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Review Paper

Environmental Degradation, Ecosystem Disruption, And Its Influence on the Spread of Vector-Borne Diseases

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Key Words

Environmental degradation, Vector-borne diseases, Malaria, Dengue, Climate change, Public health strategies, Ecosystem disruption.

Abstract

The paper will explore the contribution of environmental degradation to the spread of vector-borne diseases (VBDs), i.e., malaria and dengue. Some of the environmental forces that influence the habitat of the vectors, like the mosquito, include deforestation, urbanization, and climate change, resulting in increased diseases being transmitted. The paper will focus on examining how environmental degradation contributes to the intensification of the incidence of VBDs in the affected regions, with reference given to the breeding capacity of disease vectors due to changing ecologies. The study has used ecological data analysis, climate modeling, and health surveillance records to evaluate the association between environmental change and malaria and dengue epidemics in vulnerable populations. It could be by mapping the geographic distribution of the cases of the disease in various areas of environmental degradation, and comparing it with climate and land-use data. The research results have shown that there is considerable correlation of poor waste management, deforestation, and urban sprawl with increased incidences of VBDs, particularly in the tropics. Increasing environmental degradation also interferes with ecosystems and wildlife habitats, which provide ecological conditions that favor high breeding and transmission of diseases by mosquitoes. These ecological changes also exacerbate the fragility of human populations, with particular focus on tropical areas and biodiversity loss, whereby vectors reproduce with even greater speed. The paper highlights the need for environmental management and control measures in a bid to mitigate the effects of environmental degradation on human health. The good policies that would consider not only the protection of the environment but also the control of the vectors will be very vital in reducing the spread of diseases like malaria and dengue.

Introduction

Human activities that have led to environmental degradation (through deforestation, urbanization, and climate change) have significant effects on ecosystems and the health of the population. Changes in natural landscapes and the distortion of ecosystems may create favorable conditions for the spread of vector-borne diseases (VBDs) (Pandey et al.,

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2021). Such diseases, carried by organisms such as mosquitoes, ticks, and fleas, thrive in environments with optimal conditions, including Temperature, humidity, and water availability. Specifically, environmental changes are increasingly associated with increased vector-borne disease cases, such as malaria and dengue. These diseases, whose transmission is influenced by mosquitoes such as the Anopheles and Aedes species, have become a major public health concern in most regions of the world. Industries such as deforestation, which alter ecosystems and population density in specific areas, also provide new breeding sites for mosquito species (Vora, 2008). On the same note, high urbanization and climatic changes have altered rainfall distribution and Temperature variation, which has widened the scope for disease-carrying vectors. Sutherst, (2004) points out the contribution of climate change to the geographic spread of these vectors and their ability to spread diseases into novel areas, especially the tropics and subtropics, where favorable weather supports mosquito growth.

In tropical and subtropical regions, where the diseases are already at the endemic stage, the need to pay attention to the VBDs in terms of environmental degradation is especially acute. These regions are extremely intolerant of variations in environmental conditions, including temperature and precipitation, which have a direct impact on the mosquito life cycle and its ability to transmit diseases. Natural ecosystems and wildlife also become unstable due to environmental degradation, which changes the interaction between species that favor the survival of vectors and the spread of pathogens. Loss of biodiversity lowers the number of natural predators of mosquitoes and ecological buffers that would otherwise check the dynamics of the disease. Research indicates that the ecological changes that occur as a result of climate, such as an increase in temperature and changes in precipitation, remodel the behavior and distribution of the vectors in the natural environments (Patil et al., 2017). In a similar manner, any disturbance in the habitat structure and the wildlife community may provide novel breeding habitats, which multiply the chances of malaria and dengue outbreaks in the degraded landscapes (Githeko et al., 2000). Such ecological connections underscore the importance of considering the idea of the emergence of vector-borne diseases as a result not just of environmental change that is instigated by human actions, but also a result of instability in the broader ecosystem. The increasing global temperatures, the resulting climate change, the increasing incidence of extreme weather patterns, as well as the failure to predict rainfall patterns, have further exposed these areas to the spread of malaria, dengue, and other VBDs. Tol & Dowlatabadi, (2001) argue that climate change can cause significant changes in the distribution of these diseases because it can change the habitats of the vectors.

Disease prevention and control can only be achieved when the relationship between the environment and the occurrence of VBDs is understood. This paper seeks to research the role of certain environmental influences in promoting malaria and dengue, including deforestation,

urbanization, and climate change. This study aims to inform population health policies and enhance the management of VBDs in endemic areas by examining the links between VBDs and these environmental changes. According to Obradovic et al., (2022), there is a need to devise integrated measures to monitor environmental health impacts, particularly in disease-prone areas. Ma et al., (2022) also focus on the role played by ecological considerations in the study of the mechanism of climate change as a cause of the spread of vector-borne diseases. Furthermore, as Walsh et al., (1993) expound, deforestation exposes an individual to these diseases by leaving them exposed to new habitats where the vectors have a higher chance of survival.

Literature Review

The connection between environmental modification and the spread of vector-borne diseases (VBDs), especially malaria and dengue, is well documented. Environmental factors such as temperature, rainfall, humidity, and land directly affect the multiplication of the disease-carrying mosquitoes. The increase in temperatures and changes in precipitation patterns has been attributed to the expansion of their geographic distribution. Increased Temperature helps the mosquito to develop faster, and the rainfall alteration forms stagnant water, which is good for breeding. Also, land use alterations, including deforestation and urbanization, have disturbed natural habitats and provided the vegetation with poor habitats. In this case, deforestation has been proven to support significant mosquito vectors that carry human pathogens. With agricultural development, caused by forest clearing, the disruption of natural ecosystems creates new mosquito breeding habitats, thus increasing disease spread Burkett-Cadena & Vittor, (2018).

Deforestation is an important factor in enhancing the spread of VBDs. The destruction of forests alters the local microclimate, making it more favorable to mosquito larval growth. Poor waste management is also a factor that contributes to the increase in mosquitoes. Examples of such breeding environments are stagnant water and waste collection in cities, specifically in inadequately maintained drainage systems. Containers and rubbish are littered, and this eventually collects rainwater, thus offering a breeding area to the mosquitoes. The problem is also exacerbated by urban sprawl, in which fast-growing cities lack adequate infrastructure to handle garbage and wastewater. The significance of vector control has been highlighted in several research papers, which document that controlling mosquito populations is key to managing VBD outbreaks, along with controlling long-term diseases such as malaria and dengue Metachew & Nemeon, (2024).

The fast urbanization in the area has contributed to both malaria and dengue outbreaks due to environmental degradation. Poor sanitation, high population density in urban areas, and an insufficient waste management system create an environment where vectors flourish. These cities tend to be very ineffective in managing water, and this is a factor that leads to stagnant water that breeds mosquitoes. This is especially observed in tropical and subtropical areas, where the impacts of environmental

degradation are most felt, leading to increased rates of disease transmission. Due to the increasing prevalence of these diseases in urban areas, especially where environmental management is poor, there is a concept of an integrated approach to public health that aims at minimizing the risk associated with environmental alterations. Another key variable that enhances the transmission of VBDs is climate change, which affects vector distribution and makes vectors highly active when the climate is hot, resulting in higher outbreak rates of diseases such as malaria and dengue Wilson et al., (2020).

Other aspects that are discussed by Pandey et al. (2021) include the role of climate change alongside the distribution of vectors, in the severity and prevalence of disease outbreaks. The changing climatic conditions have contributed to the rise in the prevalence rate of these diseases in some of the vulnerable regions. The above factors explain why it is important to observe and learn the influence of environmental degradation on the transmission of VBDs. Good control measures, based on vector control and disease reduction, are key to curbing these emerging threats, particularly in areas where urbanization is rapidly growing and environmental degradation is widespread (Hussain et al., 2024).

Objectives of the Study

The primary research question of the study is to discuss the degradation of the environment and the spread of malaria and dengue diseases in their areas of occurrence. The change in environment, deforestation, urbanization, and climate change have been shown to influence the change in the distribution and behavior of vectors like the mosquitoes that carry these diseases. Through examining the connection that exists between environmental degradation and malaria and dengue, the research undertaken seeks to offer a clearer insight into the effects that environmental problems have on the rising cases of malaria and dengue, particularly in the regions of the tropics and subtropics. This will assist in developing the most significant environmental conditions that will facilitate the propagation of these illnesses. In addition to the first objective, there are minor objectives of the research. Some of the key secondary objectives include evaluation of the association between environmental factors, such as Temperature, rainfall, changes in land use, and poor waste management on the one hand, and the prevalence of vector-borne diseases on the other hand. When these factors are assessed, the study would put in place the most likely changes in the environment that would be related to the rise in incidence of malaria and dengue. The analysis will be utilized in determining the environmental conditions predisposing to the disease to be targeted and inform the appropriate intervention.

The other significant secondary objective is to determine the effectiveness of environmental management in curbing the spread of malaria and dengue. This involves the assessment of the current strategies, including the programs on vector control, waste management, and protection of the natural habitats, to evaluate the effectiveness of the measures towards alleviating the effects of environmental degradation on the transmission of the disease. This study will help recommend ways to improve disease control and

prevention tools in susceptible areas by identifying the successes and limitations of existing interventions.

Methods

In this study, an observational design will be adopted to determine the relationship between environmental degradation and malaria and dengue transmission in the affected regions. Observational design enables the collection and analysis of real-time environmental data and the prevalence of VBDs without controlling variables, providing an accurate representation of the situation in various areas. Several sources will be used to gather data on the effects of environmental alterations on the propagation of malaria and dengue.

The data to be gathered will be that of environmental and health data. Environmental data will comprise land use, deforestation, climatic patterns, and the quality of water. The data will be obtained through satellite images and a land-use database to identify the change in the forest cover, urban sprawl, and agricultural encroachment. Climate data such as Temperature, rainfall, and humidity levels will be acquired using climatic meteorological stations as well as climate models. The water quality data, such as the standing water and contamination rates, will be taken using local water testing programs and reports from the environmental agency. Part of the health data that will be offered will be malaria and dengue cases, which are gathered by the health surveillance systems, hospital registers, and monitoring of the vectors. This data will consist of verified cases of malaria and dengue, segregated by locality, age bracket, and severity. The surveillance data will be utilized to identify seasonal patterns in these diseases and the regions that transmit the diseases most.

Statistical analysis will be carried out to compare environmental factors with the frequency and distribution of malaria and dengue incidences. The relationship between disease incidence and environmental changes (e.g., temperature rise, deforestation) will be analyzed using regression analysis. Also, the geographic distribution of the disease cases will be analyzed by means of spatial mapping to see how the diseases are distributed in geographic terms and how these distributions compare with the environmental conditions (land use and water quality), to become familiar with the areas of high-risk and possible hotspots of the disease spread.

It is shown in Figure 1 that Temperature, wind patterns, relative humidity, and precipitation are the different environmental factors that influence the spread of diseases caused by vectors like malaria and dengue. It shows how these environmental variables vary, affecting the migration, lifespan, and genetic composition of mosquito vectors, which are significant in the spread of disease. The picture demonstrates how environmental degradation, especially climate change, can promote the development of pathogens, alter mosquito distribution, and extend the period during which mosquitoes can survive, thereby increasing the spread of vector-borne diseases.

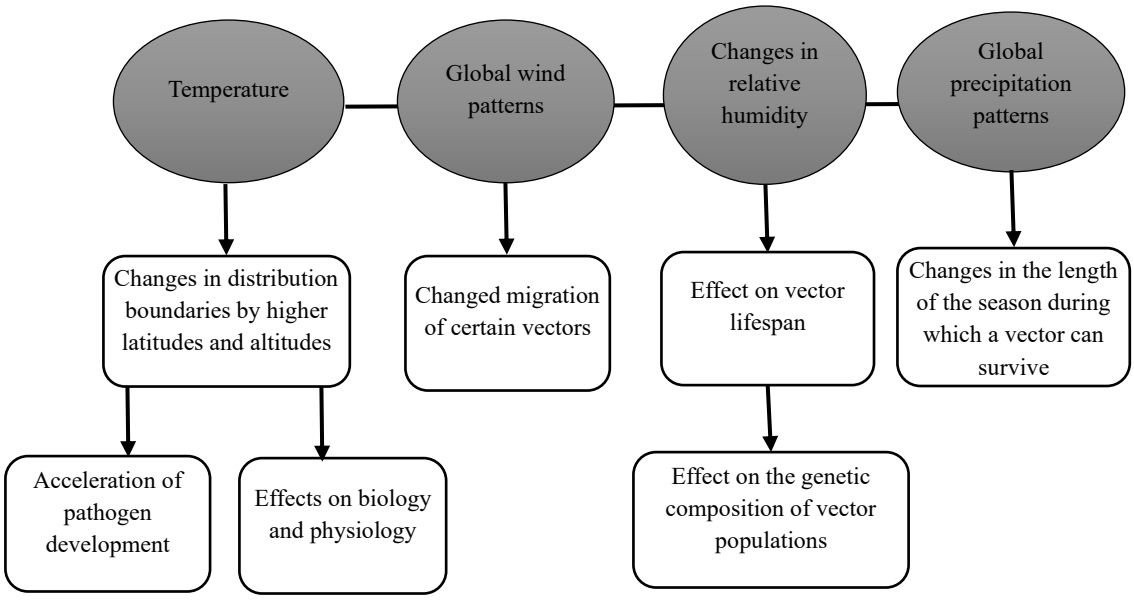

Figure 1: Impact of Environmental Factors on the Spread of Vector-Borne Diseases

Table 1: Environmental and Health Data for Malaria and Dengue Analysis

Region	Deforestation Rate (%)	Average Temperature (°C)	Rainfall (mm)	Water Contamination (mg/L)	Malaria Incidence (cases/1000)	Dengue Incidence (cases/1000)
Region A	15%	29	1200	0.5	50	35
Region B	30%	31	1500	0.8	70	50
Region C	10%	28	900	0.3	40	25
Region D	40%	33	1800	1.0	90	65
Region E	25%	30	1300	0.6	60	45

In Table 1, the environmental statistics for five regions are introduced, including deforestation rates, mean Temperature, precipitation, and water pollution rates. It also entails the malaria and dengue incidence rates of each region. The information will be used to match environmental conditions with disease prevalence and to identify patterns and trends that will help define the effects of environmental degradation on disease spread. The findings will be used to analyze the roles of deforestation, climatic and water-quality changes in the spread of malaria and dengue.

Result

This was suggested by the environmental analysis and prevalence of malaria and dengue, which showed a high level of correlation between degradation of the environment and the spread of the vector-borne diseases (VBDs). The results indicate that regions with high deforestation, high Temperatures, high levels of rainfall as well as poor water quality have high rates of malaria and dengue. In order to be more specific, locations with a deforestation percentage of more than 30% showed a considerable rise in malaria and dengue cases particularly in areas where the

average Temperature exceeded 30o C. Also, regions with elevated rainfall and water pollution (which can be considered a sign of stagnant water bodies) experienced a relative expansion of mosquito breeding grounds, which directly led to increased disease prevalence.

The rates of incidence in regions with moderate deforestation (about 15-25 percent) were less but they remained high as compared to regions with minimal deforestation. This means that in case of moderate environmental degradation, the disease transmission is facilitated. Temperature statistics also showed that there is a great relation and as the overall Temperature increased by 1 C, the prevalence of malaria and dengue was increased as well. This is in line with the biological facts that high temperatures reduce the breeding cycle of mosquitoes and such diseases are spread fast.

Table 2: Malaria And Dengue Incidence By The Environmental Factor

Region	Deforestation Rate (%)	Average Temperature (°C)	Rainfall (mm)	Water Contamination (mg/L)	Malaria Incidence (cases/1000)	Dengue Incidence (cases/1000)
Region A	15%	29	1200	0.5	50	35
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The summary of the environmental factors and the rates of malaria and dengue incidence in the different regions are summarized in table 2. The statistics indicate that the more the deforestation, Temperature, rainfall, and water pollution, the more the incidence of the two diseases. The malaria and dengue were highest in areas that were more degraded, particularly those areas that had more than 30 percent of the area deforested. This proves the fact that the transmission of the vector-borne diseases is closely connected with the environmental degradation. The results of such provide a strong urgency regarding the need to improve environmental management and disease-prevention intervention based on populations to mitigate the spread of these diseases.

Figure 2 represents a correlation between various environmental variables (deforestation, Temperature, rainfall, and water contamination) in five locations. The heatmap can distinguish the variability of the factors across the regions and the effect of the environmental loss on disease transmission. Higher value on deforestation, Temperature, and water contamination is associated with higher environmental transformation and this would provide an environment that would facilitate breeding of vectors. The heatmap would allow some valuable information about how environmental degradation leads to the proliferation of such vectors as malaria and dengue and, therefore, be used to determine the steps to be undertaken to control the disease spreading.

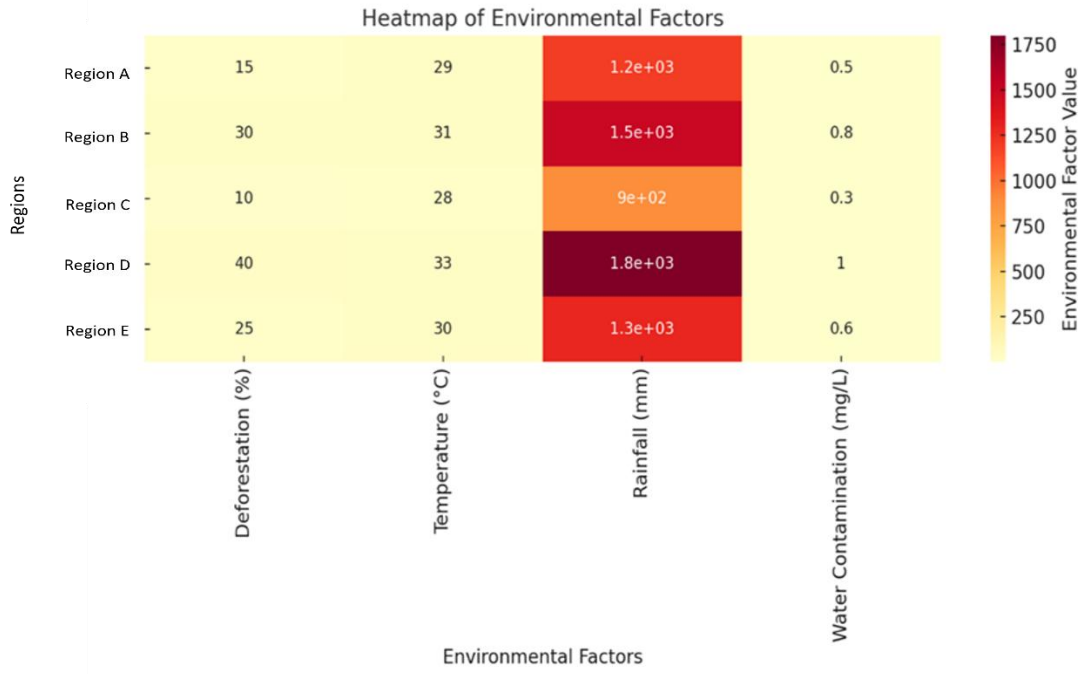

Figure 2: Heatmap of Environmental Factors Across Regions

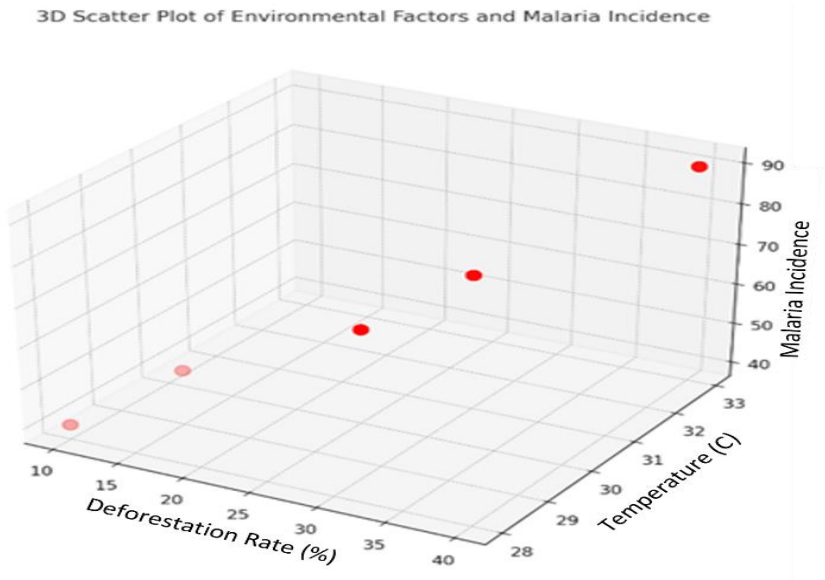

Figure 3: 3D Scatter Plot of Environmental Factors and Malaria Incidence

Figure 3 is a visualization of the correlation between deforestation rates, Temperature, and the occurrence of malaria. The plot shows that malaria cases are associated with high deforestation rates and high temperatures across various areas. The graph illustrates the interactions among the effects of the three variables in a 3D space, depicting the role of the environment in transmitting malaria. The intensity of deforestation and temperature increase results in increased malaria cases, which is why the combined environmental and population health interventions are required to

reduce the impact of environmental degradation on disease spread.

The heatmap indicates that the more intense deforestation, Temperature, and water contamination are, the more severe the environmental degradation. Such environments favour mosquito breeding, which can increase the risk of malaria and dengue. The visualization highlights the need for targeted interventions in areas experiencing severe environmental change.

Conclusion

In this paper, the significant cause of environmental degradation is explained in the transmission of the vector-borne diseases like malaria and dengue. Its findings are a good indication that environmental factors, including deforestation, increase in temperature, increase in rainfall and low water quality, are conducive to the breeding and reproduction of disease-carrying mosquitoes. Regions that have experienced more deforestation and urbanization, as well as, a shifting climate have highly contributed to malaria and dengue. These results demonstrate that environmental degradation does not only disturb the ecosystems, but also encumbers the health of the people, as it facilitates the spread of the diseases through vectors. The paper emphasizes on the need to have integrated environmental management policies through sustainable land use, effective waste management and mitigation of climate change. Furthermore, the enhancement of ecological degradation matters in terms of the spread of diseases; consequently, the enhancement of the system of vectors control and the expansion of the public health facilities infections in the weak areas are needed (Prashanth, 2025). In addition to direct effects on human health, environmental degradation compromises the ecological strength of the ecosystem to provide space to the mosquito vectors, which can multiply diseases and spread more easily. The loss of biodiversity and fragmentation of habitation increases the ability of vectors to persist in areas of infectious disease outbreaks with no inherent restraints. The fortification of the protection of ecosystems and environment management is hence vital to long-term control of the vectors-borne diseases. Combining the ecological restoration approach with the community-based-public-health initiatives can significantly improve the capacity of vulnerable groups to overcome the stress of subsequent diseases. The underlying causes of environmental degradation, particularly in tropical and subtropical regions, have to be ascertained with the view of ensuring that the malaria and dengue burden is reduced. It is an urgent and long-term intervention that would help save the environment and human health and make sure the growing threat of spreading a disease of the vectors will be appropriately addressed in the face of the current environmental changes.

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