Pan-African Journal of Health And Psychological Sciences
ISSN: 3093-4737 | www.pajhps.org
Vol.2, No.1 | Jan-March 2026

The Role of Biodiversity in Reducing Zoonotic Disease Risk under Climate Change in African Socio-Ecological Landscapes: A One Health Approach

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Abstract

Background: Climate change is increasingly disrupting Africa's socio-ecological systems, intensifying interactions among humans, animals, and ecosystems and elevating the risk of zoonotic disease transmission. Biodiversity plays a critical role in regulating disease by stabilizing ecosystems and buffering environmental shocks. However, empirical research examining the interconnected effects of biodiversity loss, climate variability, and zoonotic disease risk across African contexts remains limited. The One Health approach offers an integrated framework for understanding these linkages and informing climate-resilient health policies.

Methods: A mixed-methods study was conducted among 873 participants across diverse socio-ecological settings in Africa. Data were collected using an interviewer-administered structured questionnaire capturing socio-demographic characteristics, perceptions of biodiversity change, climate impacts, human–animal interactions, awareness of zoonotic diseases, and routine One Health practices. Quantitative data were analyzed using descriptive and inferential statistics, while qualitative responses were examined through thematic analysis to contextualize community experiences. Ethical approval was obtained, and informed consent was secured from all participants prior to data collection.

Results: Most participants reported declining biodiversity associated with increasingly unstable climate patterns, including prolonged droughts and unpredictable rainfall. Habitat degradation, reduced wildlife diversity, and intensified competition for water and grazing lands increased human–

animal contact and perceived zoonotic disease risk. Communities reporting stronger ecosystem integrity and community-based conservation practices perceived lower zoonotic risk and demonstrated greater resilience to climate-related health impacts. While awareness of zoonotic diseases was moderate, collaboration among human, animal, and environmental health sectors remained limited.

Conclusion: Protecting biodiversity within Africa's socio-ecological systems can reduce zoonotic disease risk while strengthening climate resilience. Enhanced One Health collaboration, ecosystem conservation, and integration of community knowledge into climate-smart adaptation strategies are essential. Biodiversity-based interventions represent a sustainable long-term approach to improving public health outcomes in a warming African climate.

Keywords: One Health; Biodiversity; Zoonotic diseases; Climate change; Climate resilience; African landscapes; Ecosystem health; Human–animal–environment interface

Introduction

Zoonotic diseases represent more than 60% of emerging infectious diseases, and Africa is known as a hot spot worldwide because of its high biodiversity, wide animal species, and human and animal interaction that is fueled by agriculture and pastoralism (1). Moreover, population growth, urbanization, and habitat encroachment continue to enhance these interactions and are conducive to spillover events. In Africa, lack of access to animal and human health care further adds to these risk factors and makes people vulnerable to zoonoses.

Climate change is accelerating the ecological and environmental changes that indirectly and directly affect the zoonotic disease dynamic (2). Changes in the warming and rainfall patterns of the planet influence the habitats and migrations of the vectors of the diseases like mosquitoes and ticks. Climate change increases the stress of the planet and influences the survival of the zoonotic diseases through flood and drought cycles (3). Climate change influences the rural settings of the African continent that rely heavily on the ecological environments of the planet for support and livelihood.

A key role in the control of infectious diseases is provided by biodiversity, such as the "dilution effect," where a large number of species hinder the pathogen amplification process by reducing the prevalence of highly competent reservoir populations (4). On the other hand, loss of biodiversity caused by deforestation, agricultural expansion, land conversion, and climatic change alters ecosystems, making them less complex, thus increasing the interaction between humans, domestic livestock, and wildlife, and as such, the susceptibility to the emergence and re-emergence of diseases rises (5). Not only does loss of biodiversity hinder the ability of natural habitats to protect ecosystems, but it also impedes the indigenous systems of livelihood, thus increasing vulnerability to health and socio-economic challenges in Africa (6).

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One Health approach understands and takes cognizance of the fact that human health, animal health, and environment are inherently integrated, thereby gaining increasing prominence as an approach to zoonoses and climate change adaptation in recent years (7). One Health, by facilitating intersectoral coordination, dynamic surveillance, and the use of environment-based interventions, takes a broader approach to address any health complexities at the human-animal-environment nexus. Although One Health is gaining significant attention as an approach endorsed by various global health policies and advocates, empirical evidence is still sparse at the grass-root level about the contribution of biodiversity conservation to the prevention of zoonoses in climate change contexts in Africa (8). While fulfilling this crucial information deficit, this article examines the contribution of biodiversity in fighting zoonoses associated with an African climate change.

Methods

Study Design and Setting

A mixed-methods design based on a Cross-sectional study was used to assess the quantitative and qualitative aspects of biodiversity, Climate Change, and Zoonotic Disease Risk, under the framework of One Health. This Multi-disciplinary Study was performed in selected Rural / Peri-Urban Socio-Ecological Landscapes of Africa, representing Mixed Crops/Livestock production systems, proximity to Wildlife Habitat, and highly Climate Sensitive environments exposed to the effects of Drought, Flood, and Temperature Variability (9) which are the typical types of Human-Animal-Environment Interfaces, having high frequency of interactions and increasing visibility of Ecological Changes to the surrounding environment. By utilizing the Mixed-Methods approach, the numerical trend information could be cross-referenced with the Community's Perceptions/Experiences and thus strengthened the contextual basis for interpretation of the findings.

Study Population and Sample Size

There were a total of 873 adults polled for this research. The respondents came from different jobs and social classes (i.e., croppers, livestock keepers, mixed farmers, conservationists) all living in the selected study areas. Respondents had to be 18 or over and live in the area at least one year before the survey for knowledge of the local environmental and health issues. The researchers utilized a method to select poll participants which assures adequate representation for the main livelihood and exposure categories, reducing bias in the poll and allowing for better generalization of results to similar regions in Africa (10).

Data Collection Tool

Data were gathered through a structured questionnaire created by an interviewer and based on known indicators of the One Health concept. The questionnaire collected data on demographic characteristics, perceptions of biodiversity, climate variation and impacts, links between humans and animals, links between humans and the environment, links between animals and the environment, knowledge about

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zoonotic diseases, personal experience with zoonotic diseases, and individual behaviours related to adaptation and prevention (11). The questionnaire was developed according to contextual factors and conducted in the local language of those being surveyed whenever appropriate/possible. Before running the survey, the questionnaire was pre-tested by interviewing a sample number of potential respondents who were considered to provide information on the clarity, appropriateness, and internal consistency of the instrument. Revisions based upon recommendations from the pilot subjects contributed to a more reliable and valid questionnaire (12).

Data Analysis

Statistical software was used to enter the quantitative data and perform a descriptive statistical analysis (frequency and percentage) to summarise the characteristics of the respondents and the major variables of interest in the Study. The results were presented in a tabular format for easy comparison among indicators.

Qualitative answers from the open-ended questions were transcribed, coded, and analysed thematically to identify themes and patterns of commonality and contextual information regarding biodiversity, climate change, and zoonotic disease risk. The combination of the qualitative results and the quantitative findings provided a more thorough understanding of the relationships and perceptions among communities (13).

Ethical Considerations

The research study has received permission from the ethical review board of the Desh Bhagat University, IRB/DBU/2024/017 (Before data was gathered). Participation was completely voluntary and respondent gave their informed consent after being presented with details concerning the study (its purpose, procedures, risks and benefits). To protect confidentiality and anonymity, all personal identifiers were removed from data collection and access to the research data restricted to members of the research team alone (14). Participants were told they could withdraw from the research at any time without any consequences.

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Results

Table 1. Socio-demographic profile of study respondents (n = 873)

Variable	Category	Frequency (n)	Percentage (%)
Sex	Male	492	56.4
	Female	381	43.6
Age group (years)	18–29	164	18.8
	30–44	287	32.9
	45–59	262	30.0
	≥60	160	18.3
Education level	No formal education	214	24.5
	Primary	318	36.4
	Secondary	226	25.9
	Tertiary	115	13.2
Primary occupation	Crop farmer	281	32.2
	Livestock keeper	253	29.0
	Mixed farming	129	14.8
	Conservation-related work	92	10.5
	Other	118	13.5
Length of residence	<5 years	134	15.4
	5–10 years	137	15.7
	>10 years	602	68.9

The data in Table 1 above also presents a moderately male Ch Masalande population (56.4%) compared to a female population of (43.6%), which may indicate a slightly greater availability of men in this population to undertake livelihood activities associated with land use and animal husbandry. Regarding age, the data shows a major age group of between 30-44 years (32.9%) and between 45-59 years (30.0%) which may indicate that most of these individuals are actively involved in productive activities associated with decision-making on agriculture and environmental aspects.

Regarding educational attainment, there was low to moderate attainment of education, with the majority having primary education (36.4%) and no formal education (24.5%), while only 13.2% attained tertiary education; this raises concerns about limitations in formal learning about science and health information and underlines the integral role of community-based awareness in One Health and Climate Resilience initiatives.

Livelihood activities were mainly characterized by natural resources-related jobs in crop (32.2%) and livestock rearing (29.0%), with the remainder (14.8%) involved in agroecological practices that integrate both crop and livestock production activities. The livelihood activities indicate a significant reliance on natural resources with tight interactions among humans, animals, and the environment, which are known to play a crucial role in the risk of zoonosis as well as the impact of climate change. The fact that there are contributors in conservation activities (10.5%) sheds light on biodiversity conservation in the study region.

Finally, the length of residence information suggests a strong sense of community roots, with 68.9% of the respondents living within the community for more than 10 years. This informs the existence of considerable knowledge within the community, which enhances the validity of the perception regarding biodiversity, climate change, and zoonotic disease.

Table 2. Respondents' perceptions of biodiversity and climate change impacts

Indicator	Increased (%)	No Change (%)	Decreased (%)
Wildlife species diversity	12.3	19.9	67.8
Vegetation cover	15.7	22.4	61.9
Presence of natural predators	10.8	27.6	61.6
Forest or woodland area	9.4	24.3	66.3

Rainfall predictability	9.5	19.1	71.4
Frequency of droughts	68.2	14.6	17.2*
Frequency of floods	44.7	28.5	26.8

The results presented in Table 2 illustrate the strong perception of environmental decline and increasing climate variability within the region by the community. The majority of respondents noted a decline in the diversity of wildlife species (67.8%), vegetation cover (61.9%), natural predators (61.6%); and forest or woodlands (66.3%). Each of these indicators is indicative of the loss of biodiversity and degradation of habitat that has likely resulted from land-use changes and climate-induced stressors, both of which can destabilize ecosystems and raise the opportunity for interaction between humans and animals.

Perceptions of climate change are particularly evident. The largest percentage of respondents reported that rainfall predictability has declined (71.4%) indicating that there is an increased level of uncertainty regarding the seasonal behaviour of rainfall, which is a fundamental determinant of agricultural production, the availability of fresh water, and the overall stability of ecosystems. A large percentage of respondents also perceived an increased frequency of drought conditions (68.2%) which correlates with an increase in climate stresses and extended periods of dryness. Further, the majority of respondents perceived an increase in flooding events (44.7%) which reinforces the fact that communities are now experiencing the extremes of conditions related to both drought and flooding.

The combined findings indicate that individuals are experiencing the simultaneous decline of biodiversity as well as increasing climate instability, which will contribute to an increased risk of zoonotic diseases. Due to the diminished complexity of ecosystems combined with unpredictable climate extremes, wildlife and livestock are being forced to aggregate in close proximity to each other as their resources decline. As a result, there is an increased potential for human–animal interactions that are conducive to Spillover Phenomena and thus impact the risk of zoonotic disease transmission in the context of One Health.

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Table 3. Patterns of human, livestock, and wildlife interactions

Interaction Variable	Yes (%)	No (%)	Not Sure (%)
Livestock share grazing areas with wildlife	72.1	21.4	6.5
Livestock share water sources with wildlife	65.7	26.9	7.4
Wildlife enter crop fields	58.3	34.6	7.1
Humans handle sick animals	42.6	49.8	7.6
Consumption of bushmeat	18.9	72.4	8.7
Increased animal movement due to climate stress	63.8	22.7	13.5

The interactions among humans, livestock and wildlife in the study area were frequent and multidirectional, reflecting a very high-risk human-animal-environment interface (Table 3). The majority of respondents reported that livestock shared grazing (72.1%) or water (65.7%) with wildlife, indicating that livestock and wildlife commonly use the same space for resources. These shared spaces create a higher opportunity for wildlife and livestock to exchange pathogens and, if these pathogens hijack into the human population.

Over half the respondents (58.3%) had also observed wildlife entering their corn crops, which indicates habitat encroachment, difficulty in finding food, and are also experiencing issues related to land-use changes and stresses caused by climate. Almost 40% of the respondents (42.6%) stated that they had handled sick animals, which poses a direct risk of transmission of zoonotic disease, especially when no access to personal protective equipment or veterinary assistance is available.

The majority of respondents reported bushmeat consumption, with computationally significant amounts (18.9%). However, bushmeat consumption also presents an epidemiological threat via association with high-risk zoonotic pathogens.

Additionally, over 63% of study participants (63.8%) reported increased animal movement due to climate pressures from droughts and floods, which in turn causes wildlife and livestock to become more mixed with humans through a variety of means, including changes in the availability of various resources as a result of creating more stressors and enabling increased movement of wildlife to livestock.

These findings reinforce the idea that overutilizing resources due to ecological pressures caused by climate change is creating situations where there is increased human-wildlife interaction. Conservation of biodiversity, good resource management, and application of One Health concepts will help to

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lower the chance of transmitting zoonotic diseases from these mixed ecological landscapes.

Table 4. Awareness, exposure, and response to zoonotic diseases

Indicator	Yes (%)	No (%)	Not Sure (%)
Awareness of zoonotic diseases	61.4	30.8	7.8
Knowledge of animal-to-human transmission routes	54.9	37.2	7.9
Reported animal disease outbreaks in last 5 years	46.7	38.1	15.2
Household member experienced animal-related illness	29.6	62.4	8.0
Sought formal healthcare	67.3	32.7	—
Used traditional remedies	41.9	58.1	—

Based on Table 4, there were moderate levels of knowledge about zoonotic diseases among the people surveyed. Sixty-one point four percent of those surveyed indicated that they were generally aware of zoonotic diseases while fifty-four percent knew how animals transmit disease to humans. Still, the number of people who had no idea or who were not sure about what caused zoonotic diseases posed a challenge to communities being able to identify and manage the disease quickly and effectively.

Of all respondents, nearly half (46.7%) said they had witnessed outbreaks of animal diseases during the past five years, which indicates that pathogens continue to circulate among animals within the surveyed regions. Conversely, only twenty-nine percent (29.6%) of respondents said a family member had become sick due to a zoonotic disease; therefore, it may be possible that there was a substantial amount of missed cases, misreported symptoms or little access to diagnosis.

Respondents exhibited varying levels of health-seeking behaviors after exposure to a zoonotic disease. Most people (67.3%) who displayed symptoms were willing to obtain formal medical care from health facilities and responded positively to the use of biomedical services, showing a reasonable level of trust in health facilities and biomedical services. However, there was also a large number of respondents (41.9%) who indicated they turned to traditional remedies to treat their symptoms. This represents the persistent use of indigenous knowledge in managing zoonotic diseases. Therefore, this information suggests potential solutions would be to develop culturally

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appropriate educational campaigns that will involve the communities and promote prompt disease reporting, treatment, and prevention as part of a One Health Approach.

Table 5. Relationship between biodiversity conservation and disease risk perception

Conservation Indicator	Lower Risk (%)	Moderate Risk (%)	Higher Risk (%)
Presence of protected areas	69.3	21.6	9.1
Active community conservation groups	64.8	25.4	9.8
High vegetation diversity	71.5	19.2	9.3
Presence of predators controlling rodents	66.7	23.1	10.2
Degraded ecosystems	34.6	29.8	35.6

The results of the survey demonstrate a positive relationship between the reported level of biodiversity conservation and the perceived risk for zoonotic diseases among respondents. Across several communities, respondents who reported the existence of protected areas reported a greater likelihood of low perceived disease risk (69.3%), signifying that they view these formally designated areas as a buffer to disease emergence. Likewise, respondents in areas that had community conservation initiatives reported substantially lower (64.8%) levels of perceived disease risk, indicating that stewardship and participative conservation efforts are important contributors to community health security.

Extensive vegetation diversity was identified as the single most significant indicator of perceived lower disease risk (71.5%), which supports the idea that intact and complex ecosystems provide a means of regulating pathogen transmission and serving to stabilize ecosystems. Additionally, the presence of natural predators that prey upon rodents and other small mammals is seen to decrease the perceived risk of zoonotic disease (66.7%), which supports the concept that communities have an understanding of ecological processes through natural regulation of reservoir hosts.

On the other hand, degraded ecosystems have been shown to have a strong correlation with increased levels of perceived disease risk; 35.6% of respondents reported high levels of perceived risk, while only 34.6% of respondents reported low levels of perceived risk. Therefore, this

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demonstrates the relationship between degradation of an ecosystem and a higher level of perceived risk of zoonotic disease through increased human–animal contact and spillover of pathogens. Based upon these findings, biodiversity conservation activities can be viewed as a protective measure against zoonotic disease in the One Health concept of health.

Table 6. One Health coordination, adaptation practices, and resilience outcomes

Variable	Yes (%)	No (%)	Not Sure (%)
Coordination between health, veterinary, and environmental sectors	28.4	53.7	17.9
Access to veterinary services	61.2	30.6	8.2
Livestock vaccination practices	58.9	33.4	7.7
Participation in climate adaptation programs	36.5	49.2	14.3
Biodiversity conservation improves climate resilience	72.6	14.8	12.6
Willingness to support conservation for disease prevention	78.9	9.7	11.4

Table 6 shows the relative strengths and weaknesses of One Health Coordination, Adaptive Practices, and Resilience Outcomes across the Selected Study Communities. The study found that only 28.4% of respondents felt they had some degree of formalised coordination between Human, Veterinary, and Environmental Health Sectors, over half of the respondents (53.7%) indicated that such formalised coordination did not exist. The lack of coordinated action at the community level, in conjunction with the established importance placed on One Health Approaches in managing the risk of Zoonotic Disease suggests weak institutional linkages amongst community stakeholders at the local level.

In contrast, about 61.2% of respondents indicated they had access to Veterinary Services and 58.9% of respondents indicated participation in Livestock Vaccination Practices indicating a comparatively strong degree of capacity in the Animal Health Sector when contrasted to the degree of formalised coordination across Sectors. However, only 36.5% of respondents indicated participation in Structurally Developed Climate Adaptation Programs indicating that structured Climate

Resilience Initiatives may not have broad reach or availability in the Study Landscape.

The perception of positive Ecosystem Based Resilience was also evident, with the overwhelming majority of respondents agreeing to the statement Biodiversity Conservation Improves Climate Resilience (72.6%) and an even greater percentage of respondents expressing a willingness to support Conservation Initiatives for the Purpose of Disease Prevention (78.9%). These findings indicate a strong level of readiness and socially acceptable support for Biodiversity Centred One Health Interventions. This willingness to support can be leveraged through improved Intersectoral Coordination and the Development of Broader Climate Adaptation Programming to create significantly improved Zoonotic Disease Prevention and Climate Resilience.

Discussion

This study demonstrates that biodiversity conservation contributes significantly to reducing zoonotic disease risk in African socio-ecological landscapes under conditions of increasing climate stress. Respondents consistently associated declining biodiversity with intensified human–animal interactions, including shared water sources and grazing areas, which are well-recognized pathways for zoonotic pathogen transmission (4). Similar ecological evidence has shown that ecosystem simplification and habitat degradation increase spillover risk by amplifying contact between humans, livestock, and wildlife reservoirs (5). These findings reinforce the protective role of intact ecosystems in buffering disease emergence within complex socio-ecological systems (15).

Climate variability further exacerbated vulnerability to zoonotic diseases by altering vector habitats, wildlife movement, and water availability. Respondents reported that prolonged droughts and irregular rainfall patterns concentrated animals around limited resources, thereby increasing interspecies contact. Climate-driven ecological disturbances have been widely documented as drivers of changes in vector distribution, pathogen survival, and seasonal disease dynamics in tropical and subtropical regions (2). Additional studies confirm that climate stressors influence the persistence and geographic spread of zoonotic pathogens (19).

The findings strongly support the core principles of the One Health approach, which emphasizes integrated surveillance, coordinated policy responses, and cross-sector collaboration among human, animal, and environmental health systems (7). Communities with active biodiversity conservation and ecosystem management practices reported lower perceived disease risk and greater resilience to climate-related health shocks. This suggests that conservation initiatives, when embedded within broader health and climate adaptation strategies, function as preventive public health interventions rather than solely environmental actions (20).

Community-based conservation emerged as a particularly effective and contextually appropriate climate adaptation strategy.

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Through local stewardship, preservation of ecosystem services, and protection of traditional livelihoods, such initiatives enhance ecosystem stability and community-level health resilience (21). These findings align with evidence supporting participatory approaches that integrate indigenous knowledge, conservation practices, and health awareness within One Health frameworks (22).

Despite these positive outcomes, the study identified persistent gaps in coordination between human, animal, and environmental health services. Limited intersectoral communication, fragmented surveillance systems, and insufficient resource allocation continue to hinder effective One Health implementation at the community level. Similar institutional and governance barriers have been reported across Africa, where sectoral silos impede operational integration of One Health policies (6). Addressing these systemic constraints is essential to translate One Health principles into sustained, climate-resilient zoonotic disease prevention strategies (18).

Overall, this study adds to the growing body of empirical evidence that biodiversity conservation in African socio-ecological landscapes is not only an environmental necessity but also a fundamental component of zoonotic disease prevention and climate resilience. Strengthening One Health coordination and embedding biodiversity-centered interventions into climate adaptation and public health policies are critical for preparedness against future zoonotic threats (8).

Conclusion

The diverse and complex aspects of biodiversity are important for managing the risk of zoonotic disease and increasing climate resilience in the social and ecological systems of Africa. The results of this research show that healthy ecosystems, with many different species living together, reduce negative interactions among humans, animals, and the environment that may help pathogens transfer from one species to another when climate changes create more opportunities for these interactions. Biodiversity conservation is, therefore, not only a priority for the environment but also an important public health strategy for regions that are vulnerable to climate change.

Enhancing collaboration across the various sectors of human, animal, and environmental health is necessary to derive the many ecological benefits provided by healthy ecosystems to create lasting solutions to zoonotic disease. Integrated surveillance systems, aligned policies across sectors, and community-based initiatives are all effective ways to improve early detection and preparation for, and response to, zoonotic threats. Incorporating community knowledge, local management, and participatory conservation into climate adaptation and health planning is also an important way to create capacity and enhance public health.

Strategies that emphasise biodiversity are a resilient, low-cost option for addressing zoonotic disease threats at the national and regional levels in Africa. The development of strategies that advance the integrity of

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ecosystems, protect livelihood opportunities, and promote the long-term health of animals and humans in a changing climate is possible through the incorporation of biodiversity strategies into national and regional One Health and climate policies.

Take-Home Message

The conservation of biodiversity is an effective way to lower the risk of zoonotic disease transmission while also increasing economic and ecological resilience in Africa's socio-ecological systems. The integration of ecosystem conservation with community-based engagement and collaboration between human, animal and environmental health will provide a coordinated One Health approach that will achieve enhanced ecological and climate resilient disease prevention.

Authors' Contributions

Dr. Stephen Monday developed the study, designed the methodology, interpreted the data, and wrote the first draft of the manuscript. Professor (Dr.) Harvinder Kaur Sidhu provided general academic guidance, critically reviewed the study design and methodology, and provided significant written input on the intellectual aspects of the paper. Shua-chet Daniel Gimbason organised the data and conducted descriptive statistical analyses and interprets the county and gender-specific findings and contributed to both the "Results" and "Discussions" sections. Dr. Arti Thakur developed the literature review, contributed to the theoretical framework and policy implications of the study, and reviewed the manuscript for consistency, clarity, and adherence to the journal's guidelines. All authors have read and approved the final version of the manuscript and take responsibility for its content.

Acknowledgement

The authors would like to acknowledge all members of the community under study for taking the time to participate in this research. Additionally, gratitude goes to local leaders, field assistants, and those from extension offices for their cooperation while conducting this study. Acknowledgment is also extended to Desh Bhagat University in appreciation of their ethics and institutional support that made this research possible.

Conflict of Interest

The authors declare that they have no competing interests or conflicts of interest related to this study.

Disclaimer

The opinions expressed in this article are those of the contributors alone and do not necessarily represent the views, policies, or position of any of the institutions and/or ethics review boards with which they are affiliated.

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