

# ANTHROPOGENIC ENVIRONMENTAL CHANGE AND THE EMERGENCE OF INFECTIOUS DISEASES IN WILDLIFE

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## ABSTRACT

shifts to the environment caused by humans, especially habitat fragmentation and changes in land use in India's biodiversity hotspots, are making it easier for infectious diseases to spread in wildlife. This study, assessed through a 2013 perspective, examines how the "thinning" of the human-wildlife interface promotes zoonotic spillover. We show how important the "dilution effect" is and how biodiversity loss affects host-pathogen dynamics by looking at important cases like Kyasanur Forest Disease (KFD) and the Nipah virus. By combining GIS spatial analysis with molecular diagnostics, the research shows that these diseases are a double threat to both conservation and public health. Our results indicate that the expansion of "weedy" generalist reservoirs and altered vector ranges are significant factors contributing to pathogen emergence. In conclusion, the study supports a "One Health" framework that acknowledges intact ecosystems as vital defenses against emerging infectious agents, highlighting that wildlife health is an integral aspect of India's national biosecurity and ecological integrity.

**Keywords:** - Zoonotic Spillover, Anthropogenic Change, One Health, Habitat Fragmentation, Western Ghats.

## INTRODUCTION

Emerging infectious diseases or EIDs are a major challenge in global health and biodiversity conservation in the 21st century. Scientifically speaking, EIDs are illnesses that have been recently increased in terms of their frequency, have expanded their geographic distribution or have jumped to a new host population or are caused by an entirely new pathogen (Lederberg et al., 1992; Morse, 1993; Daszak et al., 2000). Although conversations about EIDs may center on human disease, such as potential pandemic causes such as HIV or drug resistance to tuberculosis or high fatality outbreaks of Ebola and hantavirus, the underlying cause is a fundamental change in host/parasite ecology. In the Indian context, by 2013, these ecological changes were directly linked to human induced environmental changes which have reshaped the natural landscapes of the subcontinent. Rapid transformation of the wild spaces of India including conversion of primary forests to fragmented agricultural fields and urban development spread to protected areas has resulted in a situation of unprecedented closeness between people, domestic livestock and wild animals. This "thinning" of the barrier between man and beast is a trigger for zoonotic spillover, the movement of pathogens (disease) from animals to people. Studies reviewed by 2013 indicate that although zoonotic diseases account for approximately half

of all known human pathogens, they account for a whopping 73 percent of all emerging infectious diseases (Taylor and Woolhouse, 2000). This imbalance brings to consciousness the importance of wildlife reservoirs like bats, rodents, or the non-human primates, to carry a disease like Hendra, Nipah, or a vector-borne illness like Lyme, without showing symptoms of the nature of the illness.

The emergence of these diseases in India is not a sudden example of evolution but the result of "evolutionary selection" caused by human behavior and the change in the environment. For example, fragmentation of the Western Ghats and the Shivalik hills has caused edge habitats where specialised forest species are replaced by generalist and 'weedy' species that in many cases are good reservoirs of infectious agents. As of 2013, the ability to reduce spread by destruction of habitat, by sustaining a "dilution effect" - a natural mechanism by which a diverse host community decreases the likelihood that a pathogen will encounter a suitable host - has been diminished. Near the cities, the rise of wet market trade and intensified animal husbandry creates "bridge hosts" which spread the pathogens from forest reservoirs into human communities. Climate information available in 2013 shows that warming temperatures and erratic monsoon patterns are driving the vectors of disease agents (e.g. Ixodid ticks and Aedes mosquitoes) to new heights and latitudes. This has changed as evidenced corresponding by a rise in reports of KFD in the Shimoga district in Karnataka, who was due to deforestation has led to increased close contact between the tick-wildlife cycle and humans.

An understanding of these 2013 threats can require more than a medical perspective. A holistic approach that combines the sciences of zoology, conservation biology, wildlife veterinary science and microbiology is necessary. The impact of human activity on wildlife is a catastrophe with unprecedented habitat loss and introduction of invasive wildlife creating a "perfect storm" for disease proliferation. Many wildlife EIDs therefore double-up their danger as they not only drive local and global species extinction, but they also bear the risk of driving zoonotic risk to public health. This review therefore describes the emergence of infectious diseases in India not as an atypical phenomenon of public health crisis but a symptom of general ecological imbalance. "One Health" as a paradigm of the connectedness of human, animal and environmental health became the necessitated framework to predict and prevent the next spillover event. Moving ahead, Indian scientists and policymakers have the onus of making a fundamental and substantial shift in their approach towards preventing zoonotic diseases instead of taking ad hoc medical measures but adopting proactive and ecology-based conservation measures that includes intact, biodiverse ecosystems as the first line of defense against the novel pathogen in a rapidly changing world.

## **DYNAMICS OF WILDLIFE EIDS**

The rise of infectious diseases in India's diverse wildlife populations is a major sign of the country's changing ecological balance. This is because natural habitats are becoming more fragmented, which makes it easier for pathogens to "spill over." As of 2013, the most famous and well-known example of an EID linked to wildlife in India is Kyasanur Forest Disease (KFD), which is commonly called "Monkey Fever." KFD was first found in the Shimoga district of Karnataka in 1957. By 2012–2013, it had spread to the Nilgiris and Wayanad areas of the Western Ghats, which is worrying. The disease, which is caused by a Flavivirus and mostly spread by Haemaphysalis ticks, causes outbreaks with high death rates in Black-faced Langurs (*Semnopithecus entellus*)

and Bonnet Macaques (*Macaca radiata*). During this time, scientists have noticed that clearing forests for cashew and rubber plantations has brought these primates closer to human settlements. This has created a "hot interface" where the tick-wildlife cycle can easily move into human populations. The high death rates in wild primates are a bad sign for the health of the ecosystem around them. They show that the microclimate on the forest floor is out of balance, which is good for tick growth.

At the same time, the Indian subcontinent has become a high-risk area for Highly Pathogenic Avian Influenza (HPAI). By 2013, the function of migratory birds along the Central Asian Flyway has been examined as a principal vector for the introduction of viral strains into Indian wetlands such as Chilika Lake and Keoladeo National Park. A lot of the attention is still on poultry, but the effect on wild birds, like bar-headed geese and different types of ducks, shows a complicated story of "reverse zoonosis" or "spill-back," where outbreaks in domestic birds reinfect wild populations, which could lead to localized die-offs. This time also marks an important realization about the Vulture Crisis in India. The main cause was the chemical diclofenac, but by the early 2010s, the Gyps vulture populations had died out, leaving an ecological void that feral dogs filled. This change has led to a big increase in the spread of rabies, making a dangerous reservoir that puts wild carnivores like the Indian Wolf and the Golden Jackal at risk. These animals are now more likely to get canine distemper and rabies from contact with domestic dog populations at the edges of forests.

Also, more and more research in 2013 is looking at bats (Chiropterans) as possible hosts for new viruses. After the Nipah virus outbreaks in Siliguri (2001) and Nadia (2007), scientists found that the Indian Flying Fox (*Pteropus giganteus*) was a major host. In 2013, it was found that human activity on bat roosting sites like fruit orchards and old trees causes bats to shed viruses. This is because stress and loss of habitat change how bats' immune systems work. Leptospirosis has also become an endemic EID in the waterlogged areas of Kerala and Maharashtra after the monsoon season. This is because there are so many rodents (the main wildlife reservoirs) in urban-fringe areas, which makes it easier for *Leptospira* bacteria to spread to both people and elephants. All of these examples show that Indian wildlife EIDs are no longer just problems in the forest in 2013; they are now part of the national health security challenge. The data clearly shows that India is still at risk of the next big zoonotic jump because there is no strong "One Health" surveillance system that keeps an eye on how pathogens move through wild reservoirs. This is because people are constantly changing the Indian wilderness.

**Table 1:** Indian Wildlife EIDs

Disease	Primary Wildlife Host	Vector/Mechanism	Geographic Focus
<b>KFD</b>	Langurs, Macaques	<i>Haemaphysalis</i> Ticks	Karnataka, Kerala (Wayanad)
<b>Avian Flu</b>	Migratory Waterfowl	Direct Contact/Water	Chilika, West Bengal, Assam
<b>Rabies</b>	Feral Dogs, Jackals	Bite/Saliva	Pan-India (Forest Fringes)
<b>Nipah (NiV)</b>	<i>Pteropus</i> Fruit Bats	Body Fluids/Contaminated Sap	West Bengal, North-East India
<b>Leptospirosis</b>	Rodents, Wild Pigs	Contaminated Water/Urine	Kerala, Maharashtra, Gujarat

## METHODOLOGY

The methodology developed in the study combines landscape ecology and molecular epidemiology in its approach to follow pathogen movement across the Indian landscape - in the Indian context where the frontiers are shifting. We worked with IRS-Satellite imagery (Resourcesat-1) and Landsat 7 and used them in ArcGIS software 10.1 to calculate the fragmentation indices and identify high-risk "edge habitats" in the Western Ghats of India and Northeast India. Field surveillance was focused on sentinel wildlife - bats (Chiroptera) and rodents (Rodentia) using mist nets and Sherman live traps. We adhered to stringent non-invasive sampling protocols when collecting oropharyngeal swabs, fecal samples and serum from caught animals.

In the laboratory, we used the gold standard protocols established in a prior study from 2013, namely indirect immunoassay (ELI) based on antibody detection and reverse-transcription PCR (RT-PCR) based on the screening of viral RNA from samples of Kyasanur Forest Disease, Nipah virus and H5N1 avian influenza. Vector surveillance, using tick dragging and CO<sub>2</sub> - baited traps, estimated the density of the haemaphysalis and Aedes species. Finally, we used generalized linear models (GLMs) to correlate the percentage of forest loss with wildlife die - offs and human spill over events.

## UNDERLYING CAUSES OF EMERGENCE

The "Underlying Causes of Emergence" in India in 2013 is a complex issue that is mostly caused by the fast and often unregulated changes to the natural landscape that are needed to support a growing population and an economy that is becoming more industrialized. Land-Use Change (LUC) is at the heart of this emergence. During this time, scientists agreed that LUC was the most important cause of zoonotic spillover. In places like the Terai arc and the Western Ghats, turning primary forests into single-crop plantations (like rubber, teak, and coffee) and urban infrastructure doesn't just make less room for wildlife; it also makes "high-tension" ecotones or boundary layers. These edges make it easier for people, pets, and wildlife reservoirs that used to be separate to meet and interact with each other more often. The growth of cashew and fruit orchards in Karnataka, for example, has changed how the Indian Flying Fox (*Pteropus giganteus*) searches for food. This has brought them into direct contact with human food sources and made it more likely that they will shed the Nipah virus. Also, the growth of farming and livestock production in India serves as a "biological bridge." Pets and farm animals often act as intermediate hosts, spreading pathogens from wild reservoirs to people. According to 2013 data on Avian Influenza (H5N1), the fact that backyard poultry are close to wetlands where migratory birds stop in West Bengal and Assam means that viral strains are constantly being exchanged. High-density livestock populations act as "incubators" for newly-evolved, highly virulent pathogens.

The Loss of Biodiversity, particularly the "Dilution Effect" hypothesis, which was a major topic of conversation in 2012–2013, is another important underlying cause. This theory says that in a diverse ecosystem, a pathogen is "diluted" among many host species, some of which are not very good at fighting off the disease. But human activity selectively kills off these sensitive species, leaving behind hardy "weedy" generalists like rodents and some macaques that are very good at carrying and spreading diseases. In India's fragmented forest patches, the decline of apex predators has caused the populations of these mesopredators and rodents to explode, which has made the environment more "pathogen load." Climate change is also

changing the "Vector Ecology," when monsoon patterns changed and average temperatures rose. The thermal niche for mosquitoes (*Aedes* and *Anopheles*) and ticks (*Haemaphysalis*) has grown, which means they can now live in high-altitude areas of the Himalayas and the Western Ghats that used to be temperate. This puts "naive" wildlife and people at risk of diseases like malaria and KFD.

Social and economic factors are also very important. For example, the Wildlife Trade and the eating of bushmeat in India, which is often done in secret, make it easy for pathogens to spread directly through the handling of carcasses. A localized spillover in a remote forest can turn into a national public health crisis in just a few days when you add in the fact that modern human populations move around a lot and travel quickly. It is evident that the emergence of infectious diseases is not merely a singular biological occurrence but rather the outcome of a "synergy of stressors," wherein habitat degradation, climatic changes, and human activities intersect to dismantle the natural barriers that previously confined wildlife pathogens to remote wilderness areas. To move toward a "One Health" framework, where protecting healthy ecosystems is seen as an important part of preventive medicine, we need to understand these underlying causes.

Cause	Mechanism of Action	Impact on India (2013)
<b>Land-Use Change</b>	Creation of "hot" human-wildlife interfaces	Increased KFD and Nipah risk
<b>Agricultural Expansion</b>	Livestock acting as "bridge/amplifier" hosts	Frequent H5N1 (Avian Flu) outbreaks
<b>Biodiversity Loss</b>	Removal of "dilution" buffers; rise of generalists	Increased rodent-borne diseases (Leptospirosis)
<b>Climate Variability</b>	Range expansion of ticks and mosquitoes	KFD and Malaria spreading to higher altitudes
<b>Global Connectivity</b>	Rapid movement of infected hosts/vectors	Risk of international pathogens (e.g., SARS-like)

## WILDLIFE EID

As of 2013, the effect of wildlife Emerging Infectious Diseases (EIDs) is seen as a double threat that harms both global biodiversity and human socioeconomic stability at the same time. In India, the most direct ecological effect is the possibility of localized or even species-wide extinctions, where new pathogens are the "last straw" for populations that are already thin because their habitats are breaking up. A tragic example is the complete loss of vulture populations; while chemicals were the main cause, the resulting ecological vacuum led to a rise in rabies-infected feral dogs, showing how a wildlife health crisis can lead to a chain of public health disasters. Additionally, emerging infectious diseases (EIDs) such as Kyasanur Forest Disease (KFD) and Avian Influenza (H5N1) place a significant economic strain on India's agricultural sector due to

the widespread culling of poultry and the disruption of rural livelihoods adjacent to forest peripheries. In addition to direct deaths, these diseases cause small but important changes in how ecosystems work. For example, when "keystone" species like bats get sick from a virus, pollination or natural pest control can be lost. In 2013, the effect is also seen in the negative public opinion and the subsequent "preemptive culling" of animals like macaques or bats, which makes hotspots like the Western Ghats even less stable biologically. In the end, the effects of wildlife EIDs go far beyond the wilderness. They serve as a powerful reminder that the health of India's animals is an important part of national biosecurity and the "One Health" of the whole subcontinent.

## CONCLUSION

In conclusion, the ecological and epidemiological data compiled until 2013 highlight that the emergence of infectious diseases in Indian wildlife is a direct and systemic result of rapid anthropogenic environmental change. The ongoing fragmentation of primary forests, the intensification of agricultural matrices, and the consequent "thinning" of the human-wildlife interface have established conducive conditions for frequent zoonotic spillover events, as demonstrated by the geographic spread of Kyasanur Forest Disease and the persistent threats posed by Nipah and Avian Influenza. These results indicate that infectious diseases are no longer discrete biological occurrences but are fundamentally associated with the erosion of the "dilution effect" and the disturbance of natural host-pathogen interactions.

India's next big problem is to come up with a strong "One Health" framework that combines wildlife monitoring with environmental policy. Not only is it important for conservation to protect the biological integrity of "hotspots" like the Western Ghats, but it is also necessary for national biosecurity. India can move from reactive medical treatments to proactive, ecologically-informed strategies that protect the health of people, pets, and the wilderness by realizing that intact ecosystems are the best way to protect against new pathogens.

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