sectors in the region may be needed to best prepare for potential public health concerns.

ECOWAS MEMBER STATES

BENIN

Benin is a narrow country bordered by Nigeria, Niger, Burkina Faso, and Togo. The official language is French, and the capital city is Porto-Novo. Benin is made up of five natural regions: the coastal region, with sandy beaches, tidal marshes, and lagoons; the barre country, a fertile plateau with swampy areas; the Benin plateaus, made of clay on a crystalline base; the Atakora Mountains, a continuation of the Togo Mountains; and the Niger plains, extending from the northeast of the country to the Niger River Valley. In 2017, the estimated population was 11,003,000 with 56% of the population living in rural areas, and 44% living in urban areas. Although the southern provinces of the country make up only one-fourth of the total area, more than two-thirds of the population live in this area. Clusters of the population are concentrated near the port of Cotonou and the capital of Porto-Novo. Nearly 43% of Benin's population is under the age of 15 and 87.3% are under the age of 45. Major livestock include cattle, sheep, goats, pigs, horses, and poultry. Fishing occurs in lagoons and rivers, and coastal fishing practices are growing. A majority of fish are exported to Nigeria or Togo. Wildlife includes elephants, leopards, monkeys, and wild pigs in the "W" National Park in the north of the country, as well as snakes and many species of birds. A majority of the rainforest that previously covered most of the southern part of the country has been cleared.[39]

BURKINA FASO

Burkina Faso is a land-locked, French-speaking, West African country bordered by Ghana, Côte d'Ivoire, Togo, and Benin to the south; Niger to the east; and Mali to the north and west. The capital and economic center of the country is Ouagadougou. Burkina Faso's land is dominated by savanna in the north and forest in the south. There are two distinct seasons in Burkina Faso: the rainy season (June to September) and the dry season (October to May).[40] The 2017 estimate of Burkina Faso's population

was 19,635,000, with 68.5% living in rural areas and 31.5% in urban areas. About 45% of the population is under the age of 15, and about 89% is under the age of 44. The long dry season makes produce and land cultivation of crops difficult but allows for livestock rearing and exportation. Eighty percent of the population of Burkina Faso is engaged in agriculture, with almost all the population involved in livestock farming.[41] In 2014, Burkina Faso had more than 9 million cattle, 13 million goats, 9 million sheep, 42 million poultry of various types, and 15,000 camels.[42, 43] Agriculture accounts for 32% of Burkina Faso's GDP.[44–46]

CAPE VERDE

Cape Verde is an island country off the coast of West Africa, to the west of Senegal. The capital of Cape Verde is Praia and the official language is Portuguese. There are nine inhabited islands, one uninhabited island, and several islets. The soils of the islands are primarily volcanic or igneous in origin, and are generally shallow, coarse, and rocky. In general, the islands tend to suffer from cyclical droughts and shortages of rainfall. The precipitation that does occur generally comes as torrential downpour, causing erosion and destruction of dams. The climate of the country is moderate, with temperatures ranging between the low 20s and high 20s (degrees Celsius). In 2017, the population of Cape Verde was estimated to be 538,000, with 65.5% living in urban areas and 34.5% living in rural areas. Those who live in rural areas tend to live in villages in remote fertile valleys or in coastal towns. The primary focus of Cape Verde's economy is services, including tourism and transport. Agricultural pursuits are severely limited by the droughts, poor soil quality, and poor grazing practices for goats and sheep. The only indigenous mammal on the island is the long-eared bat. Feral goats are present and are the descendants of domestic goats brought to the island. Monkeys are introduced from the African continent and the rodent population is likely descended from rodents

that came in on ships. There are over 100 species of birds, but only two species are indigenous. Given that no livestock are indigenous to the islands, the introduction of these animals has altered the ecosystem of the country. Since independence, the government has focused on restoration efforts.[47]

CÔTE D'IVOIRE

Côte d'Ivoire is bordered by Mali, Burkina Faso, Ghana, Liberia, and Guinea, and its southern border is the Gulf of Guinea. The official language of Côte d'Ivoire is French. There are four regions of the country: the coastal region, with several lagoons; an equatorial forest zone, which has been greatly reduced in size over the past century; a cultivated forest zone, which has been partially cleared for plantations; and a savanna zone, with a plateau that provides land for stock breeding. The northern half of the country is characterized by this high savanna. Moving inland from the coast, elevation rises steadily. The western border, shared with Guinea and Liberia, consists of mountain ranges. Mount Nimba is the highest point of the country and is situated along the border where Guinea, Liberia, and Côte d'Ivoire meet. In 2017, the population estimate of Côte d'Ivoire was 24,537,000 people, with 45.8% living in rural areas and 54.2% in urban areas. Over 37% of the population is under the age of 15 and nearly 86% is under the age of 45. Over half of the workforce is employed in agricultural pursuits. Livestock are abundant in the northeast, but the country also imports livestock from Mali and Burkina Faso. Fishing is a major traditional occupation and is also done commercially. Wildlife of the forest zone is similar to that of Ghana. In the savanna region, there are many species of antelope, lions, and some herds of elephants. There are also multiple national parks in the country, which serve as wildlife preserves.[48]

THE GAMBIA

The Gambia is a country along the Atlantic Ocean. The capital is Banjul, and the official language is English. The climate is tropical with a heavy rainy season between June and October. The heaviest

and longest rainy season is along the coast and shortens moving eastward. Average temperatures range from the mid-20s nearest the coast and approach upper 20s further inland (degrees Celsius). The Gambia is surrounded on almost all sides by Senegal, with its remaining border being the Atlantic Ocean. The Gambia River runs through the middle of the country and is navigable throughout the length of the country. The Gambia is the smallest non-island country in Africa, and one of the most densely populated. In 2017, the population estimate was 2,117,000 people, with 59.6% living in urban areas and 40.4% living in rural areas. Banjul, the capital, is a major urban center. Nearly 86% of the population is under the age of 45. The country's small coastline limits marine fishing and there are few wild animals native to the country. Stock farming receives government support, but herd sizes are limited by water scarcity and lack of suitable land for pasture.[49]

GHANA

Ghana is a country known for its wealth of national resources and rich history. Ghana can be divided into three main geographic regions: the northern savanna zone (approximately two-thirds of the country), the southern forest zone (approximately one-third of the country); and the coastal region.[50] Ghana's climate is tropical, and the northern zone is dominated by two seasons: a wet season (April to October) and a dry season (November to March). In the southern forests, there is a bimodal rainfall system with two distinct wet seasons, one from April to July and another from September to November.[50, 51] The annual mean temperature ranges from 26 to 29 degrees Celsius and humidity varies from 12% to 100%, depending on the season and region. The 2017 estimate of Ghana's population was 28,855,000, with approximately 46% of the population engaged in agriculture.[51] Of people involved in agriculture, 74% are involved in livestock farming and crop farming, with 5% engaged in livestock production alone.[52] Ghana is noted to have 1.8 million cattle, 7.1 million goats, 4.9 million sheep, 760,000 pigs, and 80.3 million poultry.[53] Other livestock in Ghana include donkeys, horses

(approximately 14,800), rabbits, and grasscutters.[52] There are approximately 570,000 dogs and 126,000 cats.[53] Most commercial agriculture production comes from the forest zone, where cacao (cultivated extensively in the country), timber, minerals, and crops are grown and harvested. However, the northern savanna zone is well-suited to livestock breeding, as is the coastal region for fish and seafoods.[50, 51] Ghana is considered a biologically rich country with 16 Wildlife-Protected Areas (PAs), five coastal Ramsar Sites, and the Accra and Kumasi Zoos. There are also community owned Wildlife Sanctuaries. Ghana's estimated wildlife richness includes 220 species of mammals, 725 species of birds (including 176 regular seasonal migrants), 74 species of bats, 37 species of rodents, and many others.[54]

GUINEA

There are four geographic regions in Guinea: Lower Guinea, the area along the coast and coastal plains; the Fouta Djallon, an area of rocky highlands to the east; Upper Guinea, which consists of the Niger plains extending northeast towards the Sahara; and the Forest Region, also known as Guinea Highlands, in the southeastern corner of the country. In 2017, the estimated population of Guinea was 1,341,000, with approximately 63% living in rural areas and 37% living in urban areas. Guinea is an agricultural country, with agriculture and its associated activities accounting for about 75% of employment in the country. Common livestock include Ndama cattle, sheep, goats, horses, donkeys, chickens, and Muscovy ducks. In Lower Guinea, fish account for an important portion of trade, and other than some poultry and goats, domestic animals are rare. In Upper Guinea, domestic animals are more common. Big game is sparse in Guinea, but common wildlife include baboons, hyenas, monkeys, chimpanzees, and a variety of snakes.[55]

GUINEA BISSAU

Guinea Bissau is a coastal country in West Africa consisting predominantly of lowlands along the coast and some hills inland. The official language is

Portuguese, and the capital and largest city of the country is Bissau. Guinea Bissau, which includes the Bijagos archipelago, is a primarily low-lying country with a pronounced rainy season. The climate of the country is generally tropical with two seasons: a hot and rainy season from June through November, and a hot and dry season during the remaining months, with April and May being the hottest. Tides can reach up to 100km inland. In the southeastern part of the country, elevation reaches approximately 180 meters. The 2017 estimate of the population was 1,548,000 people, of which approximately 51% live in rural areas and 49% in urban areas. Much of the population lives in small villages or main towns. Over 89% of the population is under the age of 45. There are three ecological zones in Guinea Bissau, giving the country significant biodiversity. The first is the tidal estuaries, which are inhabited by aquatic birds, reptiles, snakes, and other coastal swamp animals. In the plains and savanna regions monkeys, apes, leopards, and Bovidae such as antelopes and gazelles can be found. Wild animals are hunted for their meat and hides. The country relies heavily on agricultural pursuits to support its economy, including livestock such as pigs, goats, sheep, cattle, and poultry. Fish and shrimp are also raised for both domestic consumption and export. A majority of the labor in Guinea Bissau is dedicated to subsistence level agricultural production.[56]

LIBERIA

The official language of Liberia is English, and the capital is Monrovia. The country shares borders with Sierra Leone to the northwest, Guinea to the north, and Côte d'Ivoire to the east. The southern and western borders are made up by the Atlantic Ocean. Liberia has four different geographic regions: coastal plains with low, sandy beaches that extend up to 40km inland, lagoons, swamps, and rocky promontories; a region of rolling hills suitable for agriculture and forestry; a plateau region with low mountains; and the northern highlands near the country's border with Guinea, made up of mountains in the Nimba Range. The climate of Liberia is mostly warm and humid year-round. The dry season is from November through

April, with the remaining months being the rainy season. Deforestation and drought have affected the climate and extended the dry season in some areas. The 2017 population estimate for Liberia was 4,280,000 people. Approximately 51% of the population lives in urban areas and 49% lives in rural areas. The population is relatively young, with 42% of the population being under the age of 15 and 86% of the total population being under 45. Agriculture is the leading sector of the economy, with approximately one-fourth of the workforce employed within it. Access to potable water was limited during the civil war, but surface water and groundwater reserves are abundant and frequently replenished during the rainy season. Livestock raised by traditional farmers include goats, chickens, and ducks. During Liberia's civil war, many animals such as monkeys, antelopes, pygmy hippopotamuses, elephants, and leopards were hunted for food. The populations of these species are recovering but are not as abundant as they previously were. There are numerous species of reptiles, bats, birds, and fish found within the country's large wildlife reserves.[57]

MALI

Mali is a land-locked country in West Africa. Sixty-four percent of Mali's area is rural. Two major rivers flow through Mali: the Niger and the Senegal. The country has four bioclimatic areas in 49 agroecological zones in addition to the inner Niger Delta, each characterized by specific ecosystems. These include the Saharan zone in the north, which covers two-thirds of the country, with annual rainfall less than 150mm; the Sahelian zone in the center, with rainfall between 200 and 550mm; the Sudanian zone to the south, with rainfall varying from 600 to 1,200mm per year; and the Sudano-Guinean zone in the southernmost part of the country, with rainfall averaging more than 1,200mm per year.[58] The inner Niger Delta, in the center of the country, is characterized by a Sudano-Sahelian climate with rainfall between 200 and 600mm per year and hydrologic and specific ecologic conditions.[59] The population of Mali was estimated to be 17,885,245 in 2017, with 67% being people under 25 years of age and only 3.03% being people over 60 years of

age. Most of the population resides in the southern part of the country and along the Niger River. Mali's economy, dominated by the informal sector, is based on primary production (agriculture, livestock, fishing, and aquaculture), which covers almost 80% of the active population. Mali has the second largest animal population of ECOWAS and the largest of West African Economic and Monetary Union (WAEMU). According to statistics from the minister in charge of livestock in 2016, the breakdown of livestock is as follows: 10,622,750 cattle, 36 million sheep and goats, 1 million camels, 38,587,450 chickens—of which more than 90% are backyard poultry—and 1.5 million horses and donkeys. The pig population is estimated at less than 100,000.[60] The livestock sector accounts for 15% of Mali's GDP. Mali exports about 20% of its animal products to several countries in West Africa, including Côte d'Ivoire, Ghana, and Nigeria. Most livestock in Mali are produced in extensive production and smallholder systems where they co-exist freely with wildlife. Mali is characterized by wildlife co-existing side-by-side with livestock and humans, especially in rural areas, providing a perfect setting for the emergence and spread of zoonotic diseases. Mali's wildlife is characterized by a diversity of species and a relatively small number of staff to protect them. It has more than 136 species of mammals, including 70 species of large mammals.[58] There are at least 640 species of birds, of which 15 are considered rare. Migratory birds spend 75% of the time in the Central Niger Delta where they protect themselves from the harsh winter and fatten to face the journey to Europe. They are taking advantage of the abundant food and breed between two migrations.

NIGER

Niger is a landlocked country surrounded by Algeria, Libya, Chad, Nigeria, and Benin. The capital city is Niamey, and the country is named after the Niger River. The official language of Niger is French. Agriculture and associated products are the largest contributors to Niger's economy in both employment and percentage of gross national product (GNP). Livestock constitute a major portion of this and are a main export. Cattle,

sheep, and goats are raised to produce meat, milk, and hides. Niger lies south of the Tropic of Cancer. The northern two-thirds of the country is made up of dry, tropical desert lands, and the country is in one of the hottest regions in the world. The southern third of the country has a single, short, rainy season, lasting from one to four months depending on latitude. In every region except the far north, August is the rainiest month. In the far north, rainfall is unpredictable. The 2017 estimate of the population was 20,706,000 people, with 81.3% living in rural areas and 18.7% in urban areas. The life expectancy at birth is 63.8 years for males and 65.1 years for females. In the desert region, animal life is limited to animals that can endure hunger and thirst, including dromedary camels. Moving south to the Sahel zone, ostriches and gazelles can be found. In the cultivated region, wildlife has partially disappeared, but antelopes, elephants, and warthogs can be found. In the extreme southwestern savanna, the "W" National Park serves as a reservation for antelopes, lions, buffalo, elephants, and hippopotamuses.[61]

NIGERIA

Nigeria is a country on the western coast of Africa. The country shares borders with Niger, Chad, Cameroon, and Benin. Its southern border is the Gulf of Guinea. The official language is English, but hundreds of languages are spoken throughout the country. Nigeria has a tropical climate, with rainy seasons dependent on location. In the south, the rainy season is from March through November, and the length of the season generally decreases towards the north. In the northernmost regions of the country, the rainy season is from mid-May through September. Nigeria is the most populous country on the African continent, with a 2017 estimate of 195,050,000 people. Approximately 52% of the population lives in rural areas and 48% in urban areas. Around two-thirds of the population participate in agricultural production for a living and most is done in the form of small-scale subsistence farming.[62] Nigeria is estimated to have approximately 145 million chickens; 19.5 million cattle; 72.5 million goats, 41.3 million sheep, 11.6

million ducks, 1.2 million turkeys, 7.1 million pigs, 1 million donkeys, and 28,000 camels.[63] Many animals that previously inhabited entire regions of savanna or forest in the country can now only be found in protected places such national parks. Some of these animals include camels, lions, and wild pigs. Rodents in the country include squirrels, porcupines, and cane rats.[62]

SENEGAL

Senegal is the westernmost country on the African continent. The official language is French, and the capital is Dakar, one of Africa's most important harbors. The city serves as an economic and cultural center for all West Africa. Senegal borders Mauritania to the north, Mali to the east, Guinea and Guinea Bissau to the south, and the Atlantic Ocean to the west. Senegal surrounds The Gambia on all sides except the west. There are two distinct seasons in Senegal: a rainy season that lasts from June to October, and a dry season that lasts from November through May. In 2017, the estimated population of Senegal was 14,988,000, with approximately 57% living in rural areas and 43% in urban areas.[64] Nearly two-thirds of the workforce is involved in agricultural pursuits, and many of these individuals are involved in livestock farming. Agricultural production and sales account for 17.5% of Senegal's GDP.[65] Senegal is noted to have approximately 3.3 million cattle, 6.3 million goats, 5.4 million sheep, 400 thousand pigs, and 30 million poultry.[66–68]

SIERRA LEONE

Sierra Leone is bordered by Guinea to the north and east, Liberia to the south, and the Atlantic Ocean to the west.[69, 70] Sierra Leone has a tropical climate with two distinct seasons: the rainy season (May through October) and the dry season (November through April). There are four distinct physical regions: the coastal swamp, the peninsula, the interior plains and plateau, and the mountains.[70] The 2017 estimate of Sierra Leone's population was 7,461,000, with about 60% of the population being under the age of 25.[24] Sierra Leone's two largest industries are agriculture and mining.[71] Over 75% of the population in Sierra Leone is engaged in agriculture,

with the predominant form of agriculture being food crops. [70] Approximately 90% of cattle are found in the Northern Province, within the Koinadugu and Bombali districts.[72] Unfortunately, much of Sierra Leone's wildlife was adversely affected by the country's civil war from 1991–2002, but several reserves are now helping to rehabilitate the wildlife populations.[70]

🇹🇬 TOGO

Togo is a French-speaking country located between Ghana and Benin. The southernmost border of Togo is a 51km coastline on the Gulf of Guinea, and the country extends 515km to its northernmost border shared with Burkina Faso. Togo has six separate geographic regions: a coastal region with sandy beaches and lagoons; the Outachi Plateau region with red, iron-bearing soil; the tableland, drained by the Mono River; the Togo mountains, home to Mount Agou, the highest peak in Togo at 986 meters; a savanna region surrounding the Oti River sandstone plateau; and a region of granite and

gneiss which includes the cliffs of Dapaong. Togo has a tropical climate. The southern region has two rainy seasons, one from mid-April through June and a second from mid-September to October. The northern region has a rainy season from June through September. The 2017 estimate of Togo's population was 7,231,000 people, with 60.5% living in rural areas and 39.5% living in urban areas. Approximately 41% of the population is under the age of 15, and about 86% of the total population is under the age of 45. A large percentage of the population is involved in agricultural pursuits. Much of Togo's agricultural production is made up of subsistence farming and products produced for local consumption, such as fish, but export crops include cocoa beans, coffee, shea nuts, cotton, and palm kernels. In the plateau and northern regions, cattle, sheep, and pigs are the main livestock. Wildlife are less common, but monkeys, snakes, crocodiles, hippopotamuses, and lizards can be found in areas throughout the country. In the northern Keran Forest Reserve, there are also herds of wild buffalo, warthogs, and antelope.[73]

Photo 5.   A group of giraffes in Togo.

ONE HEALTH ZOONOTIC DISEASE PRIORITIZATION FOR ECOWAS

To begin addressing zoonotic disease challenges within the ECOWAS region, an OHZDP Workshop was held from December 3–7, 2018, at the Novotel Hotel in Dakar, Senegal. The purpose of this 5-day workshop was to use a multisectoral, One Health approach to identify zoonotic diseases of greatest regional concern for ECOWAS. The specific goals of the prioritization process were:

1. To use a multisectoral, One Health approach to prioritize endemic and emerging zoonotic diseases of greatest regional concern that should be jointly addressed by human, animal, and environmental health ministries and other partners using a One Health approach.

2. To develop next steps and action plans for addressing the prioritized zoonotic diseases through a multisectoral, One Health approach.

The effort was supported by ECOWAS, FAO, CDC, and USAID. Trained US CDC facilitators and regional FAO facilitators facilitated the OHZDP Workshop for ECOWAS. Workshop participants represented human, animal, and environmental health ministries from all 15 ECOWAS Member States. Observers from regional and international organizations were also present to observe the workshop proceedings and support future activities for the priority zoonoses.

Photo 6.   A man casting a fishing net in the Niger River meadow close to Niamey, Niger.

WORKSHOP METHODS

The OHZDP process uses a mixed methods prioritization process developed by the CDC's One Health Office. The methods have been previously described in detail (Appendix A).[1, 74] Workshop organizers began to prepare and plan for this workshop months in advance. The first step of the process was to identify a region-specific list of potential zoonotic diseases of concern. A disease was selected if it was known to be spread between animals and people and thought to occur in or surrounding the region. Participants first reviewed the initial zoonotic disease list to focus on for prioritization. A list of 30 zoonotic diseases, shown in Appendix C, was considered during the OHZDP Workshop for the ECOWAS region.

During the workshop, participants developed five criteria for ranking the 30 zoonotic diseases. Once the five criteria were developed, one categorical question was developed for each criterion through group discussion. The questions were developed to best measure each criterion. All questions had ordinal, binomial, or multinomial answers. The ordinal nature is necessary for the scoring process and each answer choice was given a score, determined by the participants. Each ECOWAS Member State then individually ranked their preferences for the relative importance of each criterion. Each country's ranking was then entered into the OHZDP Tool by a facilitator and a group weight for each criterion was calculated. Facilitators and participants answered each question for each zoonotic disease using data identified through an extensive literature search, as well as information from WHO, OIE, ProMED, and other relevant websites. Data on disease transmission, severity, pandemic and epidemic potential, economic impact, prevention and control, and environmental impact were collected for each zoonotic disease at the region and country level. If information for a particular zoonotic disease was not available for the region, global data were used.

After scoring all zoonotic diseases, decision tree analysis was used to determine the ranked zoonotic

Photo 7. The village of Ganvie, Benin is the largest stilted village in Africa.

disease list. Each weighted criterion was applied across each question's answers for each zoonotic disease. The scores of all five questions for each zoonotic disease were summed. The largest raw score was then normalized, giving that zoonotic disease a normalized score of 1. See Appendix C for a complete listing of raw and normalized scores for all zoonotic diseases that were considered for prioritization.

The zoonotic diseases with their raw and normalized scores were presented to the participants for discussion. Workshop participants then utilized the ranked OHZDP list to discuss and decide on a final prioritized list of zoonotic diseases (Table 1). After the participants decided on the priority zoonotic diseases, participants developed next steps and action plans to address the priority zoonotic diseases.

CRITERIA SELECTED FOR RANKING ZOONOTIC DISEASES

The criteria for ranking zoonotic diseases selected by the ECOWAS Member States are listed in order of importance below (Appendix D).

1. Severity of Disease

The first ranked criterion was the severity of disease in the ECOWAS region. This was assessed using the case fatality rate in both humans and animals (livestock and wildlife). Diseases with a case fatality rate greater than or equal to 15% in animals or humans received a score of two (2) points. Diseases with a case fatality rate greater than or equal to 5%–15% in humans or animals received a score of one (1) point. Diseases with a case fatality rate less than 5% in both the human and animal sectors received a score of zero (0).

2. Prevention and Control Capacity

The second ranked criterion was prevention and control capacity. This was assessed by determining whether any effective preventive or therapeutic measure (vaccine or antimicrobial) existed for humans and/or animals. Diseases for which there existed an effective prevention or therapeutic measure for humans and animals received a score of two (2) points. Diseases for which there existed an effective preventive or therapeutic measure in humans or animals received a score of one (1) point. Diseases for which there was no effective preventive or therapeutic measure for humans or animals received a score of zero (0).

3. Epidemic and Pandemic Potential

The third ranked criterion was epidemic and pandemic potential, assessed by determining the time frame in which the pathogen had most recently caused an epidemic in humans or animals in the ECOWAS region. If the pathogen had caused an epidemic in humans or animals in the ECOWAS region within the past 5 years, it received a score of two (2) points. If the pathogen had caused an epidemic between 5 and 10 years prior, it received a score of one (1) point. If the pathogen had never caused an epidemic in the region, or if the most recent epidemic in humans or animals was more than 10 years ago, it received a score of zero (0).

Photo 8. Fishing boats on Mindelo Beach in Cape Verde.

4. Ability to Detect the Disease

The fourth ranked criterion was the ability to detect the disease in the region. This was assessed via evidence of a One Health surveillance system for the disease (investigation, laboratory, or data sharing) in the ECOWAS region. If a surveillance system was in place for all three sectors (human, animal, and environmental health) within five or more ECOWAS countries, it received a score of two (2) points. If a surveillance system was in place for 2 sectors within five or more ECOWAS countries, it received a score of one (1) point. If a surveillance system was in place for 1 or fewer sectors, it received a score of zero (0).

5. Socio-Economic and Environmental Impact

The fifth ranked criterion was the social, economic, and environmental impacts of disease. Diseases that were both on the World Organisation for Animal Health (OIE) reportable disease list and were determined to be potentially affected by climate change (either the host range, vector, or reservoir), received a score of two (2) points. Diseases that were either present on the OIE list or potentially affected by climate change received a score of one (1) point. Diseases that were neither on the OIE list of notifiable diseases nor potentially affected by climate change received a score of zero (0).

[The OIE list was agreed upon by the Member States as a proxy to measure socio-economic impact]

PLANS AND RECOMMENDATIONS

After finalizing the list of priority zoonotic diseases, the workshop participants discussed recommendations and further actions that could be taken, using a regional approach to address the priority zoonotic diseases. Participants were asked to make recommendations for how to approach the priority zoonoses in thematic areas including One Health coordination, surveillance and laboratory, response and preparedness, prevention and control, workforce development, and research needs. A summary of the most prominent recommendations organized by theme follows:

Photo 9. Woman walking through a market, Benin.

ONE HEALTH COORDINATION

- Strong regional and national coordination for One Health is important in the ECOWAS region. This should include regular coordination around routine One Health activities and programs as well as emergency response. Equal involvement of all One Health sectors including human, animal, and environmental health is important. Equity among all engaged sectors and recognition of the involvement of all sectors is needed. ECOWAS Member States recognize the need to increase engagement of the environmental health sector in this region.

- The Regional Disease Surveillance and Control Center in Abuja is designated as the ECOWAS regional One Health coordinating institution to ensure sustainability of One Health coordination at the regional level. Currently, WAHO is responsible for One Health coordination at the regional level as the Regional Disease Surveillance and Control Center is being operationalized.

- Currently, there are varying levels of One Health coordination within ECOWAS Member States. National level coordination should include both ministerial coordination as well as technical level coordination. Within each member state, both levels should establish routine collaboration, communication, and coordination.

  - Over half of the ECOWAS member states have established National One Health Platforms or coordinating mechanisms, while the rest are either in the process of establishing a formal coordination mechanism or have not yet begun the process. All countries in the ECOWAS region should strengthen national One Health coordination by establishing or continuing to support a sustainable National One Health Platform or coordinating mechanism.

- Currently, there is a need to strengthen One Health coordination across ECOWAS Member States. Collaboration across human, animal, and environmental health sectors should be established, strengthened and made sustainable at the regional level.

  - A network is needed for national level points of contact (POCs) to quickly communicate, coordinate, and collaborate around One Health issues for the priority zoonotic diseases. National level POCs from each Member State's National One Health Platform and coordinating mechanism should be provided to the ECOWAS Regional Center for Surveillance and Disease Control, which serves as the regional One Health coordination mechanism for ECOWAS.

  - Establishing regional One Health meetings, both standing and as needed, will allow national level focal points to network, exchange information, and share lessons learned and best practices around One Health topics including the priority zoonotic diseases.

  - Opportunities should be sought to socialize One Health at single sector meetings especially regarding the priority zoonotic diseases.

  - Regional organizations should be encouraged to coordinate—rather than hold separate meetings—when relevant to strengthen One Health Coordination.

  - Country representatives and regional representatives who attend these meetings should share outcomes, reports, and advocate for agreements made at these meetings with One Health partners and stakeholders in their countries or region.

  - The ability to share key reports, documents, and guidance across One Health focal points is needed. An appropriate mechanism to do this should be established. For example, an electronic database could be used to store information for continuity of institutional knowledge.

- To advance One Health coordination, a governance document should be jointly created by all sectors and disseminated to national and regional partners responsible for One Health coordination. This governance document should include stakeholder and partner roles and responsibilities, how One Health coordination works within the region, the need for a shared budget for One Health work at the country level, and guidance on building sustainability at the national and regional level.

- In addition to a governance document, a One Health strategic plan for the ECOWAS region should be created with a focus on the priority zoonotic diseases.

- Information sharing:
  - Data and information sharing across sectors should be incorporated into regional One Health coordination plans as well as at sub-regional levels when appropriate.
  - One Health Emergencies: National Emergency Operations Centers (EOCs) should be leveraged for information sharing across the region.

- To support sustainability of One Health at both the national and regional levels, it is important to advocate and increase high level awareness with political leadership.
  - Active involvement in high profile assessment and planning initiatives is one way to increase high level awareness and support. For example, using the International Health Regulations (2005) which is a whole government, highly visible activity, will allow countries in the region to include One Health activities in their National Action Plans for Health Security.

- Results of One Health assessments and tools used in countries should be shared and linked to build on outcomes and have a maximum impact.
  - Several countries in the ECOWAS region have already completed the PVS-IHR Bridging Workshop to strengthen One Health coordination

  - WHO and OIE, in collaboration with other partners, are working to improve the consideration of the veterinary sector in IHR implementation and are proposing to countries to implement PVS-IHR Bridging Workshops to further elaborate on good governance and shared roadmaps for efficient One Health coordination.

- One Health focal points and advocates should use consistent language around One Health to ensure stakeholders at the community and political levels understand the messages.

- ECOWAS should advocate for funding to support One Health activities and strategic plans in the region.

- ECOWAS should advocate for engagement of all 15 Member States in major international projects with One Health relevancy in the region, such as World Bank's Regional Disease Surveillance System Enhancement (REDISSE) project.

Photo 10. Guinea baboon (*Papio papio*) eating fruit.

SURVEILLANCE AND LABORATORY

- The Regional Animal Health Center and the West African Health Organization have ongoing regional surveillance activities. It is recommended to strengthen and expand existing relevant regional surveillance networks through the following:
  - ➤ Assure the integration of identified priority zoonotic diseases into the list of diseases under surveillance for each sector.
  - ➤ Improve the integration of all three sectors to strengthen a One Health approach to surveillance.
  - ➤ Enhance the existing regional DHIS2 platform for data sharing related to priority zoonotic diseases and incorporate the environmental sector into this activity.
  - ➤ Coordinated surveillance plans incorporating the human, animal, and environmental health sectors should be considered, and joint investigations conducted to ensure a One Health approach for disease detection and control.
    - › This can provide an opportunity to address issues including trans-border surveillance; event-based surveillance (EBS); and community-based surveillance (CBS).

- Standardizing wildlife surveillance across the same ecosystems at the sub-regional level is needed. Identification of major gaps in wildlife surveillance are opportunities to develop standard regional guidelines and practices. The creation of regional guidelines and standard practices for linking surveillance data and systems should include a review and incorporation of best practices from countries with ongoing efforts.
  - ➤ Standardization would help the sub-region and Member States comply with international conventions (for example, the Convention on International Trade of Wild Flora and Fauna) and international disease efforts (for example, the eradication of rinderpest in 2010).

- ➤ When developing standardized surveillance practices, regional migration patterns for wildlife species should be considered. Additionally, wildlife species in the sub-region for which there is a threat of extinction related to priority zoonotic diseases should be considered.

- Existing laboratory networks and diagnostic capacity should be strengthened and integrated between sectors using a One Health approach.
  - ➤ Reference laboratories in the region should be available to diagnose the priority zoonotic diseases and other One Health issues.
  - ➤ Consider consolidating laboratory services to support multiple sectors.
  - ➤ Develop and strengthen national and regional specimen transport networks.
  - ➤ Coordination across supporting laboratories in other countries in the region should be a priority for sustainability.
  - ➤ Work to assure that regional laboratories meet the standards for inclusion in established international laboratory networks (for example, OIE, FAO, and WHO laboratory networks).

- Biosafety and biosecurity for laboratories is an important issue for the ECOWAS region.
  - ➤ Existing laboratories in the region should aim to adhere to international biosafety and biosecurity standards.
  - ➤ Authorities should ensure the integration of appropriate biosafety and biosecurity in laboratory development, especially to protect the countries where the reference labs are being established.
  - ➤ Challenges exist with biosafety and biosecurity during sample collection and transport in the ECOWAS region. This is of particular concern to the region with regards to international shipment of specimens. It is recommended to develop and adhere to best practices for sample collection and shipment.

- There is an identified need for sub-regional risk mapping of the priority zoonotic diseases in order to guide and focus surveillance attention on the appropriate hotspots. Focused attention on areas of increased risk will help to maximize limited resources.
- ECOWAS Member States should continue to discuss and make action plans around strengthening a One Health approach relating to laboratory and surveillance efforts.

Photo 11. Camels traveling through the desert in Mali.

RESPONSE AND PREPAREDNESS

- ECOWAS Member States recommend that response plans are developed for all priority zoonotic diseases using a One Health approach. If a plan for a priority zoonotic disease already exists, it should be reviewed to determine if it includes a One Health approach and updated if it does not. If a plan does not exist for a priority zoonotic disease, a plan should be developed using a One Health approach. Response plan development should include all One Health sectors, including the environment. Response plans for the priority zoonotic diseases are relevant to the national, sub-regional, and regional levels.
- In order to build on existing and historical linkages as a step towards the development of regional response plans, member states should meet with bordering countries to harmonize response plans and standard operating procedures and to draft agreements for cross-border assistance with outbreaks.
  - ➤ Lessons learned from individual countries in the region that have already been through the response planning process for priority zoonotic diseases should be shared. A regional meeting could be held to review and synergize response plans for priority zoonotic diseases for national, sub-regional, and regional levels.

- To ensure that response plans are effective, plans must be implemented and excercised to ensure coordination between One Health sectors and countries remains strong.
- Communication is a vital component of a One Health response. Sharing of weekly epidemiological reports by sector can help promote a One Health approach, ensuring that all sectors and countries have the information they need to respond effectively and collaboratively.
- Having a trained group of One Health professionals who can respond to outbreaks is vital. Rostering of One Health rapid response teams whose members have been trained on epidemiology and emergency management should be considered in order to ensure that responders are available quickly, should the need arise. Responders could be available to support national and/or regional needs.
- The information sharing and coordination structures created during the establishment of Emergency Operations Centers (EOCs) should be expanded to address One Health needs around health emergencies.
- ECOWAS Member States should reconvene on a regular basis to discuss response and preparedness needs for the priority zoonotic diseases and One Health coordination.

PREVENTION AND CONTROL

- Regarding prevention and control of the priority zoonotic diseases in the ECOWAS region, the availability of medical countermeasures and vaccination is an important need.
- Synergize rabies control programs and vaccine requisitions.
  - ➤ Consider using the Stepwise Approach for Rabies Elimination (SARE) in line with "The Zero by 30 Campaign" to eliminate dog-mediated human rabies deaths by 2030.
  - ➤ Map dog bite data to determine problem areas for control activities.
  - ➤ Access canine rabies vaccines through the OIE for rabies vaccination campaigns to ensure use of a safe and effective vaccine.
- A One Health prevention and control plan for anthrax in the ECOWAS region should be developed.
- Initiate technical networks to coordinate projects for priority zoonotic diseases at the country and/or sub-regional level; relevant technical networks for priority zoonotic diseases can be expanded to the regional level as appropriate.
- Harmonize and synergize surveillance systems to ensure data and information sharing across human, animal, and environmental health sectors.
- Harmonize sub-regional and regional legislative efforts for prevention and control activities involving human, animal, and environmental health sectors related to the control of the priority zoonotic diseases. This includes, but is not limited to, abattoirs, quarantine, border measures, sanitation, effective waste management from human, animal, or environmental sources or recycling and vector control.
- ECOWAS Member States should reconvene at least twice per year to have detailed discussions around prevention and control efforts for the priority zoonotic diseases.

Photo 12. Malachite kingfisher, Senegal.

WORKFORCE DEVELOPMENT

- Workforce capacity building was identified as an important need for the ECOWAS region. This included training in the veterinary health and environmental health sectors, as well as specifically focused laboratory training for enhanced diagnostics.
- Existing international training programs in the region include REDISSE trainings for participating countries, Field Epidemiology Training Program (FETP) and Field Epidemiology and Laboratory Training Program (FELTP), and In Service Applied Veterinary Epidemiology Training (ISAVET). In addition, individual countries have their own training programs that vary throughout the region.

Specific recommendations for workforce development were made in the following areas:

Initial workforce capacity building

- Human resources and training resource mapping (cartography) should be undertaken regarding current capacity, infrastructure and training opportunities, and institutions in the region.
  - ➤ Multiple workforce training needs were recognized, including addressing limited staffing capacity across sectors and impending retirement of staff.
  - ➤ Existing mapping exercises in the relevant sectors that have been conducted by partner organizations should be taken into account.
- Implement programs at the regional, sub-regional, or national level to build and expand the core workforce among the human health, animal health, and environmental health sectors (including laboratory professionals), based on needs and available resources.
  - ➤ Develop objectives and timeline of next steps to achieve workforce strengthening goals and monitor progress.


Photo 13.   African herdsman walking his cows.

Core workforce training programs

- Core workforce training programs should include the following:
  - ➤ Human health sector: physicians and medical officers, nursing staff, community health workers, surveillance officers, and others.
  - ➤ Animal health sector: veterinarians, veterinary surveillance officers, para-veterinarians, community animal health workers, and others.
- Training of laboratory staff should build and strengthen diagnostic capacity and link between sectors using a One Health approach. Competencies trained should include biosafety and biosecurity as well as quality assurance and quality management.
  - ➤ Establish a regional/national reference and training lab within the region to limit reliance on foreign research institutions and encourage recruitment of trained laboratory professionals.
- Risk communication training should be provided across sectors in the region and dedicated communications staff should be trained.

In service post-graduate training for workforce development

- Establish a trained group of One Health professionals to jointly respond to outbreaks.
- Develop a roster of trained epidemiology emergency management staff for One Health rapid response teams. Responders should be available to support national and/or regional needs.
  - ➤ Build on already existing ECOWAS Regional Rapid Response Teams (ERRRT) and other relevant teams using a One Health approach.
- Support the implementation of in-service training, providing sector-specific and One Health technical knowledge for staff responsible for disease surveillance and response at the regional, sub-regional, and national levels, with focus on the priority zoonotic diseases.
- Training, field experience, and exercises should be done using a One Health approach, bringing the human health, animal health, and environmental health sectors together.
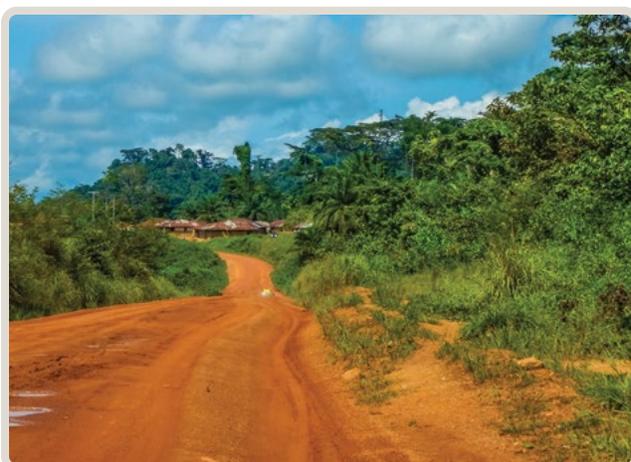
Photo 14.   A road through the jungle in Liberia.

Training programs can be harmonized and conducted together while still providing sector-specific competencies and training in order to maximize resources.

- Formal training specific to the environmental sector and wildlife management is needed and should be provided to meet the needs of Member States across the region.

- Integrate staff from sectors responsible for environment and wildlife management into existing One Health and in-service training programs so all sectors receive the same basic knowledge.

- In-service training programs should be sustainable, and implemented at the regional, sub-regional, and Member State levels as needed, and as resources can support (e.g., regional or sub-regional FETP and ISAVET training).

- Training should develop a workforce capable of supporting surveillance and response at the local, district, sub-national, and national levels (corresponding to FETP/FETPV Frontline, Intermediate, and Advanced levels).

- Member States should identify and allocate resources to ensure that sustainable in-service training is provided to establish and maintain a strong workforce able to address priority zoonotic diseases and other One Health Issues.

- Member States should identify and allocate resources to support staff doing in-service

training to conduct research and field studies related to the priority zoonotic diseases through programs such as FETP, FELTP, ISAVET, and others.

RESEARCH NEEDS

- Technical knowledge forms the basis of effective prevention, detection, and response to zoonotic diseases. Filling regional gaps in expertise and data should be a priority of ECOWAS Member States.

- A One Health discussion around research gaps is needed for the priority zoonotic diseases.

  ➤ Convene experts from One Health sectors across the ECOWAS region to identify specific research needs for the priority zoonotic diseases. These should include scientific and intervention research.

  ➤ Develop a regional network of multisectoral and multidisciplinary researchers whose work focuses on the priority zoonotic diseases with the purpose of sharing information and knowledge (for example, research methodologies and results); specific terms of reference should be developed for this network. The regional network of multidisciplinary and multisectoral researchers should be linked to other One Health networks, field epidemiologists and laboratorians, as well as the regional One Health coordination mechanism.

    › Researchers should be encouraged to apply for excellency grants targeting the research needs of the priority zoonotic diseases.

    › Researchers should identify university student theses (human, animal and environmental health focus) of greatest interest to the Member States on topics related to the priority zoonotic diseases.

    › Collaborate with partners to identify and allocate resources to support student research efforts.

    › Identify and allocate resources to support training of FETP/FELTP/FETPV/ISAVET participants in conducting research related to the priority zoonotic diseases.

Photo 15. Banana plantation, Cape Verde.

APPENDIX A: Overview of the One Health Zoonotic Disease Prioritization Process

U.S. Centers for Disease Control and Prevention: Overview of the One Health Zoonotic Disease Prioritization Workshop https://www.cdc.gov/onehealth/global-activities/prioritization.html
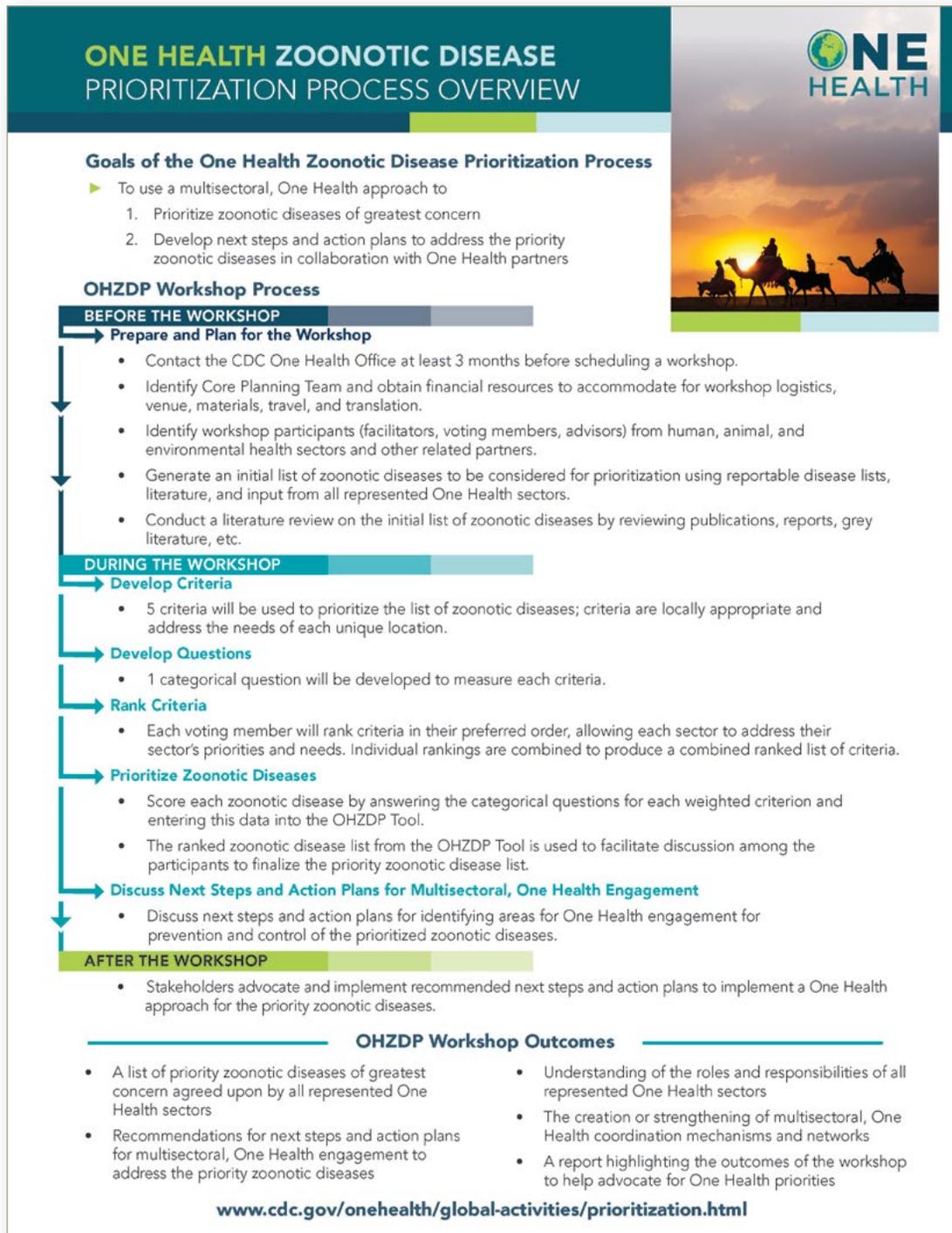
APPENDIX B: Participants from the One Health Zoonotic Disease Prioritization Workshop for ECOWAS

Member States

Country	Name	Organization	Title/Position
Benin	Bertin Dossa Bossou	Directorate General for the Environment and Climate	Head, Pollution and Nuisance Management Service, Focal Point of the Stockholm Convention on Persistent Organic Pollutants
Benin	François Kossouoh	National Directorate of Public Health/Ministry of Health	Head, Department of Decentralization and Public Private Partnership
Benin	Taeratou Aminou	National Center for Biological Products for Veterinary Use (CNPBV)/Directorate of Livestock	Head, National Center for Biological Products for Veterinary Use (R/CNPBV)
Burkina Faso	Joseph Savadogo	General Directorate of Veterinary Services	Director General of Veterinary Services
Burkina Faso	Joseph Youma	Ministry of the Environment, Green Economy, and Climate Change	Departmental Researcher/Secretariat of the Ministry (MEECC)
Cape Verde	Maria de Lourdes Spencer Lopes Dos Santos	National Institute of Public Health (INSP)	Medical Assistant
Côte d' Ivoire	Affou Séraphin Wognin	Ivory Coast Anti-Pollution Center (CIAPOL)/Ministry of the Environment and Sustainable Development (MINEDD)	Chief of Service, Laboratory of Microbiology, Ecotoxicology, and Radioecology
Côte d' Ivoire	Sopi Mathilde Tetchi	National Institute of Public Health (INHP)	Head, Reference Center for the Care and Epidemiological Surveillance of Human Rabies
Côte d' Ivoire	Vessaly Kallo	Sub-Directorate Division of Animal Heath (SDSA)/Directorate of Veterinary Services (DSV)	Deputy Director of Animal Health (MRAH)
Gambia	Binta Sambou	Ministry of Environment Climate Change and Natural Resources, Department of Parks and Wildlife Management	Wildlife Conservation Officer
Gambia	Ousman Ceesay	Ministry of Agriculture, Department of Livestock Services	Deputy Director General for Animal Health
Gambia	S. Jobarteh Bolong	Department of Public and Environmental Health	Director, Public and Environmental Health
Ghana	Ernest Akyereko	Ghana Health Service	Public Health Services Officer
Ghana	Kingsley Mickey Aryee	Ministry of Food and Agriculture, Veterinary Services Directorate	Chief Veterinary Officer
Ghana	Samsom Asare-Boadu	Ministry of Environment, Science Technology and Innovation, Environment Directorate	Wildlife Conservation Officer

Country	Name	Organization	Title/Position
Guinea	Facinet Sylla	Ministry of Livestock, Veterinary Public Health Division	Surveillance Epidemiologist
Guinea	Mamadou Bhoye Sow	Ministry of the Environment, Waters, and Forests, Guinean Office of Parks and Reserves	Deputy Director General, Guinean Office of Parks and Reserves and Vice-President of the One Health Platform in Guinea
Guinea Bissau	Bernardo Cassama	Ministry of Agriculture, Forestry, and Livestock, General Directorate of Livestock	Director
Guinea Bissau	Guilherme da Costa	Ministry of Natural Resources and Environment, General Inspectorate of the Environment	Director General of the Environment
Liberia	Joseph R. N. Anderson	Ministry of Agriculture, Animal Health Service	Director of Livestock/Veterinary Services/Chief Veterinary Officer
Liberia	Levi Z Piah	Environmental Protection Agency	Chief Technical Advisor
Mali	Boubacar Bass	Ministry of Livestock and Fisheries, National Directorate of Veterinary Services	Deputy National Director
Mali	Souhayata Yacouba Haidara eps Maiga	Ministry of the Environment, Sanitation, and Sustainable Development	Technical Advisor, One Health Focal Point
Mali	Soumaila Fofana M	National Health Directorate	Surveillance Epidemiologist
Niger	Abdoul Malick Haido	Ministry of Livestock	Director of Animal Health
Niger	Maina Bila	Ministry of Hydraulics and Sanitation, Directorate General of the Environment and Water and Forests	Deputy Director General of the Environment and Water and Forests
Niger	Zaneidou Maman	Ministry of Public Health, Division of Surveillance and Epidemiological Response	Data Manager
Nigeria	Chukwuma Anyaike	Federal Ministry of Health	Director/National Coordinator Neglected Tropical Diseases Elimination Programme
Nigeria	Muhammad Aligana	Federal Ministry of Agriculture and Rural Development, Veterinary Public Health Division	Deputy Director
Nigeria	Rita Azuka Okea	Federal Ministry of Environment	Head, Environmental Health and Sanitation
Senegal	Babacar Ngor Youm	Ministry of the Environment, National Parks Directorate	Inspector General of the Environment
Senegal	Jean Pierre Diallo	Ministry of Health and Social Action, Directorate General for Health Direction of Prevention	Directorate General for Health Direction of Prevention
Senegal	Mathioro Fall	Ministry of Livestock and Animal Production	Head of the Epidemiological Surveillance Bureau
Sierra Leone	Amadu Tejan Jalloh	Ministry of Agriculture, Forestry and Food Security	Deputy Director of Livestock and Veterinary Services

Country	Name	Organization	Title/Position
Sierra Leone	Florence Grace Max-Macarthy	Ministry of Health and Sanitation	Influenza Surveillance Officer
Sierra Leone	Lovetta Yatta Juanah	Environment Protection Agency	Senior Regional Environment Officer
Togo	Tanah Modjosso epse Djankla	Ministry of Agriculture, Livestock and Fisheries	Head, Hygiene and Food Control Division of Animal Origin
Togo	Tsidi Agbeko Tamekloe	National Institute for the Coordination of Surveillance and Disease Prevention	Coordinator
Togo	P'Malinam Essolakina Bafei	Ministry of the Environment and Forest Resources	Toxicologist, Pharmacologist

Observers

Country	Name	Organization	Title/Position
Gambia	Arss Seka	West Africa Livestock and Innovation Center	Officer-In-Charge
Ghana	Sheila Mensah	United States Agency for International Development	Senior Communications, Monitoring and Evaluation Advisor
Ghana	Seydou Samake	United States Agency for International Development	Regional Sanitary and Phytosanitary Advisor for West Africa
Mali	Arahmatoulaye Diallo	ECOWAS, Regional Animal Health Centre	Workshop Support Services
Mali	Konate Adama	ECOWAS, Regional Animal Health Centre	Workshop Support Services
Mali	Mamadou Traore	ECOWAS, Regional Animal Health Centre	Workshop Support Services
Mali	Vivian N. Iwar	ECOWAS, Regional Animal Health Centre	Ag. Executive Director
Nigeria	Oyeladun Funmi Okunromade	Nigeria Centre For Disease Control	Field Epidemiologist
Senegal	Anderson Latt	World Health Organization, Regional Office for Africa	Epidemiologist
Senegal	Rianatou Bada	Inter-State School for Sciences and Veterinary Medicine	Chief, Department of Microbiology, Immunology, and Infectious Pathology
Senegal	Philippe Rwatana Mutwa	United States Agency for International Development	Global Health Security Agenda Advisor
Senegal	Modou Moustapha Lo	National Laboratory for Veterinary Studies and Research, Senegalese Institute of Agricultural Research	Virologist/Pathologist
Senegal	Papa Serigne Seck	Cabinet of the Prime Minister	Technical Advisor for Livestock, Health, Animal Production and Fishing/One Health Focal Point
Switzerland	Stephane de La Rocque	World Health Organization	Technical Adviser
United States	Jarrad Marles	Defense Threat Reduction Agency	Regional Science Manager, Biological Threat Reduction Program

Country	Name	Organization	Title/Position
United States	Joel Montgomery	U.S. Centers for Disease Control and Prevention, National Center for Emerging and Zoonotic Infectious Diseases	Deputy Associate Director of Infectious Disease Preparedness
United States	Nicki Pesik	U.S. Centers for Disease Control and Prevention, National Center for Emerging and Zoonotic Infectious Diseases	Associate Director of Infectious Disease Preparedness

Workshop Facilitators

Country	Name	Organization	Title/Position
Mali	Lassina Ouattara	Food and Agriculture Organization, Mali	Country Team Leader, Emergency Center for Transboundary Animal Diseases (ECTAD), OHZDP Facilitator
Senegal	Youssouf Kabore	Food and Agriculture Organization, Senegal	Veterinarian, OHZDP Facilitator
Ghana	Ismaila Seck	Food and Agriculture Organization, Regional Office for Africa	Regional Epidemiologist, Emergency Center for Transboundary Animal Diseases (ECTAD), OHZDP Facilitator
United States	Casey Barton Behravesh	U.S. Centers for Disease Control and Prevention, One Health Office	One Health Office Director, OHZDP Facilitator
United States	Grace Goryoka	U.S. Centers for Disease Control and Prevention, One Health Office	Health Scientist, OHZDP Facilitator
United States	Nadia Oussayef	U.S. Centers for Disease Control and Prevention, One Health Office	Public Health Analyst, OHZDP Facilitator
United States	Julie Sinclair	U.S. Centers for Disease Control and Prevention, One Health Office	CDC One Health Liaison to the OIE, OHZDP Facilitator
United States	Nick Schaad	U.S. Centers for Disease Control and Prevention, Center for Global Health	Epidemiologist, OHZDP Facilitator
United States	Kate Varela	U.S. Centers for Disease Control and Prevention, One Health Office	Veterinary Medical Officer, OHZDP Facilitator
United States	Sean Shadomy	U.S. Centers for Disease Control and Prevention, One Health Office	CDC One Health Liaison to the FAO, OHZDP Facilitator

Core Planning Team Members

Name	Organization	Title/Position
Vivian Iwar	ECOWAS, Regional Animal Health Centre	Ag. Executive Director
Remi Dao Balabadi Bawoumondom	ECOWAS, Regional Animal Health Centre	One Health Coordinator/RAHC Liaison Officer to WAHO & RCDSC
Lassina Ouattara	Food and Agriculture Organization, Mali	Country Team Leader, Emergency Center for Transboundary Animal Diseases (ECTAD), OHZDP Facilitator
Youssouf Kabore	Food and Agriculture Organization, Senegal	Veterinarian, OHZDP Facilitator
Ismaila Seck	Food and Agriculture Organization, Regional Office for Africa	Regional Epidemiologist, Emergency Center for Transboundary Animal Diseases (ECTAD), OHZDP Facilitator

| Name	Organization	Title/Position
Papa Serigne Seck	Cabinet of the Prime Minister, Senegal	Technical Advisor for Livestock, Health, Animal Production and Fishing/One Health Focal Point
Casey Barton Behravesh	U.S. Centers for Disease Control and Prevention, One Health Office	One Health Office Director, OHZDP Facilitator
Grace Goryoka	U.S. Centers for Disease Control and Prevention, One Health Office	Health Scientist, OHZDP Facilitator
Nadia Oussayef	U.S. Centers for Disease Control and Prevention, One Health Office	Public Health Analyst, OHZDP Facilitator
Julie Sinclair	U.S. Centers for Disease Control and Prevention, One Health Office	CDC One Health Liaison to the OIE, OHZDP Facilitator
Nick Schaad	U.S. Centers for Disease Control and Prevention, Center for Global Health	Epidemiologist, OHZDP Facilitator
Kate Varela	U.S. Centers for Disease Control and Prevention, One Health Office	Veterinary Medical Officer, OHZDP Facilitator
Sean Shadomy	U.S. Centers for Disease Control and Prevention, One Health Office	CDC One Health Liaison to the FAO, OHZDP Facilitator
Zandra Andre	United States Agency for International Development	Global Health Security: Team Lead, Côte d'Ivoire and West Africa Technical Advisor
Sheila Mensah	United States Agency for International Development, West Africa	Senior Communications, Monitoring and Evaluation Advisor
Philippe Mutwa	United States Agency for International Development, Senegal	Global Health Security Agenda Advisor
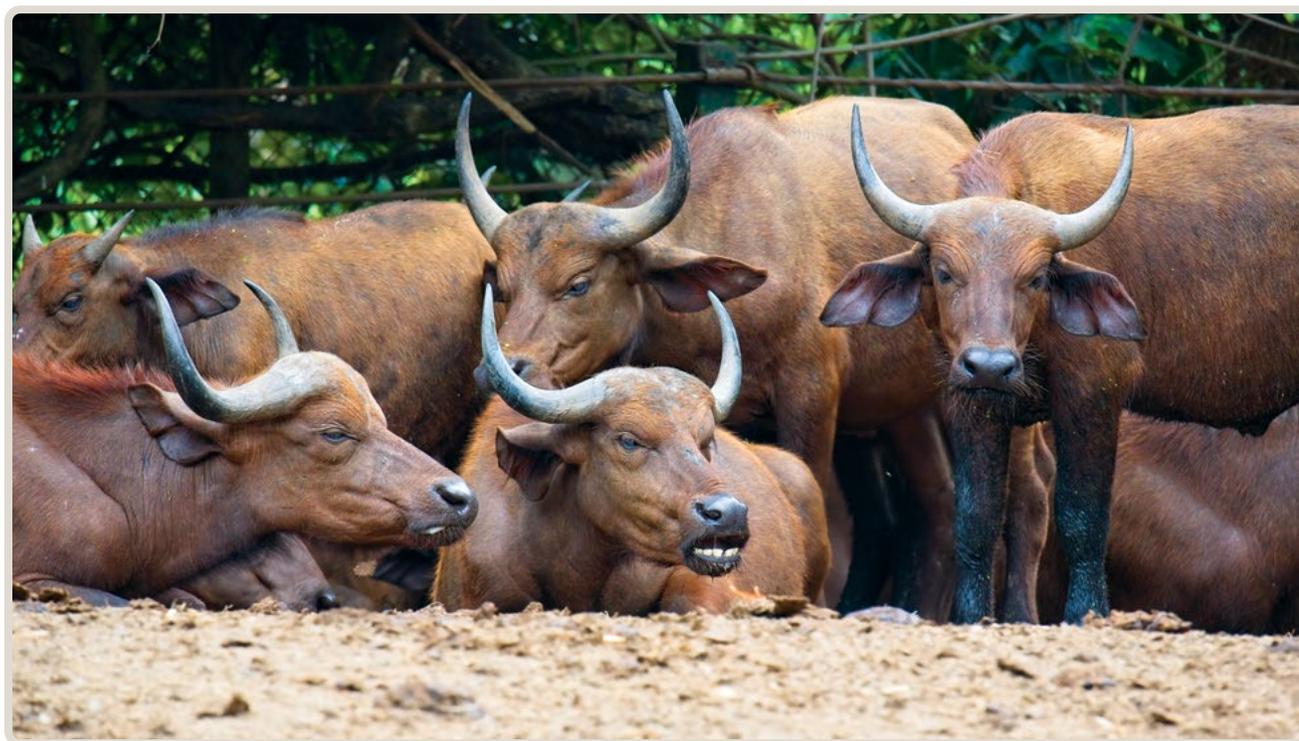
Photo 16. Herd of watusi, Mali.

APPENDIX C: Zoonotic Diseases Considered for Prioritization among ECOWAS

Final results of prioritization and normalized weights for 30 zoonotic diseases. The top priority zoonotic diseases selected by ECOWAS Member States representing all ministries active in zoonotic disease work are shown in **bold**.

Rank	Disease	Raw Score	Normalized Final Score
1	**Anthrax**	**1**	**1**
2	Leishmaniasis	0.920634909	0.920634909
3	Echinococcosis	0.841269818	0.841269818
4	**Rabies**	**0.832673256**	**0.832673256**
5	**Rift Valley fever**	**0.824734211**	**0.824734211**
6	**Zoonotic influenzas**	**0.824734211**	**0.824734211**
7	**Trypanosomiasis**	**0.824734211**	**0.824734211**
8	Leptospirosis	0.783398542	0.783398542
9	**Ebola**	**0.766862935**	**0.766862935**
10	Brucellosis	0.741733628	0.741733628
11	**Yellow fever**	**0.687497844**	**0.687497844**
12	Campylobacteriosis	0.662368537	0.662368537
13	**Crimean-Congo hemorrhagic fever**	**0.649468422**	**0.649468422**
14	West Nile Fever	0.649468422	0.649468422
15	**Zoonotic tuberculosis**	**0.64583293**	**0.64583293**
16	Listeriosis	0.607475235	0.607475235
17	Plague	0.607475235	0.607475235
18	Fascioliasis	0.607475235	0.607475235
19	Cysticercosis	0.566467839	0.566467839
20	Salmonellosis	0.562832346	0.562832346
21	*Escherichia coli*	0.416999417	0.416999417
22	**Marburg**	**0.415673839**	**0.415673839**
23	Middle East Respiratory Syndrome (MERS)	0.415673839	0.415673839
24	Monkeypox	0.412695864	0.412695864
25	Toxoplasmosis	0.409060372	0.409060372
26	Hepatitis E	0.329695281	0.329695281
27	**Lassa fever**	**0.313159674**	**0.313159674**
28	Q fever	0.307543948	0.307543948
29	Trichinellosis	0.291665859	0.291665859
30	Dracunculiasis	0.233794583	0.233794583

APPENDIX D: The Numerical Weight for Each Criteria and Associated Question Used for Ranking Zoonotic Diseases during the OHZDP ECOWAS Workshop

1. Severity of Disease (weight = 0.36)

Question: What is the case fatality rate for the disease in animals and human in the ECOWAS region?

Answer:

☐ Case fatality rate in one or both sectors ≥15%   2 points

☐ Case fatality rate in one or both sectors ≥5–<15%   1 point

☐ Case fatality rate in both sectors <5%   0 points

[if data from the ECOWAS region was not available, global data was used]

2. Prevention and Control Capacity (weight = 0.19)

Question: Is there any effective preventive or therapeutic measure (vaccine or antimicrobial) for humans and/or animals?

Answer:

☐ Animals AND Humans   2 points

☐ Animals OR Humans   1 point

☐ Neither   0 points

3. Epidemic or Pandemic Potential (weight = 0.18)

Question: Has the pathogen caused an epidemic (human or animal) in the ECOWAS region?

Answer:

☐ Within the past 5 years   2 points

☐ Within the past ≥5 and <10 years   1 point

☐ Never or more than 10 years ago   0 points

4. Ability to Detect (weight = 0.16)

Question: Is there a One Health surveillance system for this disease (investigation, laboratory, or data sharing) in the ECOWAS region?

Answer:

☐ For all three sectors   2 points

☐ For two (2) sectors   1 point

☐ For one (1) sector or none of the sectors   0 points

[if five or more ECOWAS countries had a surveillance system for a disease in a particular sector, the sector was considered to have a surveillance system for that disease]

5. Socio-Economic and Environmental Impact (weight = 0.12)

Question: Is the disease on the OIE list of notifiable diseases AND is the disease potentially affected by climate change (host range, vector or reservoir)?

Answer:

☐ Yes to both   2 points

☐ Yes to one   1 point

☐ No   0 points

[the OIE list was agreed upon by the Member States as a proxy to measure socio-economic impact]
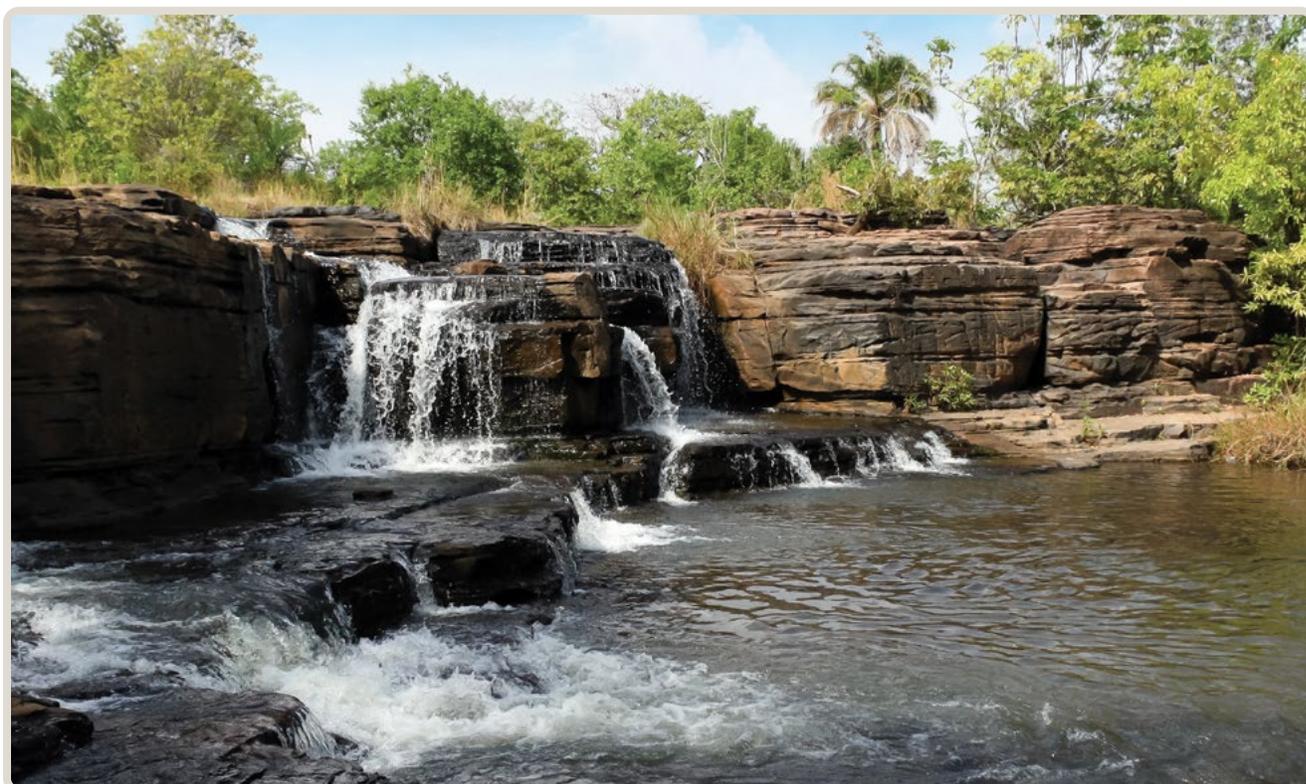

Photo 17. Banfora cascades in Burkina Faso.

REFERENCES

1. U.S. Centers for Disease Control and Prevention. *Overview of the One Health Zoonotic Disease Prioritization*. 2017 [cited 2017 April 12]; Available from: https://www.cdc.gov/onehealth/pdfs/zoonotic-disease-prioritization-workshop.pdf.

2. Rist CL, A.C., Rubin C., *Prioritizing Zoonoses: A Proposed One Health Tool for Collaborative Decision-Making*. PLoS ONE, 2014. 9(10).

3. U.S. Centers for Disease Control and Prevention. *Overview of the One Health Zoonotic Disease Prioritization*. 2017; Available from: https://www.cdc.gov/onehealth/pdfs/zoonotic-disease-prioritization-workshop.pdf.

4. Food and Agriculture Organization of the United States, *Anthrax outbreaks: a warning for improved prevention, control and heightened awareness*. Empres Watch, 2016. 37.

5. Kracalik, I.T., et al., *Modeling the environmental suitability of anthrax in Ghana and estimating populations at risk: Implications for vaccination and control*. PLoS Neglected Tropical Diseases, 2017.

6. U.S. Centers for Disease Control and Prevention. *Rabies*. 2018; Available from: https://www.cdc.gov/rabies/index.html.

7. World Health Organization. *Rabies*. 2019; Available from: https://www.who.int/news-room/fact-sheets/detail/rabies.

8. Dao, B.K., H., *One Health-Based Zoonosis Situation Review in Economic Community of West African States (ECOWAS)*. 2017, Regional Animal Health Centre: Bamako, Mali.

9. Dodet, B., *The fight against rabies in Africa: From recognition to action*. Vaccine, 2009. 27(37): p. 5027–32.

10. U.S. Centers for Disease Control and Prevention. *2014–2016 Ebola Outbreak in West Africa*. 2019; Available from: https://www.cdc.gov/vhf/ebola/history/2014-2016-outbreak/index.html.

11. World Health Organization. *Ebola Virus Disease*. 2019.

12. Hambese, H., et al., *Ebola Virus Disease in Domestic and Wild Animals: A Review. Journal of Pharmacy and Alternative Medicine*, 2016.

13. Krueger, W.S. and G.C. Gray, *Swine influenza virus infections in man*. Curr Top Microbiol Immunol, 2013. 370: p. 201–25.

14. Dawood, F.S., et al., *Estimated global mortality associated with the first 12 months of 2009 pandemic influenza A H1N1 virus circulation: a modelling study*. Lancet Infect Dis, 2012. 12(9): p. 687–95.

15. European Food Safety Authority, et al., *Scientific report on the avian influenza overview October 2016–August 2017*. EFSA Journal, 2017.

16. U.S. Centers for Disease Control and Prevention. *Influenza (Flu)*. 2019; Available from: https://www.cdc.gov/flu/index.htm.

17. Müller, B., et al., *Zoonotic Mycobacterium bovis-induced tuberculosis in humans*. Emerg Infect Dis, 2013. 19(6): p. 899–908.

18. World Organisation for Animal Health. *Bovine Tuberculosis*. 2017 [cited 2017 November 12]; Available from: www.oie.int/fileadmin/Home/eng/Media_Center/docs/pdf/Disease_cards/ BOVINE-TB-EN.pdf.

19. World Health Organization. *Trypanosomiasis, human African (sleeping sickness)*. 2019; Available from: https://www.who.int/news-room/fact-sheets/detail/trypanosomiasis-human-african-(sleeping-sickness).

20. U.S. Centers for Disease Control and Prevention. *Sleeping Sickness*. 2019; Available from: https://www.cdc.gov/parasites/sleepingsickness/index.html.

21. World Health Organization. *Human African trypanosomiasis The current situation*. 2019; Available from: https://www.who.int/trypanosomiasis_african/country/country_situation/en/.

22. World Health Organization. *Human African trypanosomiasis, Epidemiological Situation*. 2019; Available from: https://www.who.int/trypanosomiasis_african/country/en/.

23. Vanhecke, C., et al., *[Human African trypanosomiasis in mangrove epidemiologic area. Presentation, diagnosis and treatment in Guinea, 2005–2007]*. Pathol Biol (Paris), 2010. 58(1): p. 110–6.

24. Kagbadouno, M.S., et al., *Epidemiology of sleeping sickness in Boffa (Guinea): where are the trypanosomes?* PLoS neglected tropical diseases, 2012. 6(12): p. e1949-e1949.

25. Food and Agriculture Organization, *Fighting tsetse—a scourge to African farmers, in FAONewsroom*. 2002, Food and Agriculture Organization of the United Nations: Rome, Italy.

26. U.S. Centers for Disease Control and Prevention. *Sleeping Sickness, Treatment*. 2019; Available from: https://www.cdc.gov/parasites/sleepingsickness/treatment.html.

27. World Health Organization, R.O.f.A. *Yellow Fever*. 2017; Available from: https://www.afro.who.int/health-topics/yellow-fever.

28. World Health Organization. *Increased risk of urban yellow fever outbreaks in Africa*. 2019; Available from: https://www.who.int/csr/disease/yellowfev/urbanoutbreaks/en/.

29. World Health Organization. *Yellow Fever*. 2019; Available from: https://www.who.int/news-room/fact-sheets/detail/yellow-fever.

30. Chippaux, J.-P., A.J.J.o.V.A. Chippaux, and T.i.T. *Diseases, Yellow fever in Africa and the Americas: a historical and epidemiological perspective*. 2018. 24(1): p. 20.

31. UNICEF, *Nearly one billion people in Africa to be protected against yellow fever by 2026*. 2018.

32. U.S. Centers for Disease Control and Prevention. *Yellow Fever*. 2019; Available from: https://www.cdc.gov/yellowfever/index.html.

33. Taylor, L.H., S.M. Latham, and M.E. Woolhouse, *Risk factors for human disease emergence*. Philosophical transactions of the Royal Society of London. Series B, Biological sciences, 2001.356(1411):p.983–989.

34. U.S. Centers for Disease Control and Prevention. *One Health Basics*. 2017 [cited 2017 Jul 14]; Available from: https://www.cdc.gov/onehealth/basics/index.html.

35. Food and Agriculture Organization, *ECOWAS and FAO discuss Animal Health and Production Networks*. 2016: FAO Regional Office for Africa.

36. World Health Organization. *Lassa Fever – Nigeria*. 2019; Available from: https://www.who.int/csr/don/14-february-2019-lassa-fever-nigeria/en/.

37. CIRAD, *Emerging diseases | is MERS-CoV a threat for Africa?* 2018.

38. World Organisation for Animal Health., *Cross Border Movements of Animals and Animal Products and Their Relevance to the Epidemiology of Animal Diseases in Africa*, O.R.C.f. Africa, Editor. 2015.

39. Ronen, D., S.S. Adotevi, and R. Law, *Benin, in Encyclopedia Britannica*. 2019.

40. Echenberg, M., et al., *Burkina Faso, in Encyclopedia Britannica*. 2019.

41. United States Agency for International Development. *Burkina Faso: Agriculture and Food Security*. 9 August 2017]; Available from: https://www.usaid.gov/burkina-faso/agriculture-and-food-security.

42. Food and Agriculture Organization of the United Nations. *Country profile: Burkina Faso*. 9 August 2017]; Available from: http://www.fao.org/ag/AGP/AGPC/doc/Counprof/BurkinaFaso/BurkinaFeng.htm.

43. Ministere des Ressources Animals, *Annuaires des statistiques de l'elevage*, 2014. 2014.

44. Burkina Faso, *Programme National du Secteur Rural (PNSR) 2011–2015*. 2012.

45. MRA/PNUD, *Contribution de l'élevage à l'économie et à la lutte contre la pauvreté, les déterminants de son développement*. 2011.

46. MRAH, *Plan d'actions et programme d'investissements du sous-secteur de l'élevage (PAPISE 2016–2020), Rapport provisoire*. 2017.

47. Shaw, C.S., R.A. Lobban, and W.M. Bannerman, *Cabo Verde, in Encyclopedia Britannica*. 1999.

48. Comhaire, J.L., R.J. Mundt, and N.E. Lawler, *Côte d'Ivoire, in Encyclopedia Britannica*. 1999.

49. Gailey, H.A., E.R.A. Forde, and A. Clark, *The Gambia, in Encyclopedia Britannica*. 1999.

50. Boateng, E.A., et al., *Ghana, in Encyclopedia Britannica*. 1999.

51. Ministry of Food and Agriculture. *Agriculture in Ghana: Facts and Figures*. 2015; Available from: http://www.agrofood-westafrica.com/fileadmin/user_upload/messen/agrofood-Westafrica/Brochure/AGRICULTURE-IN-GHANA-Facts-and-Figures-2015.pdf.

52. Ministry of Food and Agriculture. *Ghana Livestock Development Policy and Strategy*. 2016; Available from: http://mofa.gov.gh/site/wp-content/uploads/2016/11/GHANA-LIVESTOCK-DEVELOPMENT-POLICY-AND-STRATEGY-final.pdf.

53. Veterinary Service Directorate, *VSD Annual Report*. 2017.

54. Ministry of Lands and Natural Resources, F.C., Wildlife Division. 2018.

55. O'Toole, T.E., *Guinea, in Encyclopedia Britannica*. 1998.

56. Galli, R.E., et al., *Guinea-Bissau, in Encyclopedia Britannica*. 1999.

57. Jones, A.B., D.R. Petterson, and S.E. Holsoe, *Liberia, in Encyclopedia Britannica*. 1999.

58. Imperato, P.J., A. Clark, and K.M. Baker, *Mali, in Encyclopedia Britannica*. 1999.

59. United States Geological Survey, E.R.O.a.S. *West Africa: Land Use and Land Cover Dynamics*. 2018; Available from: https://eros.usgs.gov/westafrica/node/147.

60. Mali Minister of Livestock. 2018, Ministry of Livestock.

61. Fuglestad, F. and D. Laya, *Niger, in Encyclopedia Britannica*. 1999.

62. Ajayi, J.F.A., et al., *Nigeria, in Encyclopedia Britannica*. 1999.

63. Times, P., *Nigeria releases census of goats, sheep, pigs, other livestocks in country, in Premium Times Nigeria*. 2016.

64. Camara, C., A. Clark, and J.D. Hargreaves, *Senegal, in Encyclopedia Britannica*. 1999.

65. Seck, M., K. Marshall, and M.L. Fadiga, *Policy framework for dairy development in Senegal*. 2016, ILRI: Nairobi, Kenya.

66. Food and Agriculture Organization. *FAOSTAT*. 2013; Available from: www.fao.org.

67. Sow, A., et al., *Widespread Rift Valley Fever Emergence in Senegal in 2013–2014*. Open Forum Infectious Diseases, 2016. 3(3): p. ofw149.

68. World Organisation for Animal Health, *Zoonotic diseases in humans*. 2015

69. CIA World Factbook. *Sierra Leone*. Available from: https://www.cia.gov/library/publications/the-world-factbook/geos/sl.html.

70. Sesay, S.M., D.S.H.W. Nicol, and C. Fyfe, *Sierra Leone, in Encyclopedia Britannica*. 1999.

71. Sannoh IJ on behalf of the Food and Agriculture Organization, *Agricultural and Rural Development Statistics in Sierra Leone—Key Aspects of Institutional Arrangements & Performance*. 2012, Food and Agriculture Organization,.

72. Food and Agriculture Organization. *Sierra Leone country profile*. Available from: http://www.fao.org/ag/AGP/AGPC/doc/Counprof/SierraLeone/SierraLeone.htm.

73. Decalo, S., et al., *Togo, in Encyclopedia Britannica*. 1999.

74. Rist, C.L., C.S. Arriola, and C. Rubin, *Prioritizing zoonoses: a proposed one health tool for collaborative decision-making*. PLoS One, 2014. 9(10): p. e109986.

Photo 18. Fishing vessels moored at Kent Beach along the Freetown Peninsula, Sierra Leone.
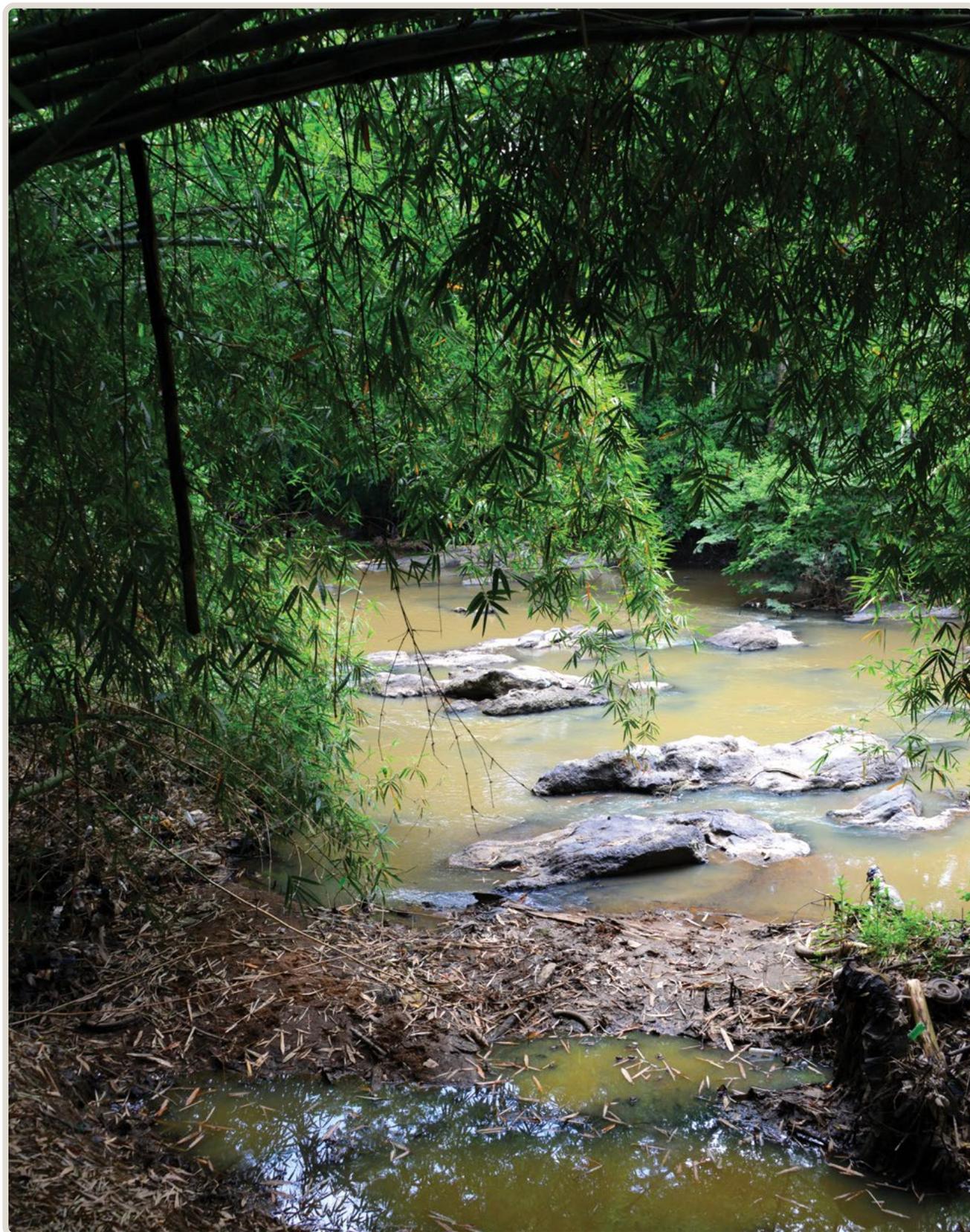
Photo 19.   Osun-Osogbo Sacred Grove, one of the last remnants of primary high forest in southern Nigeria.