17(3) 839-852, Autumn 2025

Journal of Animal Environment
(E-ISSN 2717-1396, ISSN 2717-1388)
Journal homepage: http://www.aejournal.ir

Review Paper

Effect of Environmental Changes on the Migration Patterns of Disease Vectors and Their Impact on the Spread of Diseases

Bakhtiyor Akhmedov[1*], Djahongir Muratov[2], Bakhramjon Mamatqulov[3], Nadira Mirametova[4], Turgunov Sherali Dolikhonovich[5], Saidbek Husanov[6], Irodakhon Valiyeva[7]

*[1]*Lecturer, Department of Clinical Anatomy, Karshi State University, Uzbekistan.*
Email: bakhtiyor_akhmedov@mail.ru, ORCID: https://orcid.org/0009-0002-2509-6937
[2]Associate Professor, Department of Sports Activity, Bukhara State University, Email: j.j.murodov@buxdu.uz, ORCID: https://orcid.org/0000-0003-1461-3118
[3]Professor, School of Public Health, Tashkent State Medical University, Tashkent, Uzbekistan.
Email: tma.sph@gmail.com, ORCID: https://orcid.org/0009-0008-5801-724X
[4]Associate Professor, Department of Botany, Ecology and its Teaching Methodology, Ajiniyaz Nukus State Pedagogical Institute, Nukus, Uzbekistan. Email: mirametovanadira1982@gmail.com,
ORCID: https://orcid.org/0009-0005-3293-7273
[5]Turan International University, Namangan, Uzbekistan. Email: turgunovsherali549@gmail.com,
ORCID: https://orcid.org/0009-0001-7452-4734
[6]Department of Basic Medical Sciences, Faculty of Medicine, Termez University of Economics and Service, Uzbekistan. Email: sayidbek_husanov@tues.uz, ORCID: https://orcid.org/0009-0000-2579-8299
[7]Department of Foreign Languages, Jizzakh State Pedagogical University named after A. Kadiri, Jizzakh, Republic of Uzbekistan. Email: valiyevairodaxon442@gmail.com,
ORCID: https://orcid.org/0009-0000-9686-7511

Key Words
Environmental changes, Disease vectors, Malaria, Dengue, Zika virus, Vector migration, Public health.

Abstract
Climate change, deforestation, and urbanization are environmental changes that significantly affect the migration of disease vectors, e.g., mosquitoes, which carry diseases such as malaria, dengue, and Zika. These shifts are transforming the geographic distribution and seasonality of disease transmission, posing novel challenges for public health. This paper will discuss the effects of environmental changes on the migration of disease vectors and the consequent impact on the spread of vector-borne diseases. It dwells on the interpretation of ecological drivers and analyzes their health implications. The paper reviews the literature on climate change, land-use changes, and their impacts on vector ecology. It also provides case studies of areas affected by malaria in Africa, dengue in Southeast Asia, and Zika in South America, as examples of the actual implications of vector migration. Changes in the environment have also led to the spread of disease vectors into new regions, increasing the risk of disease outbreaks. This has placed a significant burden on health systems, especially in areas that lack sufficient resources or immunity. It depends on effective strategies to control vector migration, such as vector control, monitoring, and health education for people. Environmental changes not only influence mosquito migration but also disrupt wildlife habitats, altering interactions among animals, humans, and vectors. Shifts in animal movement and behavior driven by habitat loss, climate variability, and resource scarcity can create new ecological conditions that accelerate vector expansion and pathogen transmission. To reduce the threats of environmental change to health worldwide, more research and collaboration among international partners are required.

* Corresponding Author's email: bakhtiyor_akhmedov@mail.ru
Received: 26 June 2025; Revised: 06 August 2025; Accepted: 06 September 2025; Published: 30 October 2025
(DOI): 10.70102/AEJ.2025.17.3.68

Introduction

The environment, especially climatic variations, changes in precipitation patterns, and human activities such as deforestation and urbanization, is having a significant impact on ecosystems around the globe. These changes have direct impacts on the environment in which the vectors of disease, in this case the mosquitoes, breed (Patz et al., 2000). As an example, malaria is the carrier of the Anopheles mosquito, which has conditions to survive and reproduce i.e. warm climate, stagnant water where the mosquito breeds and humid weather (Aal & Elshayeb, 2011). Environmental factors, including temperature and rainfall, are also a major determinant of these conditions, where the conditions may be formed or changed. Higher temperatures can widen the geographical range of the mosquitoes to places where they have not been before and the alteration in rain patterns can increase or decrease breeding habitats. Besides, these vectors have new breeding habitats found in the manmade changes that include deforestation, urbanization, and irrigation. The interrelationship between these environmental factors in the migration and distribution of disease vectors is very vital in forecasting the expansion of the malaria and other diseases which are transmitted by vectors (Yadav & Upadhyay, 2023). Environmental disturbance also affects animal hosts that play a role in sustaining vector populations and pathogen cycles. Climate-driven changes in wildlife movement, habitat fragmentation, and resource availability influence how animals interact with mosquitoes and other vectors (Ishtiaq, 2021). Species such as birds, rodents, and primates can serve as reservoir or amplifying hosts, and their shifting ranges often precede or coincide with the expansion of vector habitats (Patz et al., 2000). Deforestation and agricultural expansion further force wildlife into closer proximity with human settlements, increasing opportunities for pathogen spillover and vector adaptation. These ecological dynamics demonstrate that understanding vector migration requires attention not only to climatic factors but also to animal behavior and ecosystem disruption. Through such dynamics, scientists and officials in the field of health will be able to develop more effective measures to monitor and contain the spread of these diseases (Githeko et al., 2000).

It is important to know how the environmental change influences the migration patterns of the disease vectors, especially with problems of global warming and rapid urbanization (Choi et al., 2023). Precision in forecasting the potential for disease outbreaks, such as malaria, depends on a clear understanding of vector migration (Parham & Michael, 2009). On an illustrative example, with the increase in temperatures new populations may be exposed to malaria because the mosquitoes would have moved to regions where they were not before found (Rajan & Senthil, 2025). With such migration patterns observed in this respect when compared to environmental change, the bodies of public health will be in a position to allocate resources effectively and implement preventive measures to prevent outbreaks. This predictive power can be used to establish early warning mechanisms that alert relevant authorities to threats in specific regions.

Besides the predictability of outbreaks, insights into vector migration are also crucial for formulating compelling, resource-saving, specific interventions. An example is the realization that where mosquitoes are most likely to breed or migrate could help target high-risk regions, and the resulting distribution of insecticide spray and bed nets, among other preventive mechanisms, would be in places where they are most likely to be required. Likewise, environmental interventions, such as regulating water sources to provide breeding habitats for vectors or regenerating natural ecosystems to restrict vector migration, can be better targeted with knowledge of migration patterns.

Key Contributions

- To investigate how environmental changes affect the migration pattern of malaria vectors, especially in relation to climate variables, including temperature and rainfall.
- Investigating the effects of human actions (e.g., deforestation, urbanization) on the breeding environment and migration patterns of disease vectors and the effects of these alterations on disease transmission.
- To give insights into optimal strategies to be used in the event of public health interventions, as well as disease control, which are based on a knowledge of how vectors migrate to environmental changes.

The article begins with Section II, which discusses environmental factors that influence disease vectors' migration, including climate change, deforestation, and urbanization. Section III will address the effects of these changes on human health, the spread of vector-borne diseases, the rise in epidemics, and the problems they pose for public health systems. Section IV provides case studies, looking at the impact of environmental changes on disease vectors' movement with an example of malaria in Africa, dengue fever in Southeast Asia, and the Zika virus in South America. Section V points out measures used to control these effects, such as control of the vectors, surveillance schemes, and education of the population on health issues. Lastly, Section VI ends with an overview of the main arguments and the recommendations to be taken concerning future studies, as well as the request to act in order to ensure the environmental changes and migration of disease vectors.

Environmental Changes Affecting Disease Vector Migration Patterns

The habitats and behaviors of disease vectors are changing due to environmental changes. The primary causes of these changes are:

Figure 1 demonstrates the impact of global warming, climate change, and extreme conditions on the spread of malaria. Global warming boosts the mosquito life cycle, prolonging their lifespan and increasing malaria cases (Martens et al., 1995). Climate change influences the development, the breeding, and the death of mosquitos, which increases malaria by weakening immunity and changes in the environment (Arvinth, 2025). Mosquitoes can develop new habitats due to extreme conditions, like floods or drought, and disrupt their reproduction and distribution of habitats, respectively, determining malaria transmission patterns.

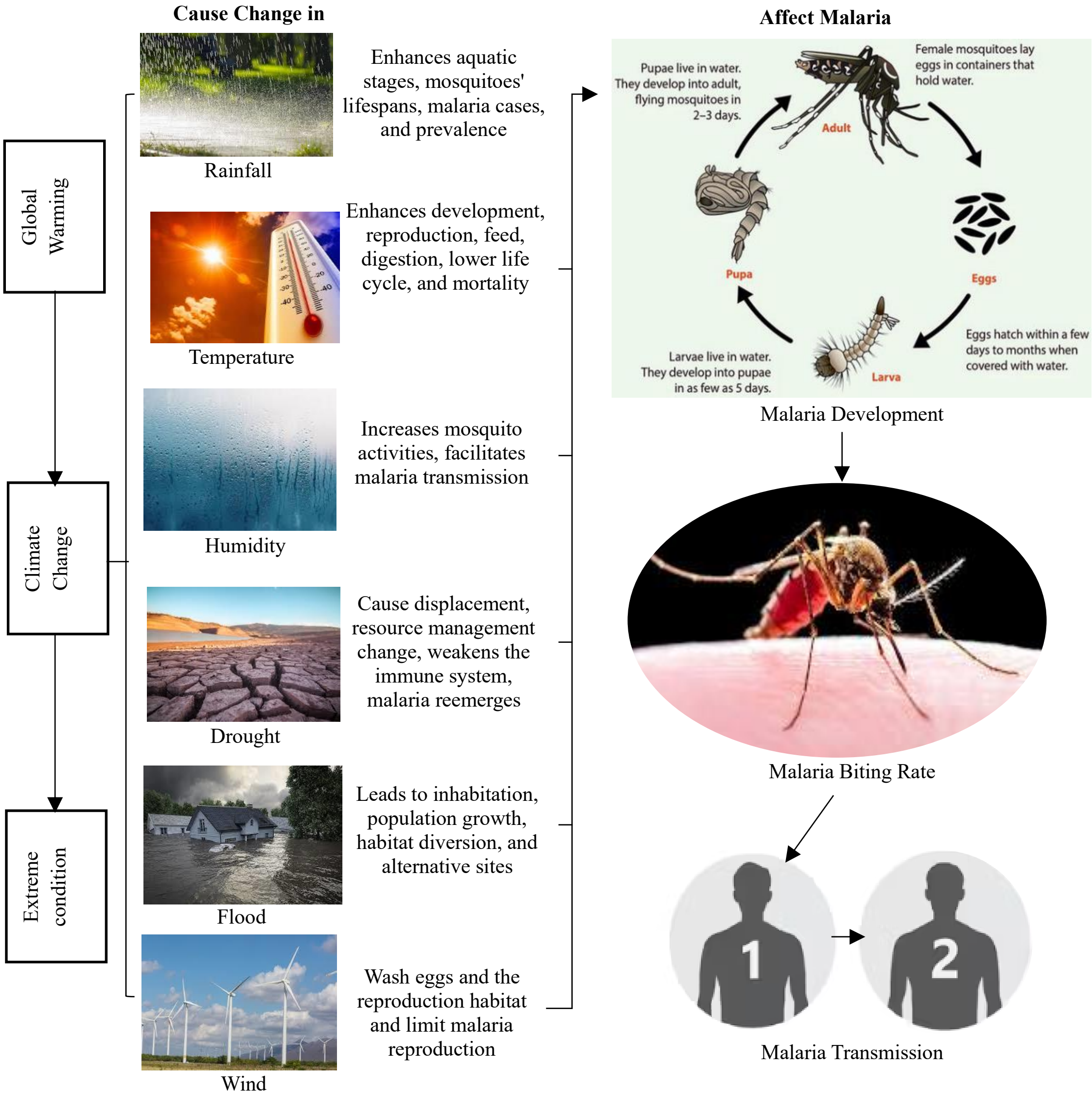

Figure 1: Impact of Environmental Factors on Malaria Transmission

Fluctuation in Temperature and Humidity

Global warming has caused massive movement of disease vectors, particularly the mosquitoes due to the increases in temperature (Ramasamy & Surendran, 2012). Higher temperatures create a more favorable climate that supports the survival and multiplication of vectors, such as the Anopheles mosquito, a vector of malaria (Ishtiaq, 2021). We can say that mosquitoes are ectothermic; their body temperature depends on the environment. Therefore, the closer the environment to the warmer the faster the process of reproduction and, thus, the higher number of generations in a year. In addition to temperature, humidity also forms a vital condition to the existence of the disease vectors as high humidity is required to help maintain the populations of the mosquitoes (McMichael, 2015). With the shift in the precipitation patterns and rising evaporation, areas that were hitherto inhabitable because of the arid climates are now offering the mosquitoes new habitats. As an example, the cooler regions will feel warmer which will stretch the geographical boundaries of the malaria vectors to greater elevation and latitude (Egbendewe-Mondzozo et al., 2011). This long-distance spread of malaria poses a threat of infecting new populations that did not have exposure to malaria before, which makes it more difficult to eradicate it (Lindsay & Birley, 1996).

Changes in Water Availability

The water supply, which is mainly determined by changes in precipitation patterns and water management practices, is an essential factor for disease vectors that reproduce in stagnant water (Ma et al., 2022). In most parts, climate change has led to more irregular rainfall patterns and more extreme weather, including both floods and drought. Excessive rain may also lead to flooding, providing good breeding grounds for mosquitoes in both urban and rural areas (Becker, 2008). The new habitats are usually found in places with limited infrastructures rendering them hard to control and manage. Droughts however have the potential of lowering the amount of natural water resources and this will force the water to collect more in small bodies and this will in turn make the water bodies good habitats to mosquito larvae. In addition to this, improper management of water by either the laying down of irrigation systems or very poorly controlled urban drainage systems, may result in stagnant water pools, which may facilitate an increase in disease vectors (Sutherst, 2004). Alterations in water availability, therefore, not only affect the number of breeding spaces but also the quality and availability of such spaces, both of which play significant roles in the distribution and spread of disease vectors (including malaria, dengue fever, and Zika virus) (Megersa & Luo, 2025).

Land Use Changes and Agricultural Expansion

Human-made land-use changes, including deforestation and agricultural expansion have significantly altered the ecosystems where disease vectors survive (Grobusch & Grobusch, 2022). New breeding areas are often formed, especially in the shape of artificial water bodies like irrigation ditches, ponds and rice paddies, because of the clearing of forests to increase agriculture or urbanization. As an example, the proliferation of rice farming establishes perfect breeding grounds of mosquito larvae since rice ponds have a lot of stagnant water. Just like this, deforestation does not balance the natural ecosystems, forming new habitats that can support disease vectors (Salazar-Hamm & Torres-Cruz, 2024). When forests are cleared, humidity and temperature levels in the region can change, making it friendlier to mosquitoes. Moreover, clearing land to facilitate agricultural activities may increase the number of open water bodies to gather rainwater and, as a result, provide breeding habitat. Moreover, agricultural runoffs that are often polluted with pesticides and nutrients can lead to the water pollution, both, the health of the lived population and the ecosystems of water bodies can be changed, the population of vectors and their ability to transmit diseases can be affected. The overall impact of more agricultural activities that are aimed at supporting the demands of an expanding global population is that the habitat of mosquitoes will also expand in number and hence propagate the diseases they transmit.

Impact of Disease Vector Migration on Human Health

Spread of Vector-Borne Diseases

Environmental changes that introduce disease vectors, such as mosquitoes, into new areas are a significant threat to human health. With the spread of these vectors, the threat of disease introduction and propagation into disease-free areas also spreads. The example of this is as the malaria causing mosquito Anopheles is found to have moved up further in altitude and regions that were formerly cold due to the increasing temperatures caused by climate change. Similarly, dengue fever-causing Aedes mosquitoes, Zika virus, and chikungunya have spread to new geographic areas due to urbanization and climate change, which create favorable breeding environments. These vectors spread, thereby risking the spread of diseases that, in most cases, have disastrous effects on populations without immunity to new infections. The increased population mobility worldwide and the alteration of migratory patterns of disease vectors increase the transmission of these diseases and make it harder to contain their spread. Human and vegetable mobility has led to the disease that was once confined to a given region becoming a global health risk, adding to the burden worldwide.

Table 1: Impact of Environmental Changes on Malaria Transmission

Environmental Change	Effect on *Anopheles* Mosquito (Malaria Vector)	Impact on Malaria Transmission
Rising Temperatures	Accelerates the mosquito life cycle, increases breeding rates	Expands malaria transmission season, raises incidence
Changes in Rainfall	More standing water for mosquito breeding	Increases mosquito population, leading to higher malaria risk
Deforestation	Creates new breeding grounds for mosquitoes	Higher vector populations and risk of malaria in new areas
Urbanization	Creates more breeding sites (e.g., water storage, construction sites)	Higher population density increases malaria transmission
Flooding and Drought	Flooding provides more breeding sites; droughts concentrate breeding in smaller areas.	Higher mosquito density and malaria risk in flood-prone or drought-affected areas
Land Use Changes (e.g., irrigation)	Irrigation creates new stagnant water bodies for mosquito breeding	Increased mosquito populations lead to higher malaria transmission

Table 1 highlights the complex association between environmental change and malaria transmission as a rapid guide to how single changes in the ecology, like climate change, urbanization, and deforestation, influence the behavior and transmission of vectors and mosquitoes. It underscores the importance of comprehending these environmental drivers as a way of coming up with an efficient malaria control mechanism.

Increase in Epidemics and Outbreaks

Introduction of disease vectors in new locations is also increasing the rate and intensity of epidemics and outbreaks. Because vectors such as mosquitoes can establish new habitats in urban centers and rural areas that have not previously had diseases such as malaria, dengue, or Zika, there is a high risk of a massive outbreak. This has mainly been observed in areas where land use and urbanization are occurring at a high rate, forming ideal breeding areas for the vectors; deforestation and agricultural encroachment. As an example, more frequent outbreaks of diseases such as dengue in tropical and subtropical regions have happened because of the increase in the population of mosquitoes due to higher temperatures and a rise in the amount of water available. In other instances, the outbreaks are witnessed in regions that are not prepared to deal with them, resulting in increased morbidity and mortality. Moreover, this has been attributed to the risk of more epidemics with the development of new diseases being carried by the vectors as they move to new regions, because the populations have no prior exposure or immunity against the new pathogens. The local healthcare systems are overburdened by such frequent epidemics, which tend to paralyze the hospitals and medical facilities, and intervene before it is too late to stop the proliferation of the illness.

Challenges for Public Health Systems

Disease vectors' migration poses many problems to the public health systems, especially in areas that are not well-equipped to combat the transmission of disease vectors. Since vectors can be transported to unprepared locations, the public health infrastructure might fail to handle the rise in the number of cases, particularly in low-resource environments. The health systems might not have the required surveillance tools to aid the detection and monitoring of the populations of the vectors, which is essential in early warning and proper intervention. Moreover, the prevalence of most diseases transmitted by vectors usually surpasses the availability of local healthcare facilities, which sometimes prove to be unable to offer proper care or facilities to the victims. Moreover, the multi-faceted approach to the fight against the vectors should involve not only medical treatment but also the control of the vectors, i.e., the spraying of the insecticides, the distribution of the bed nets, and the management of the environment, and all this is a serious investment and coordination. These efforts are complicated by the migration of disease vectors because it can be challenging to apply the control measures in new, undiscovered regions where resources are limited. With these evolving trends, there is a need to integrate these changes in the public health systems through investments in surveillance, early detection, and sustainable intervention measures to curb the health risks of migrating disease vectors.

Case Studies on the Effect of Environmental Changes on Disease Vector Migration

Malaria in the Highlands of East Africa

Malaria cases in the highlands of East Africa, which were traditionally malaria-free or had low transmission rates, have increased as a result of climate change. The rise in temperature, particularly in areas such as the Ethiopian highlands, has enabled the Anopheles mosquito to travel to elevated areas. This change in the population of mosquitoes has opened up new populations to malaria, and new outbreaks have been reported in regions that do not have immunity or healthcare facilities to respond efficiently. Alterations in rain checks have also exposed more breeding grounds, using another breeding ground, causing more problems.

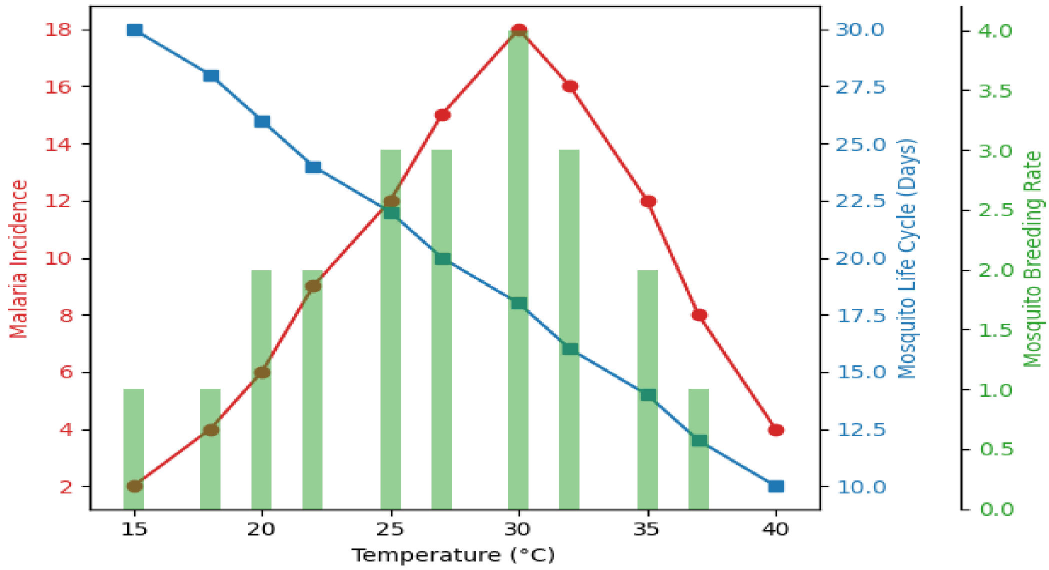

Figure 2: Temperature vs. Malaria Incidence, Mosquito Life Cycle & Breeding Rate

Figure 2 shows the correlation between temperature (in degrees centigrade) and the significant determinants of malaria transmission and mosquito behavior. It illustrates how increasing temperature affects frequency of malaria infection (red line) which peaks at approximately 30 °C which means that Anopheles mosquito breed and multiply optimally and result in high malaria levels. The mosquito's life is limited by the temperature, with the warmest temperatures ranging between 25 °C and 30 °C, resulting in the fastest cycle, which has a high capacity to reproduce and increase in population. As well, the breeding rate of mosquitoes (green bars) also shows the same tendency; the highest breeding rates are at the optimal temperatures (approximately 30 °C), which also leads to the increased risk of malaria. This graph shows that climate is important in the dynamics of diseases because it shows that variation in temperature is vital in the behavior of the mosquito and malaria distribution.

Dengue Fever in the Urban Areas of Southeast Asia

Southeast Asia also faces rapid urbanization, which has led to the large-scale spread of Aedes mosquitoes, transmitting dengue fever. This was caused by changing climate conditions. The sprawl in the cities and a lack of proper waste management systems have provided the best breeding grounds in over-saturated spaces, particularly in water holding containers, abandoned tires, and construction sites. With an increase in temperature, these mosquitoes can proliferate to relatively larger regions and cause a rise in the frequency and severity of outbreaks of dengue fever, especially in urban areas such as Bangkok, Jakarta, and Manila.

Chikungunya in the Caribbean and Latin America

In the Caribbean and Latin America, the chikungunya virus outbreak has risen, a factor that is primarily attributed to the movement of Aedes mosquitoes, the vectors of the chikungunya virus. Climate change, which has led to higher rainfall and warmer temperatures, has provided the mosquitoes with favorable conditions in these areas. These mosquitoes also spread with the help of urbanization, deforestation, and international trading, and have caused outbreaks that have taken the lives of millions of people. Chikungunya spreads, accompanied by its debilitating symptoms; this is a significant burden to the already burdened healthcare systems, which are already struggling with other endemic diseases.

Lyme Disease in North America

Environmental factor changes, such as a change in temperature and land use, have played a role in the spread of Lyme disease in North America. The black-legged tick, which carries Lyme disease, has been able to extend northward in Canada and to greater altitudes in the United States, regions that previous ticks could not inhabit due to their habitat being too cold. The increased temperature and less severe winters mean that ticks are able to stay longer in the year, particularly in new areas, which increases the rate of Lyme disease. Land use alteration that includes suburban sprawl into forests also exposes human beings to ticks, thereby enhancing the chances of getting infected.

Zika Virus in the Pacific Islands

Another instance of the influence of environmental changes on the migration of disease vectors is the spread of the Zika virus through the Pacific Islands in the mid-2010s. The mosquito Aedes aegypti, which is the cause of Zika, is known to survive in both tropical and subtropical areas. An increase in the range of mosquitoes has resulted in island countries and coastal regions as well, due to climate change. The increase in sea levels and changes in rainfall patterns have increased the breeding grounds in the coastal areas with low altitudes, which have contributed to the proliferation of the virus. The appearance of Zika in the Pacific Islands was complicated by the local infrastructure issues and the lack of access to health care, which points to the necessity to enhance the level of vector control in the potentially dangerous areas.

Strategies for Mitigating the Impact of Disease Vector Migration

Vector Control Measures

The control of vectors has been one of the building blocks of the fight against the effects of disease vector migration. The purpose of effective control of vectors is to decrease the number of disease vectors, e.g. the mosquitoes and restrict their capacity to transmit diseases. The most common ones are application of insecticides, the sale of insecticide laced bed nets and environmental management like dewatering of standing water where the mosquitoes breed. The use of insecticide spraying, either outdoors or indoors has been extensively utilized in the management of the populations of mosquitoes, but the efficacy has occasionally been restricted due to resistance. Long-term solution such as eradication of stagnant water sources or development of barriers to breeding of mosquitos is a requirement especially in areas where the population of the mosquito species is rising owing to changes in land use. Also, novel technologies in managing the vectors like genetically engineered mosquitoes, which are meant to reduce the population, are proving viable in the control of such diseases as malaria and dengue. When used together with other strategies, these approaches are helpful in reducing the population of vectors and limiting the spread of diseases especially in regions where there is migration as a result of environmental shifts.

Table 2: Strategies for Mitigating the Impact of Disease Vector Migration

Strategy	Goal	Approach
Vector Control Measures	Reduce mosquito populations and limit their ability to transmit diseases	Insecticide-treated bed nets, indoor spraying, and environmental management
Surveillance and Monitoring Programs	Track vector populations and disease cases for early intervention	Use of entomological and epidemiological data to monitor mosquito populations and disease spread
Public Health Education	Increase awareness and empower communities to take preventive actions	Educate communities about malaria prevention and mosquito control methods
Environmental Management	Alter the environment to reduce mosquito breeding sites	Drain stagnant water sources, improve waste management, and reduce water storage where mosquitoes breed
Climate Change Adaptation	Prepare for and mitigate the impact of changing environmental conditions	Implement climate-resilient public health strategies that account for shifting vector distributions
Vector Genetic Control	Reduce or eliminate mosquito populations through genetic technologies	Use genetically modified mosquitoes (sterile males, gene drive technology) to reduce mosquito populations
International Cooperation	Enhance global efforts to control vector-borne diseases	Collaboration between countries and organizations for sharing data, resources, and control methods
Vaccine Development and Distribution	Provide immunity against vector-borne diseases through vaccination	Development and widespread distribution of malaria vaccines and other disease-specific vaccines

Table 2 is a summary of the significant strategies that should be implemented to minimize the effects of environmental changes on the migration of disease vectors and disease transmission such as malaria. It consists of such approaches as control of vectors, monitoring, public health education, and adaptation to climate change, and real-life examples of their application. These are the measures to control the population of the vectors, enhance surveillance and create awareness to reduce the impact of the changing disease patterns.

Surveillance and Monitoring Programs

Monitoring and surveillance programs play a very essential role in tracing the movement and population dynamics of the disease vectors and hence an intervention can be done in time. These programs involve a mix of entomological surveillance (observing the population of the mosquitoes) and epidemiological surveillance (following the cases of diseases) to trace the patterns of migration of vectors and possible outbreaks. Monitoring environmental variations, including temperature, rainfall, and humidity, surveillance programs will be able to anticipate the changes in the distribution of vectors and determine the risk of transmitting the disease in new locations. As an example, in malaria prone areas the surveillance data may be utilized to monitor the seasonal movement of the mosquitoes of Anopheles and decide where control strategies need to be initiated and at which time. Surveillance-based early warning systems can signal potential outbreaks to the relevant public health authorities and result in faster responses, e.g. the use of insecticide-impregnated nets or specialized spraying. The surveillance systems have been enhanced with technology, including satellite surveillance and geographic information systems (GIS) where real-time information offers predictions and action against the altered dynamics of the disease vectors migration.

Public Health Education and Awareness Campaigns

Education and awareness on public health is very essential in the reduction of the effect of migration of disease vectors. These campaigns are to inform the communities on risks of the diseases caused by vectors, ways of identifying the symptoms and preventive measures they can put in place to minimize their exposure to the vectors of diseases. Education activities are commonly aimed at the need to curb breeding places such as clearance of standing water, application of mosquito's repellents and sleeping in treated bed nets. Such campaigns are significant in regions with vectors migration because the local population might not be used to the introduction of new vectors. The involvement of communities is an essential factor to consider, since local communities are likely to be in a better position to institute preventive measures in their immediate surroundings. Information on the importance of implementing changes on the environment, including climate change and land use methods, and how it affects the distribution of disease vectors may also be propagated through awareness campaigns. To develop long-term education programs that are sustainable and that will be formed with local leaders, community health workers and international organizations, the collaboration is necessary. Also, the public health awareness advertisements through social media and other communication platforms could assist in disseminating the scope of the campaign, so that the knowledge on managing vectors and prevention of diseases could reach wider groups of people.

Conclusion

The environmental factors, such as climate change, deforestation, and urbanization, have a strong influence on the migration of disease vectors such as mosquitoes, and the subsequent proliferation of diseases like malaria, dengue, and Zika. The more vectors spread to new areas, the more the threat of transmitting the disease grows, burdening the public health system in more and more areas, particularly unprepared areas. As observed in the case studies of malaria, dengue, and Zika, specific efforts are required to address these issues and reduce the associated risks in the form of controlling vectors, surveillance, and educating the population about the importance of personal health. Environmental change also modifies the ecological interactions among vectors, wildlife, and humans, enabling pathogens to circulate more efficiently in animal hosts before reaching new human populations. As wildlife ranges shift in response to temperature and habitat changes, vectors may exploit these altered animal communities, creating new hotspots for disease emergence. Strengthening vector-control programs therefore requires parallel monitoring of animal hosts and ecosystem health. Integrating wildlife surveillance with climate-sensitive public-health strategies can greatly enhance early detection and prevention of vector-borne outbreaks.

In the future, the research should be directed at the long-term consequences of environmental changes on the migration of vectors and the spread of the disease. The policies adopted in the field of public health should include methods of dealing with the underlying causes of these changes in the environment, including mitigation of climate change and sustainable land use. It is possible to mitigate the effects of the migration of vectors and lower the prevalence of the diseases transmitted by vectors by investing in early warning systems, creating innovative methods of control, and collaborating on an international level. It is necessary to take immediate measures to protect the further health of the population and eliminate the additional outbreaks of the diseases.

References

[1] Aal, Rasha A., and Ayman A. Elshayeb. "The effects of climate changes on the distribution and spread of malaria in Sudan." *American Journal of Environmental Engineering* 1, no. 1 (2011): 15-20. https://doi.org/10.5923/j.ajee.20110101.03

[2] Arvinth, N. "Interdisciplinary Perspectives on Invasive Species Risk Modelling: Bridging Ecology, Climate Science, and Artificial Intelligence." *Bridge: Journal of Multidisciplinary Explorations* 1, no. 2 (2025): 1-8.

[3] Becker, Norbert. "Influence of climate change on mosquito development and mosquito-borne diseases in Europe." *Parasitology Research* 103, no. Suppl 1 (2008): 19-28.

[4] Choi, Soo H., Jacob Beer, and Alexandra Charrow. "Climate change and the displaced person: how vectors and climate are changing the landscape of infectious diseases among displaced and migrant populations." *International Journal of Dermatology* 62, no. 5 (2023): 681-684. https://doi.org/10.1111/ijd.16636

[5] Egbendewe-Mondzozo, Aklesso, Mark Musumba, Bruce A. McCarl, and Ximing Wu. "Climate change and vector-borne diseases: an economic impact analysis of malaria in Africa." *International journal of environmental research and public health* 8, no. 3 (2011): 913-930. https://doi.org/10.3390/ijerph8030913

[6] Githeko, Andrew K., Steve W. Lindsay, Ulisses E. Confalonieri, and Jonathan A. Patz. "Climate change and vector-borne diseases: a regional analysis." *Bulletin of the world health organization* 78, no. 9 (2000): 1136-1147.

[7] Grobusch, Lena C., and Martin P. Grobusch. "A hot topic at the environment–health nexus: investigating the impact of climate change on infectious diseases." *International Journal of Infectious Diseases* 116 (2022): 7-9. https://doi.org/10.1016/j.ijid.2021.12.350

[8] Ishtiaq, Farah. "Ecology and evolution of avian malaria: implications of land use changes and climate change on disease dynamics." *Journal of the Indian Institute of Science* 101, no. 2 (2021): 213-225.

[9] Ishtiaq, Farah. "Ecology and evolution of avian malaria: implications of land use changes and climate change on disease dynamics." *Journal of the Indian Institute of Science* 101, no. 2 (2021): 213-225.

[10] Lindsay, S. W., and M. H. Birley. "Climate change and malaria transmission." *Annals of Tropical Medicine & Parasitology* 90, no. 5 (1996): 573-588. https://doi.org/10.1080/00034983.1996.11813087

[11] Ma, Jian, Yongman Guo, Jing Gao, Hanxing Tang, Keqiang Xu, Qiyong Liu, and Lei Xu. "Climate change drives the transmission and spread of vector-borne diseases: an ecological perspective. " *Biology* 11, no. 11 (2022): 1628. https://doi.org/10.3390/biology11111628

[12] Martens, W. J., Louis W. Niessen, Jan Rotmans, Theo H. Jetten, and Anthony J. McMichael. "Potential impact of global climate change on malaria risk." *Environmental health perspectives* 103, no. 5 (1995): 458. https://doi.org/10.1289/ehp.95103458

[13] McMichael, Celia. "Climate change-related migration and infectious disease." *Virulence* 6, no. 6 (2015): 548-553.https://doi.org/10.1080/21505594.2015.1021539

[14] Megersa, Dereba Muleta, and Xiao-San Luo. "Effects of Climate Change on Malaria Risk to Human Health: A Review." *Atmosphere* 16, no. 1 (2025): 71. https://doi.org/10.3390/atmos16010071

[15] Parham, Paul Edward, and Edwin Michael. "Modeling the effects of weather and climate change on malaria transmission." *Environmental health perspectives* 118, no. 5 (2009): 620. https://doi.org/10.1289/ehp.0901256

[16] Patz, Jonathan A., Thaddeus K. Graczyk, Nina Geller, and Amy Y. Vittor. "Effects of environmental change on emerging parasitic diseases." *International journal for parasitology* 30, no. 12-13 (2000): 1395-1405.https://doi.org/10.1016/S0020-7519(00)00141-7

[17] Patz, Jonathan A., Thaddeus K. Graczyk, Nina Geller, and Amy Y. Vittor. "Effects of environmental change on emerging parasitic diseases." *International journal for parasitology* 30, no. 12-13 (2000): 1395-1405.https://doi.org/10.1016/S0020-7519(00)00141-7

[18] Rajan, C., and T. Senthil. “Assessing the Impact of Invasive Species on Food Security: A CLIMEX-Based Modelling Approach.” *National Journal of Food Security and Nutritional Innovation* 3, no. 1 (2025): 1–8.

[19] Ramasamy, Ranjan, and Sinnathamby Noble Surendran. "Global climate change and its potential impact on disease transmission by salinity-tolerant mosquito vectors in coastal zones." *Frontiers in physiology* 3 (2012): 198. https://doi.org/10.3389/fphys.2012.00198

[20] Salazar-Hamm, Paris, and Terry J. Torres-Cruz. "The impact of climate change on human fungal pathogen distribution and disease incidence." *Current Clinical Microbiology Reports* 11, no. 3 (2024): 140-152.

[21] Sutherst, Robert W. "Global change and human vulnerability to vector-borne diseases." *Clinical microbiology reviews* 17, no. 1 (2004): 136-173. https://doi.org/10.1128/cmr.17.1.136-173.2004

[22] Yadav, Nidhi, and Ravi Kant Upadhyay. "Global effect of climate change on seasonal cycles, vector population and rising challenges of communicable diseases: a review." *Journal of Atmospheric Science Research* 6, no. 1 (2023). https://doi.org/10.30564/jasr.v6i1.5165