

## Wildlife-Live Stock Interaction and Related Major Zoonotic Diseases: A Review

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**Abstract:** The main thrust of this review is to overview the relationship of conservation and control of animal diseases and socio-economic impacts on interface livestock keeping communities and zoonotic diseases occurring at the wildlife-livestock-human interface areas. A zoonosis is a disease or infection that is naturally transmitted between vertebrate animals and humans. Environments where wild animals, domestic animals and humans live in close proximity within the ecological system favor the transmission of diseases between animals and humans. The most important factor that aggravates zoonoses transmission and extension of the livestock-wildlife interface are rapidly increasing livestock trade, agricultural expansion and cultural consumption practices. Coronaviruses, lent viruses, flaviviruses, paramyxoviruses and avian influenza viruses are major pathogens that are capable of transmitting from wildlife to domestic livestock as well as human. Generally management of zoonoses at the livestock-wildlife interface prior to deciding control option, factors like spatial distribution of diseases, major maintenance of hosts, transmission mode and source of infection.

**Key words:** Management • Wildlife-live stock interaction • Wildlife-pathogens • Zoonosis

### INTRODUCTION

Livestock-wildlife interface is an area where livestock producing communities have a constant and direct or indirect interaction with wild animals. Wildlife diseases become very crucial when they appear to affect wild animals, domesticated animals and humans. There is also a rising concern about emerging and re-emerging diseases in recent years, most of which appear to occur at the fertile livestock-wildlife interface [1]. Zoonoses are infections acquired from animal and pose risk to public health.

Particularly zoonosis from wildlife represents the most significance threat to global health of all emerging infectious diseases [2]. There are over 200 zoonotic pathogens [3]. According to EFSA (European food safety authority) these pathogens can be divided into two groups, food borne and non-food borne zoonotic diseases. The difficulty of attribution makes it difficult to unambiguously describe diseases as zoonoses at the livestock-wildlife interface are many diseases have multiple causes, many pathogens have multiple transmission pathways and in most cases the relative importance of zoonotic pathways is not known [4].

A large number of infectious pathogens are known to be harbored by wild animals and many have the ability to jump from wildlife to humans and livestock. Many different transmission routes exist for infectious diseases in general including direct transmission, airborne, vector-borne and indirect transmission via fomites including food [5]. The rate of zoonotic transmission are affected by intensity of infection in the wildlife reservoir, the size and/or density of the wildlife population, the nature of the contact between wildlife and humans and susceptibility of humans to infection [6].

Historically there have been huge changes in the burden of human infectious disease, the types of pathogen involved and the geographic distribution of disease, mainly related to human activities. Changes are continuing to occur and a range of factors have been associated with changes in rates of transmission, spatial distribution, routes of transmission and sources of pathogens. 73% of emerging human diseases are zoonotic and many recently emerging zoonotic diseases have originated in wildlife in developing countries [7]. More emphasis should be given on the use of bush meat in the exposure of pathogens. Where wildlife and animals have an important role in disease maintenance then control usually requires or benefits from interventions directed at

the animal host. As a consequence, control often fails because of lack of understanding of the importance of both livestock and wildlife in maintenance of disease [8].

In developing country like Ethiopia, there are limited original published researches and seminars looking at the transmission mechanism of zoonosis from wildlife. There are even less published information's regarding the relative importance of the wild life –livestock interface in the amplification of zoonotic transmission. So, creating awareness regarding the transmission mechanism, source of infection and risk factors for zoonotic diseases transmitted from wild animal-livestock to human play a pivotal role in minimizing the risk of acquiring zoonotic diseases [2]. The objective of this seminar papers are to review the best available scientific knowledge about zoonotic disease transmission through livestock and wildlife interaction and to describe interventions for controlling important zoonoses based on managing the interaction between domestic animal and wildlife.

**Wildlife:** Wildlife is normally defined as free-roaming animals (mammals, birds, fish, reptiles and amphibians). Wild animals seem to be involved in the epidemiology of most zoonoses and serve as major reservoirs for transmission of zoonotic agents to domestic animals and humans [4].

**Zoonoses:** are usually defined as diseases and infections that are naturally transmitted between animals and people [4]. The total number of zoonoses are unknown, but according to world health organization there are over 200 zoonotic pathogens [3].

According to EFSA (European food safety authority) these pathogens can be divided into two groups, food borne and non-food borne zoonotic diseases. Food borne zoonotic pathogens are causing zoonotic diseases when they contaminate food or drinking water for humans. Common bacteria and viruses causing food borne zoonotic diseases are *Campylobacter*, *Salmonella*, pathogenic *Escherichia coli*, *Yersinia*, *Calicivirus* and *Rotavirus*. Common parasitic pathogens causing food borne zoonotic diseases are *Trichinella*, *Toxoplasma*, *Giardi* and *Cryptosporidium* [9]. Non-food borne zoonotic diseases are mainly transmitted to humans through vectors (mosquitoes, ticks, flies, fleas and lice) and direct contact or close proximity with infected animal [3].

The majority of infectious diseases that affect humans are zoonoses and they constitute as much as 70 % of the emerging diseases [2]. The zoonotic diseases

also constitute a possible global health problem due to their pandemic potential to spread over the world. Regarding pandemic and emerging zoonotic diseases, there is a strong consensus that these are most efficiently fought at the origin of the epidemic, i.e. mostly in low income countries [2].

**Livestock-Wildlife Interface:** This is an area where livestock producing communities have a constant and direct or indirect interaction with wild animals. Defining the physical interface is critical to understanding disease transmission dynamics among wildlife, livestock and human populations. Wildlife usually avoids livestock and human contact unless habituated [1].

Disease interface between wildlife and livestock is not always by direct (physical contact) but also indirect, (through soils, forage, water sources, insect vectors and intermediate hosts). In recent years however, the management of livestock, wildlife and environment at the interface has presented a challenging scenario in the integration of development and environmental conservation in Sub-Saharan Africa [10].

**Effect of Wild Life on Domestic Animal and Human:** Wildlife plays a major role in disease transmission and so is important when addressing certain diseases in domestic animals or humans. Wildlife diseases are also important in their own right, with impacts on biodiversity and animal welfare [11]. The values wild life for human classified in to two ways. Direct values (consumptive use value (non-market value, game, etc.), productive use value (commercial value, fish )) [12]. And indirect (non-consumptive use value (scientific research, bird watching and option value), value of maintaining options available for the future existence value: value of ethical feelings of existence of wildlife)). These values carry different weights, which vary according to the respective interests of the stakeholders involved [13].

For this reason, the classification adopted here rather relies on a pragmatic approach differentiating between the following: the economic importance of wildlife, the nutritional value of wildlife, the ecological role of wildlife and the socio-cultural significance of wildlife [14].

**Disease Transmission Routes from Wildlife to People:** The transmission routes from wildlife to humans have three main categories: human encroachment in wildlife habitat (Human habitat expansion, deforestation and agriculture), direct contact and indirect contact with wildlife [15].

**Human Encroachment in Wildlife Habitat:** Colonization of new areas for human habitation is one of the most prominent examples of humans' incursion into natural foci of certain pathogens. The expansion of the human habitat into forest areas will, with no doubt, lead to greater proximity to wildlife species. This will be translated into a greater potential for zoonotic spillover from wildlife to humans. Therefore, infected humans will then carry the pathogens back to their habitation and be responsible for transmission of the infection [16].

Deforestation of forest areas for habitation or agriculture purposes also poses an increased risk of zoonotic infection initially for forest workers, because they acquired infection from wildlife reservoirs or vectors of zoonoses, but subsequently for humans inhabiting or making use of deforested areas [15].

Agricultural activities that result in multi-species land use, or "buffer-zones", where livestock and wildlife make use of the same space will increase contact between these animals and increase transmission. Another consequence of agricultural expansion is the development of areas that support the presence and expansion of pathogen reservoirs [17].

**Direct Contact:** Many human activities have resulted in increased contact between wildlife and humans and an associated increased in the risk of disease transmission. The following is a list of factors that have been found to have increased human contact with wildlife and increased transmission of specific zoonotic diseases. Illegal trade of wildlife: may result in the spread of exotic pathogens to new areas via infected wildlife. This poses an immediate risk of disease expansion and it is the underlying basis of some of the most well known transboundary diseases [15]. Keeping exotic animals as pets: increases the likelihood of humans being exposed to exotic pathogens. Prairie dogs housed in contact with the imported reservoir were infected and subsequent contact with these prairie dogs seemed to be the initial source of infection for affected humans [8].

**Indirect Transmission:** The two major mechanisms of indirect transmission of zoonosis from wildlife to humans are represented by water and food [17]. Through water: it is well known that using water from the same source as domestic and wild animals results in a greater effective contact among animals/humans and ultimately facilitates disease transmission [18]. Food-born (consumption of bush meat): food is an important vehicle for many zoonotic pathogens. Consumption of bush meat

represents an ideal mechanism of transmission of zoonotic pathogens. Examples include the simian foamy virus that has been found infecting people who had direct contact with fresh non-human primate meat [19]. Consumption of meat from chimpanzees found dead has been associated with Ebola outbreaks in humans; nevertheless, other investigations indicate that transmission of Ebola may be more likely to be due to handling of dead bodies of infected chimpanzees rather than via ingestion of contaminated meat [20].

**The Relative Importance of the Wildlife-Livestock Route:** The three main mechanisms for amplification of transmission between wildlife and livestock are: close contact with livestock, livestock movements and livestock markets.

**Close Contact with Livestock:** The pastoralists residing in close proximity to cattle or pig enclosures were at higher risk of acquiring mycobacterial infection, which is compatible with the aerosol transmission of *Mycobacteria* species [17]. Handling of livestock has also been proven to increase transmission of pathogens. This can be another mechanism of wildlife zoonoses amplification. Pig handlers, including farmers and veterinarians, have been shown to be at increased risk of acquiring infection with hepatitis E virus, probably from wild boars and possibly amplified through pig farms [20]. Moreover, stress to wildlife resulting from loss of habitat, higher densities and increased predation leads to changes in behavior and condition, making them manifest or amplify an otherwise unrecognized infection and perhaps causing spill-back to livestock [21].

**Contact Networks/Animal Movements:** Animal movements bring animals from different farms and areas in contact with each other. In Africa, where livestock is one of the few tradable commodities, animal movements are of special relevance in terms of disease transmission, for both animal diseases and zoonoses [17]. This is most relevant in the case of nomadic and semi-nomadic pastoralists. A clear example of the impact of animal movements on disease spread is represented by bovine tuberculosis (*Mycobacterium bovis*) and cattle in the UK. *E. multilocularis* was introduced to Northern Japan via movement of infected foxes, with domestic dogs believed to have acted as amplifiers [18]. Also *Trypanosomes brucei-rhodesiense* and cattle movements led to a human outbreak of these zoonoses in a new area in Uganda [22].

**Wet Markets:** Live animal markets are a well-known source of outbreaks. They put different hosts (infected and susceptible amplifying hosts) in contact, facilitating cross-species transmission. This is even further amplified when trade of wildlife occurs in those markets. In China, trade with infected bats and their contact with susceptible amplifying hosts in wet markets may have resulted in the establishment of a market cycle of SARS, which served as the source of infection of people and domestic animals [22]. As with livestock movements, wet markets, where many animals congregate and disperse throughout a region, have a critical role in the dissemination of infectious organisms [22].

#### **Pathogens of Wildlife Capable of Transmitting to Domestic Livestock**

**Avian Influenza Viruses:** There is considerable evidence for recombination and re-assortment in AIV and the associated mechanisms are reasonably well understood [23]. Although numerous strains of low pathogenicity circulate in the natural reservoir, wild birds, the key evolutionary step towards virulence was adaptation to domestic ducks, which then through close contact transmit the infection to chickens. Transmission and adaptation to poultry results in emergence of discrete strains, most of which fail to transmit back to wild birds, with H5N1 a notable exception [23]. H5N1 diverges from other AIV strains, especially in pathogenesis and its ability to cause disease in a wide host range including epizootic infections in wild birds [24]. Chickens are notably susceptible to H5N1 and highly pathogenic strains can devastate poultry flocks. On the other hand, domestic ducks show considerable tolerance and therefore, constitute the main reservoir host [25]. Other spill-over and dead-end hosts exist for AIV and H5N1 including humans, domestic and wild animals [26]. Pigs can act as an intermediate or reservoir host of H5N1 and other AIVs and when infected simultaneously with human or swine flu strains can evolve new viruses [27].

**Influenza A Viruses:** Aquatic birds are considered to be the main reservoir hosts of Influenza A viruses [28]. They are segmented RNA viruses that are constantly evolving by re-assortment (antigenic shift) or mutation (antigenic drift) to create new strains of different pathogenicity and host range that may spill over into new host species that have no immunity to the new strain [29].

Influenza A viruses have been found in birds, humans, pigs, horses, cats, dogs, seals, whales and other animals [28]. Swine influenza caused by several sub-types

occurs in pig populations worldwide and infection may be transmitted between pigs, between pigs and birds and between pigs and humans [28]. The H1N1 human pandemic was caused by a re-assortment of human, avian and swine viruses [30].

**Filoviruses (Ebola Virus):** infection of humans and wildlife in Central Africa represents another emerging concern with a bat association, as is the presence of Ebola viruses in other regions of the world. Available evidence is consistent with spill-over of virus from a reservoir forest host into a variety of species including great apes and humans [26]. Consumption of bush meat is considered the most plausible route for transmission of these viruses to human communities. More virus lineages are being detected as more samples are examined [19]. Evidence that the highly pathogenic Zaire strain of Ebola virus (ZEBOV) can infect pigs has raised concerns that this species has the potential to amplify these viruses, as observed with henipaviruses [19].

**Retroviruses (Lentiviruses (HIV, SIV and SFV & FIV) and Deltaretrovirus (STLV):** The adaptation of non-human primate lentiviruses to humans was probably the most significant pathogen species jump in human history. The phylogeny of current circulating Human Immunodeficiency Virus (HIV) strains is consistent with at least two such events (HIV 1 and HIV 2) over the past century that originated from chimpanzee and sooty mangabey respectively [31]. This is believed to have occurred through regular infection of humans with Simian Immunodeficiency Virus (SIV) through consumption of bush meat and subsequent viral adaptation through mutation or reassortment. Simian Immunodeficiency Virus (SIV) transmission between non-human primates (NHP) is also contributing to the evolution of primate lentiviruses. However, recent work amongst Gombe chimpanzee in Tanzania, suggests that SIV may play a more significant role in population health [32].

#### **Corona Viruses**

**Severe Acute Respiratory Syndrome (SARS-CoV):** There is good evidence that interspecies transfer of coronaviruses (CoVs) is facilitated by recombination events. A number of CoVs have been identified in wild birds and bats. Using genomics and phylogenetic analysis of known strains, virus transmission and adaptation have been demonstrated between bat species and other mammals e.g. palm civet, domestic animals and humans [33].

Although horseshoe bats (*Rhinolophus* spp.) have been shown to harbour SARS-like (SL) CoV, available evidence suggests that they are not the source of the SARS virus. A perhaps surprising implication of the genomic analysis of SARS CoV strains is the apparent rapidity with which these viruses adapted through other species into humans. Like the SIV/HIV jump from chimpanzees to humans, it is likely that human's acquired the virus through consumption of wild species [33].

**Middle East Respiratory Syndrome (MERS):** is a viral respiratory illness caused by a corona virus called Middle East Respiratory Syndrome Corona virus (MERS-CoV). MERS-CoV is a beta corona virus. It was first reported in September 2012 in Saudi Arabia. MERS-CoV used to be called-novel corona virus. Corona viruses are a large family of viruses that cause illness in humans and animals the novel corona virus, first detected in September 2012 [3].

Several victims have been known to have had contact with camels, including visibly ill camels. However, on August, 2013 a report in the Lancet showed that 50 of 50 (100%) blood serum from Omani camels and 11 of 105 (14%) from Spanish camels had protein-specific antibodies against MERS-CoV spike [34]. Countries like Saudi Arabia and the United Arab Emirates produce and consume large amounts of camel meat and there's a possibility that African or Australian bats harbor the virus which then camels carried to the MERS-CoV[35].

**Zikavirus:** A flavivirus transmitted mainly by mosquitoes in the genus *Aedes*, was discovered in 1947 in Uganda. From the 1960s to 1980s, human infections were found across Africa and Asia, typically accompanied by mild illness. The first large outbreak of disease caused by Zika infection was reported from the Island of Yap (Federated States of Micronesia) in 2007, as the virus moved from south-east Asia across the Pacific [34].

In South America, the first reports of locally transmitted infection came from Brazil in May 2015. In October 2015 Brazil reported an association between Zika virus infection and microcephaly [36].

World health organization (WHO) declared that Zika infection associated with microcephaly and other neurological disorders constitutes a Public Health Emergency of International Concern (PHEIC). By the start of February 2016, local transmission of Zika infection had been reported from more than 20 countries and territories in the Americas and an outbreak numbering thousands of cases was under way in Cabo Verde, western Africa.

Beyond the range of mosquito vectors, Zika virus infections are expected to be carried worldwide by international travel [37].

**Key Factors Influencing the Risk of the Transfer of Infections between Livestock and Wildlife in Developing Countries**

**Increases in Human Population:** The increases in human population have led to higher levels of urbanization, greater concentrations of humans and people more frequently travel and interactions over long distances; these causes rapid distribution of diseases among people and animal [38].

**Intensification of Production:** There are implications to these changes stimulated by the socio-economics of the societies we live in. For example, researchers have shown that there are risks with production units due to the constant movement on and off farms to deliver feed or to remove products for sale and that these are issues that need to be including in models and disease control programme [39].

In intensified systems, anti-microbials are used in large amounts for growth promotion or to control the diseases associated with high population densities. Many researchers raise concerns around the use of anti-microbials in the production of feed for pigs and poultry with regards to the emergence of anti-microbial resistance [40]. Recent analysis suggests that the risks of disease such as avian influenza are greater in the more intensive units that the extensive scavenge-based systems [41].

**Changes in Land Use:** Changes in land use have been divided into different areas, the urban and peri-urban and the use of agricultural or rural areas. The greater density of urban areas and the human activities associated with these changes lead to greater contact with rodent population and also an increased tendency to have companion animals in closer contact [42]. In the already settled areas of agricultural production the intensity of land use can create disease burdens [20].

**Changes in Value Chains:** The livestock supply chains have experienced increasing volumes of animals and products. This has included bush meat species and the trade in wild animal species [43]. There is significant mixing and crossover of species in live animal. The use of bush meat as a food source has been linked to the emergence of several zoonotic diseases such as SARS and HIV [8].

**Protected Areas and Management of Wild Life Diseases in Ethiopia:** Ethiopia is one of the world's rich biodiversity countries and it deserves attention regionally and globally. It has a very diverse set of ecosystems ranging from humid forest and extensive wetlands to the desert [42].

Protected areas are the main focus for the maintenance of biological diversity and contribute for economic developments of a nation. Ethiopia had 40 protected areas covers about 16.4% of the country's land area and currently more than 17.1% of its land, ranked third in African country next to Tanzania and Uganda. The country is one of few countries where the establishments of protected areas are increasing. For example: Ethiopia had only two protected areas (namely; Awash and Simien Mountains National Park) before 40 years and today has more than 55 protected areas including 21 national parks to protect and conserve the natural ecosystems and wildlife heritage of the country [44].

But recently most of protected areas of Ethiopia are exposed to severe degradations due to failure of creating alternative options like ecotourism, which are off-farm activities. There are no effective land use management plans, land use rights and ownership are confused and there is no control of resource use. Rapid immigration with unplanned and unrestricted settlement is a significant and mounting problem both within and outside the National Park. Existing settlements are growing and new settlements are appearing in previously unsettled and environmentally sensitive areas [44].

Generally, the management of wild life diseases are very weak in Ethiopia due to the following core problem: the natural resources of the protected of area are poorly managed and producing an unsustainable flow of benefits for local communities, communities and government are not working together to conserve and sustainably use resources, the area's tourism activities are not contributing to the area's management and community benefits, the government's management is too weak to deal with pressures threatening resources; and the policy framework for natural resource management, landscape level planning and protected areas is inadequate [45].

### **Management of Zoonoses at the Livestock-Wildlife Interface**

**Methods of Limiting Contact Between Livestock and Wildlife:** When zoonoses are maintained in animal reservoirs, with humans as incidental hosts, then control will usually require intervention at the animal level.

Veterinary services often consider four functions: preparedness, prevention, surveillance and response and improving surveillance is currently a major focus of international effort [46].

The avian influenza pandemic has drawn attention to the difficulty of changing the informal value chains and wet-markets that predominate in developing countries in order to reduce contact between wildlife and livestock [47].

**Reducing Wildlife Populations:** reducing wildlife populations will theoretically reduce contact rates, possibly under a threshold necessary to sustain disease in the wildlife population [48]. Population reduction has been more effective in preventing disease entering an area than in eliminating it when established. For example, intensive wild carnivore reduction in advance of spreading rabies appears to have protected domestic animals in Argentina, Switzerland and Denmark [49].

**Improving Biosecurity in Wet Markets and Informal Value Chains:** Disease control in developed countries often relies on the ability to impose compliance on farmers. A new law was introduced in 2005 prohibiting the movement and sale of wild and ornamental birds in cities and this was followed by a significant decline in the scale of the wild bird trade in Hanoi [47].

Fencing: is a logical measure to prevent contact between farmed and wild animals and has been extensively used to protect standing crops from wildlife damage, domestic animals from predation, livestock from disease and wildlife from poaching and incursion [50].

**Approaches to Control and Governance Structures:** In the global health environment over the last few decades Well-organized, centralized, vertical campaigns with highly motivated professional and massive funding were applied to diseases of high importance from the middle of the last century on, vector control programs [51].

Vector control programs: are military-style control typifies the traditional vector control programs used to control zoonoses such as Chagas and human African trypanosomosis. According to centralized vertical structure with highly motivated professional spray workers and technicians, frequently with the time-limited goal of vector elimination and massive funding [52].

One health approaches lead to better management: there are typology of nine different types of multi-sectoral interventions for neglected diseases: Linking within the

health sector—integrated chemotherapy, Environment and sanitation, Education and school health, Nutrition and food security, Economic development, Urban improvement, primary and environment care, agriculture (including forestry and animal husbandry) and promotion of tourism [53].

**Programming in Advance:** Managing the ecosystems and environment to promote health in wildlife, wildlife-focused programs, livestock and human focused programs.

**Managing Ecosystems and Environment to Promote Health in Wildlife:** this can be achieved by reducing opportunities for transmission of diseases around water and other resources, burning pasture to decrease tick populations and stocking densities and landscapes that allow livestock to avoid wildlife [50].

**Wildlife-Focused Programs:** these programs are performed by controlling of wildlife Population thorough reduction of populations (culling; birth control), replacement of populations by disease-free animals and by Managing disease in wildlife through applying increasing host resistance (vaccinations, general health), Treating disease in wildlife, rule out Regulation/prohibition of trade in wildlife and Education and sensitization that Linking to benefits of conserving wildlife (schools, natural resource use) [46].

**Livestock Focused Programs:** are done by eliminating diseased individuals or populations, Husbandry practices to manage disease (all-in-all-out; depopulation; virus exposure), increasing host resistance (vaccines, general health, manipulation gut microbes) and treatment [43].

**Human Focused Programs:** Decreasing contact with infection source. Meat inspection and hygienic Slaughter, increasing resistance of people (general health; vaccines) and Treatment of people [51-53].

## CONCLUSION

There is limited original published research looking at transmission mechanisms of zoonoses from wildlife in developing countries. There is even less published information regarding the relative importance of the wildlife-livestock interface in amplification of zoonotic transmission. Disease emergence appears to relate to opportunities for contact between domestic animals with relatively low diversity and highly diverse wild animal populations in endemic equilibrium with their pathogens.

Some of the factors that influence the emergence or re-emergence of zoonotic diseases are human demographic and social changes, globalization of human travel and commercial trade, spatial expansion and intensification of agriculture, encroachment of people and livestock into wildlife habitats, but there is limited evidence for each factor. Bats have recently been the source of a number of emerging zoonotic diseases, some of which have involved domestic livestock in transmission and amplification. A broad conclusion is that, management of zoonoses with a livestock-wildlife interface is more challenging than management of other zoonoses or non-zoonotic diseases. Where wildlife and animals have an important role in disease maintenance then control usually requires or benefits from interventions directed at the animal host. The involvement of humans, livestock and wildlife in disease transmission is often unknown. As a consequence, control often fails because of lack of understanding of the importance of both livestock and wildlife in maintenance of disease.

## Based on the above Conclusion the Following Recommendations Are Forwarded:

- Comprehensive multi-sectorial regulation should be conducted taking into consideration all the stakeholders that have been and would be impacted by wildlife conservation.
- Studies such as risk analysis, cost-benefit analysis and policy evaluation at all interface areas should be conducted.
- The implementation of wildlife legislation should be done in tandem with other legislation in order to ensure that there is effective prevention of disease transmission among the wildlife, domestic animals and humans.
- Well organized veterinary and livestock production and health centers should be established in interface areas to create awareness for livestock keepers and for sustainable wildlife conservation.

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