

Climate Change and the Rising Risk of Zoonotic Diseases: A One Health Approach

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Key Points

- **Climate change can alter disease transmission:** Changes in temperature, rainfall, humidity and extreme weather events influence vectors, wildlife movement and interactions among animals and humans, potentially changing zoonotic disease risks.
- **India faces diverse climate-sensitive zoonoses:** Japanese encephalitis, scrub typhus, Kyasanur Forest disease, leptospirosis, Nipah virus infection and avian influenza illustrate the complex links between environmental conditions, animal hosts and human exposure.
- **One Health strengthens prevention and preparedness:** Integrating climate information with human, animal and environmental surveillance, laboratory diagnostics, genomic monitoring and community participation can improve early warning and outbreak response.

Abstract

Climate change is altering environmental and ecological conditions that influence the transmission of infectious diseases, including zoonoses shared between animals and humans. Changes in temperature, rainfall, humidity and extreme weather events can affect disease vectors, wildlife movement, pathogen circulation and human exposure. In India, climate-sensitive diseases such as Japanese encephalitis, scrub typhus, Kyasanur Forest disease, leptospirosis, Nipah virus infection and avian influenza highlight the importance of understanding interactions among climate, ecosystems, animals and human activities. However, climate change is not the sole cause of outbreaks, and disease responses vary according to pathogen characteristics, ecological conditions and socioeconomic factors. Integrating climate information with veterinary, wildlife and public-health surveillance can strengthen seasonal risk assessment and early-warning systems. The One Health approach

provides a coordinated framework for improving disease detection through intersectoral collaboration, laboratory networks, genomic surveillance and community engagement. Strengthening these systems, alongside sustainable land-use practices and ecosystem conservation, can improve preparedness for emerging zoonotic threats and help protect vulnerable communities.

Keywords- Climate change; Zoonotic diseases; One Health; Climate-sensitive infections; Disease surveillance; Vector-borne diseases; Emerging infectious diseases; Early-warning systems; Genomic surveillance; Public health

When climate changes, disease risks change

Climate change reaches far beyond rising temperatures and melting glaciers. Shifting rainfall patterns, higher humidity, prolonged droughts and extreme weather events are transforming ecosystems, affecting food and water security, and influencing how infectious diseases spread. Among the major concerns are zoonoses—infections that pass between animals and humans. Approximately 60% of known human infectious diseases and around 75% of emerging infectious diseases are zoonotic, highlighting the importance of understanding how pathogens move between species (Jones et al., 2008).

Climate change does not automatically cause an outbreak, nor does it act alone. It can alter the conditions in which pathogens, animals, vectors and people interact, sometimes creating new opportunities for transmission. Deforestation, agricultural expansion, urbanisation and biodiversity loss can intensify these pressures by bringing wildlife, livestock and people into closer contact. Zoonotic disease risk must therefore be understood through the combined influence of climatic, ecological and socioeconomic factors rather than climate change alone (Plowright et al., 2017).

How a changing climate influences disease

Temperature, rainfall and humidity affect the survival, development and activity of mosquitoes, ticks and mites. Warmer conditions may accelerate mosquito development and feeding or allow certain vectors to survive in areas that were previously unsuitable. However, excessive heat can shorten their lifespan and interrupt transmission. Rainfall can create breeding habitats, while flooding may initially wash away immature mosquitoes before leaving stagnant pools behind. Drought can concentrate people and animals around scarce water sources, and storms and heatwaves can damage infrastructure and increase exposure to contaminated environments.

The effects extend beyond vectors to the ecosystems in which pathogens circulate. Changes in vegetation, soil moisture, wetlands and food availability can influence wildlife movement and alter contact between wild animals, livestock and people. Research suggests that warming may push many mammal species into new geographical ranges, creating

opportunities for viruses to encounter new hosts, although such encounters do not inevitably lead to spillover. Human activities, including intensive agriculture, irrigation and forest clearance, can amplify these pressures, while poor sanitation, occupational exposure and limited healthcare determine how severely communities are affected. Climate information is therefore most useful when interpreted alongside ecological, veterinary and public-health data (Carlson et al., 2022).

Climate-sensitive zoonoses in India

India's diverse landscapes, monsoon-dependent agriculture, large livestock populations and close interactions between people and animals create a complex setting for climate-sensitive infections. The effects vary across regions and pathogens, but several diseases illustrate how environmental conditions can influence transmission and why coordinated surveillance is essential.

Japanese encephalitis (JE) is maintained in an ecological cycle involving *Culex* mosquitoes, pigs and waterbirds, while humans are incidental dead-end hosts. Irrigated rice fields and stagnant water can provide suitable mosquito breeding habitats, making rainfall, humidity and water management relevant to transmission. Scrub typhus, caused by *Orientia tsutsugamushi* and transmitted by infected chigger mites, is associated with vegetation, soil moisture and rodent ecology. A 15-year study from Vellore, Tamil Nadu, found that scrub typhus cases peaked approximately two months after rainfall and increased with humidity. The study also reported an association between higher mean temperatures and fewer monthly cases, illustrating that climate–disease relationships are not always straightforward and may vary by location (D'Cruz et al., 2024).

Kyasanur Forest disease (KFD), found in parts of the Western Ghats, is transmitted mainly by infected *Haemaphysalis spinigera* ticks. Its occurrence is influenced by tick ecology, forest conditions and human exposure. Unusual monkey deaths can serve as warning signals in affected areas, demonstrating how wildlife surveillance can contribute to early detection. These examples show why weather data alone cannot explain disease patterns: understanding the distribution of vectors, animal hosts, vegetation and human activity is essential for identifying where and when transmission may occur.

Flooding and heavy rainfall create a different set of challenges by increasing exposure to contaminated water and soil. Leptospirosis is a bacterial infection acquired through contact with environments contaminated by the urine of infected animals, including rodents, livestock and dogs. Floodwaters can spread contamination across homes and agricultural fields, while poor drainage and damaged sanitation systems increase opportunities for exposure. Agricultural workers, sanitation workers and communities living in flood-prone areas may be

particularly vulnerable, making safe water supplies, improved drainage and environmental hygiene important components of prevention.

Nipah virus highlights the importance of understanding interactions between wildlife, domestic animals and people. Fruit bats of the genus *Pteropus* are natural hosts, and spillover depends on ecological and behavioural conditions as well as habitat change. The Malaysian outbreak of 1998–1999 involved a combination of bat ecology, agricultural intensification and land-use change, rather than climate change alone. In Kerala, surveillance conducted in 2023 detected antibodies against Nipah virus in fruit bats, reinforcing the value of wildlife monitoring. Combining such surveillance with genomic analysis can help researchers investigate viral circulation and understand relationships between viruses detected in wildlife and those associated with human outbreaks (Balasubramanian et al., 2024).

Highly pathogenic avian influenza further illustrates the links between wildlife, agriculture and infectious disease. Migratory birds, wetlands and domestic poultry form part of an interconnected ecological system in which changes in wetland availability and migration patterns may influence where wild birds congregate and how often they encounter poultry. Coordinated monitoring of wild birds, domestic flocks and wetland environments, supported by farm biosecurity and genomic surveillance, is important for detecting emerging threats and guiding timely responses.

Can climate information help predict outbreaks?

Climate information can strengthen early-warning systems by helping identify environmental conditions associated with increased disease risk. Large-scale patterns such as the El Niño–Southern Oscillation (ENSO) influence rainfall, temperature and vegetation across regions. In East Africa, climate-associated heavy rainfall and flooding have helped researchers anticipate conditions favourable to Rift Valley fever outbreaks in livestock and people. Although Rift Valley fever is not endemic in India, this example demonstrates how environmental observations can support disease forecasting.

Similar approaches could improve seasonal risk assessments for Japanese encephalitis, scrub typhus and leptospirosis in India. Combining rainfall, temperature and humidity data with information on vectors, wildlife, livestock illness, human cases and laboratory findings could help authorities identify areas where transmission risk is increasing. However, weather forecasts alone cannot reliably predict outbreaks because disease transmission also depends on pathogen characteristics, animal hosts, human behaviour and the strength of local health systems. Climate-informed forecasting is most useful when it supports timely vector control, diagnostic preparedness, public communication and other preventive measures (Kelly et al., 2020).

One Health: Connecting the dots

If zoonotic diseases emerge through interactions among people, animals and the environment, preventing them requires collaboration across all three. This is the central principle of the One Health approach, which recognises that human, animal and environmental health are closely interconnected. Public-health departments, veterinary services, wildlife authorities, agricultural agencies, environmental scientists and meteorological services each hold part of the picture. Coordinated surveillance and information sharing can help ensure that warning signs detected in one sector are not overlooked by another.

In India, strengthening One Health implementation requires closer integration of human and animal disease surveillance with environmental monitoring and climate data. Routine data sharing, joint outbreak investigations and coordinated risk assessments can help identify emerging threats earlier, while stronger laboratory networks can improve the speed and accuracy of diagnosis. Surveillance involving domestic animals, wildlife and vectors can provide early warning of pathogen circulation before large human outbreaks occur.

Genomic surveillance adds another important dimension. Whole-genome sequencing allows researchers to examine pathogen evolution, investigate transmission pathways and identify the introduction of new variants. When combined with epidemiological and ecological information, genomic data can help investigate possible sources of infection and guide targeted interventions. For pathogens such as avian influenza and Nipah virus, this approach can strengthen understanding of emerging threats. However, sequencing is most useful when sampling is representative, results are shared promptly and public-health systems can act on the findings.

Community participation is equally important. Awareness of safe farming practices, personal protection, rodent control, sanitation and appropriate precautions around wildlife can reduce exposure to infection. Training healthcare professionals, veterinarians and field workers to recognise unusual animal deaths and seasonal disease patterns can further strengthen preparedness. Sustainable land-use planning, wetland conservation, biodiversity protection and climate-resilient agriculture should also be integrated into broader climate-adaptation and public-health programmes.

Despite its potential, One Health implementation faces practical challenges. Human, animal and environmental health services often operate independently, with separate surveillance systems, institutional priorities and funding mechanisms. Limited information sharing and inadequate coordination can delay outbreak detection even when warning signs are available. Addressing these gaps requires sustained investment in laboratories, integrated surveillance platforms, trained personnel and clear institutional responsibilities. It is equally

important to recognise that risks are not shared equally: livestock keepers, outdoor workers and communities without reliable access to clean water, sanitation or healthcare may face greater exposure and fewer opportunities for timely treatment.

Looking ahead: Prevention begins before the outbreak

Climate change is reshaping the ecological conditions in which zoonotic diseases circulate, but it is not the sole driver of outbreaks. India's experience with mosquito-, mite- and tick-borne infections, flood-associated leptospirosis, bat-borne Nipah virus and avian influenza demonstrates the diversity of these risks. Effective prevention requires more than monitoring weather; it depends on recognising changing disease patterns, understanding the ecological and social factors that shape transmission, and translating early warnings into coordinated action. A well-supported One Health system can turn scattered warning signs into useful information by connecting climate forecasts with human, veterinary and ecological surveillance. By strengthening collaboration across sectors, investing in diagnostic and genomic capabilities, engaging communities and protecting the ecosystems on which people and animals depend, India can improve its preparedness for climate-sensitive zoonoses. The most effective response to a changing climate is not simply to react to the diseases it may influence, but to build systems capable of anticipating risk, protecting vulnerable communities and preventing outbreaks wherever possible.

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