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RESEARCH ARTICLE

Deforestation, Air Quality Degradation and Increased Cardiopulmonary Diseases

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ABSTRACT

Deforestation has become a key environmental factor that causes air quality deterioration with major consequences on human health. Massive deforestation changes atmospheric processes by increasing biomass burning, decreasing carbon sequestration, and raising levels of air pollutants, such as fine particulate matter, carbon monoxide and nitrogen oxide and ozone-forming compounds. These developments have led to worsening of the air quality in the local, regional, and transboundary levels. With the long-term effects of air pollution as a result of deforestation, there are an increasing number of studies indicating it to be related to negative cardiopulmonary effects, especially respiratory diseases, cardiovascular morbidity, and untimely death. The biological processes behind it are systemic inflammation, oxidative stress, endothelial dysfunction, and impaired pulmonary functioning that disproportionately impact vulnerable groups of people including children, the elderly, and people with underlying conditions. The current research paper is a synthesis of available evidence on the relationship interplay between deforestation, air quality deterioration and cardiopulmonary diseases. The abstract has incorporated both environmental and epidemiological approaches to highlighting the burden on health due to land-use change and also the necessity of a coordinated intervention at the environmental level and health-related policy level to alleviate the risks of air pollution by deforestation to the cardiopulmonary system.

Keywords: Deforestation; Air quality; Air pollution; Cardiopulmonary diseases; Public health; Environmental change

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INTRODUCTION

One of the most widespread types of environmental degradation are deforestation, which has extensive effects on both ecological balance, the structure of the atmosphere and human health. Due to deforestation to establish agriculture, cities, and mined resources, the forest has been significantly reduced in the following vital ecosystem services; carbon sequestration, purifying air and controlling climate.[1,2] Along with the loss of biodiversity and climate effects, deforestation has also become a major source of air quality degradation, specifically, through biomass burning, changes in land-atmosphere interactions, and emissions of harmful air pollutants.[3]

Land-use change has also been identified as a significant public health issue because of the degradation of air quality. Deforestation-related fires release large quantities of fine particulate matter ($PM_{2.5}$), carbon monoxide, nitrogen oxides, and ozone precursors, leading to elevated pollution levels across vast regions.[4] These pollutants can travel long distances, affecting both rural and urban populations and exacerbating existing air pollution burdens, especially in developing regions already facing rapid environmental change.[5]

A growing body of evidence links deteriorating air quality to increased cardiopulmonary diseases, including asthma, chronic obstructive pulmonary disease, ischemic heart disease, and stroke. Exposure to air pollutants triggers biological pathways such as systemic inflammation, oxidative stress, endothelial dysfunction, and autonomic imbalance, which collectively elevate cardiovascular and respiratory risks.[6,7] Climate change processes amplified by deforestation further intensify these risks by modifying pollutant dispersion, allergen distribution, and heat-related stressors that compound cardiopulmonary vulnerability.[8,9]

The health impacts of deforestation-driven air pollution are not evenly distributed. Populations in low- and middle-income regions, including parts of Africa, Asia, and Latin America, often experience higher exposure levels while having limited capacity for disease prevention and management.[10,11] Empirical studies have demonstrated associations between forest loss, increased carbon emissions, and adverse health outcomes, underscoring the intersection of

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environmental degradation and noncommunicable disease burdens.[12,13]

Against this backdrop, examining the interconnections between deforestation, air quality degradation, and cardiopulmonary diseases is essential for understanding the broader health consequences of land-use change. Integrating environmental science with public health perspectives provides critical insights into how environmental policies, forest conservation strategies, and air quality management can contribute to reducing the growing burden of cardiopulmonary diseases linked to environmental degradation.[14]

Deforestation and Air Quality Degradation

Deforestation represents a major driver of air quality degradation through its direct and indirect effects on atmospheric composition and land–atmosphere interactions. The removal of forest cover disrupts natural ecological functions that regulate air pollutants, including carbon sequestration, particulate filtration, and microclimatic stabilization. As forests are cleared for agriculture, urban expansion, logging, or mining, emissions from biomass burning, soil disturbance, and increased anthropogenic activity intensify, leading to elevated concentrations of harmful air pollutants.[1,2]

One of the most significant pathways linking deforestation to air quality deterioration is biomass burning. Forest clearing frequently involves slash-and-burn practices, releasing large quantities of fine particulate matter ($PM_{2.5}$), carbon monoxide (CO), nitrogen oxides (NO_x), and volatile organic compounds into the atmosphere. These pollutants contribute to smog formation and long-range transboundary air pollution, affecting populations far beyond deforested regions.[4,5] Empirical evidence from tropical regions demonstrates that reductions in deforestation-related fires are associated with measurable improvements in air quality and declines in pollution-related health burdens.[4]

Beyond combustion emissions, deforestation alters surface albedo, evapotranspiration, and atmospheric chemistry, thereby influencing secondary pollutant formation such as ground-level ozone. The loss of tropical forests, in particular, reduces the natural removal of ozone precursors and airborne allergens, exacerbating respiratory stress and allergic disease risks.[8,9] These processes interact with broader climate dynamics, amplifying heat extremes and stagnation events that further degrade air quality.[6,13]

In developing regions, deforestation-related air pollution is often compounded by weak environmental governance and rapid urbanization, intensifying exposure to degraded air among vulnerable populations. Studies from Asia, Africa, and Latin America highlight that environmental degradation, including forest loss, disproportionately contributes to pollution exposure where health protection systems are limited (Wang, 2004; Anakwue & Anakwue, 2014; Masood et al., 2013).[2,10,15] As a result, deforestation acts not only as an environmental issue but also as a structural determinant of air quality inequality.[11,12]

Overall, deforestation substantially degrades air quality by increasing pollutant emissions, weakening natural atmospheric regulation, and reinforcing climate-related pollution feedbacks. These processes establish a critical environmental pathway through which forest loss contributes to escalating cardiopulmonary health risks, particularly in regions undergoing rapid land-use change and environmental degradation.[6,14]

Air Pollutants Associated with Deforestation

Deforestation significantly alters atmospheric composition by disrupting natural biogeochemical cycles and increasing emissions of harmful air pollutants. Forest clearing activities particularly slash-and-burn agriculture, logging, and land conversion release large quantities of pollutants that degrade ambient air quality and contribute to adverse cardiopulmonary health outcomes. The loss of forest cover also reduces the ecosystem's capacity to filter airborne contaminants and sequester carbon, thereby amplifying pollution burdens at local, regional, and global scales.[3,13]

One of the most critical pollution sources linked to deforestation is biomass burning. Deforestation-related fires emit substantial amounts of fine particulate matter ($PM_{2.5}$), carbon monoxide (CO), nitrogen oxides (NO_x), and volatile organic compounds (VOCs). These emissions are often transported over long distances, exposing populations far from deforestation sites to degraded air quality.[4,8] $PM_{2.5}$ is of particular concern due to its ability to penetrate deep into the lungs and enter the bloodstream, increasing risks of respiratory and cardiovascular diseases.[6,7]

Deforestation also influences secondary pollutant formation. The release of NO_x and VOCs during forest fires and land-use change enhances ground-level ozone formation, especially in tropical and subtropical regions. Elevated ozone concentrations have been associated with asthma exacerbation, reduced lung function, and increased cardiopulmonary mortality.[5,9] Additionally, reduced forest cover alters local climate conditions such as temperature and humidity that can further intensify photochemical reactions and pollutant persistence.[3]

Beyond combustion-related pollutants, deforestation can indirectly increase airborne dust, pesticides, and agrochemical residues due to soil exposure and intensified agricultural activities. These pollutants contribute to chronic inflammation and long-term noncommunicable

Table 1: Major Air Quality Impacts of Deforestation

Deforestation Activity	*Primary Air Pollutants Released*	*Air Quality Effects*	*Key Supporting Evidence*
Biomass burning (slash-and-burn)	$PM_{2.5}$, CO, NO_x, VOCs	Severe particulate pollution, regional haze, reduced visibility	4,5
Loss of forest carbon sinks	CO_2, ozone precursors	Increased background pollution and secondary ozone formation	3,12
Soil disturbance and land clearing	Dust, coarse particles	Elevated particulate loading and local air degradation	1,2
Reduction of natural filtration	Allergens, airborne pollutants	Higher allergen loads and respiratory irritants	7,9
Climate–air quality feedbacks	$PM_{2.5}$, ozone	Intensified pollution episodes under heat and stagnation	8,13

disease risks, particularly in low- and middle-income regions where regulatory controls may be limited.[2,14] The cumulative exposure to multiple pollutants underscores deforestation as a multidimensional environmental health risk factor.[1,11]

Overall, deforestation acts as a catalyst for both primary and secondary air pollutants that collectively degrade air quality and elevate cardiopulmonary disease risks. Understanding the specific pollutants and their pathways is essential for designing effective land-use, air quality, and public health interventions aimed at reducing the health burden associated with forest loss.[12,13]

Pathways Linking Air Pollution to Cardiopulmonary Diseases

Air pollution generated or intensified by deforestation-related activities particularly biomass burning and land-use change affects cardiopulmonary health through multiple, interconnected biological and environmental pathways. Deforestation increases ambient concentrations of fine particulate matter ($PM_{2.5}$), carbon monoxide, nitrogen oxides, and ozone precursors, thereby degrading air quality across local and regional scales.[3,4] These pollutants penetrate deep into the respiratory tract and enter systemic circulation, triggering a cascade of adverse health effects.

One principal pathway involves respiratory system injury. Inhaled $PM_{2.5}$ and ozone cause airway inflammation, reduced lung function, and heightened bronchial responsiveness. Chronic exposure exacerbates asthma, allergic rhinitis, and chronic obstructive pulmonary disease, particularly in regions where tropical forest loss alters aeroallergen distribution and pollutant loads.[5,9] Persistent airway inflammation also compromises pulmonary defense mechanisms, increasing susceptibility to infections and long-term respiratory morbidity.[7]

A second critical pathway is systemic inflammation and oxidative stress. Fine particulates and gaseous pollutants induce oxidative stress at the cellular level, leading to endothelial dysfunction and widespread inflammatory responses. These processes play a central role in the development and progression of cardiovascular diseases, including hypertension, atherosclerosis, ischemic heart disease, and stroke.[6,13] Pollutant-induced inflammation further accelerates plaque formation and destabilization within blood vessels, elevating the risk of acute cardiovascular events.

Autonomic nervous system imbalance represents another important mechanism. Exposure to air pollutants has been associated with altered heart rate variability and increased sympathetic nervous system activity, which can precipitate arrhythmias and sudden cardiac events. This pathway is particularly relevant for individuals with pre-existing cardiovascular conditions and populations in low- and middle-income regions where environmental exposures are often compounded by limited healthcare access.[2,10]

In addition, climate–pollution interactions amplify cardiopulmonary risks. Deforestation contributes to regional climate variability, including increased temperatures and altered precipitation patterns, which in turn influence pollutant formation and dispersion. Higher temperatures enhance ozone formation and prolong wildfire seasons, intensifying exposure to harmful air pollutants and reinforcing the burden of noncommunicable cardiopulmonary diseases.[8,12]

Finally, these biological pathways operate within broader contexts of environmental degradation and social vulnerability. Communities dependent on forest ecosystems or living near deforested areas often face cumulative exposures from air pollution, occupational hazards, and socio-economic stressors, which jointly magnify cardiopulmonary disease risks.[1,11,15]

Epidemiological Evidence

Epidemiological research consistently demonstrates a strong association between deforestation-driven air

Table 2: Major Air Pollutants Associated with Deforestation and Their Health Relevance

Pollutant	*Primary Source Linked to Deforestation*	*Atmospheric Behavior*	*Key Cardiopulmonary Health Impacts*	*Supporting Evidence*
Fine particulate matter ($PM_{2.5}$)	Biomass burning, forest fires	Long-range transport, persistent	Increased cardiovascular mortality, respiratory disease, systemic inflammation	4,6
Carbon monoxide (CO)	Incomplete combustion of biomass	Short- to medium-range dispersion	Reduced oxygen delivery, exacerbation of heart disease	8
Nitrogen oxides (NO_x)	Fire emissions, machinery	Precursor to ozone formation	Airway inflammation, cardiovascular stress	3,7
Volatile organic compounds (VOCs)	Biomass burning, vegetation loss	Reacts to form secondary pollutants	Ozone-related respiratory and cardiac effects	9
Ground-level ozone (O_3)	Secondary formation from NO_x and VOCs	Accumulates under warm conditions	Asthma exacerbation, reduced lung function	5,9
Dust and agrochemical aerosols	Soil exposure, intensified agriculture	Localized suspension	Chronic inflammation, cardiovascular risk	10,14

quality degradation and increased cardiopulmonary morbidity and mortality. Population-based studies, time-series analyses, and exposure–response assessments provide converging evidence that land-use change, particularly forest clearing and associated biomass burning, elevates concentrations of harmful air pollutants that adversely affect respiratory and cardiovascular health.

Large-scale observational studies from forested and rapidly deforesting regions show that deforestation-related fires significantly increase ambient levels of fine particulate matter ($PM_{2.5}$), ozone precursors, and carbon monoxide. In Brazil, reductions in deforestation-related fires were associated with measurable improvements in air quality and substantial declines in premature mortality attributable to cardiopulmonary causes, highlighting a direct epidemiological link between forest loss, air pollution, and health outcomes.[4] Similar regional assessments emphasize that land-use change modifies atmospheric chemistry and transport processes, amplifying population exposure to cardiotoxic and pneumotoxic pollutants.[3]

Evidence from low- and middle-income countries further underscores heightened vulnerability. In Southeast Asia and parts of Africa, epidemiological profiles indicate increasing burdens of asthma, chronic obstructive pulmonary disease, ischemic heart disease, and stroke in areas experiencing rapid environmental degradation, including deforestation and urban expansion.[5,10] These impacts are exacerbated by limited healthcare access and pre-existing health disparities, reinforcing deforestation as a significant, though often underrecognized, determinant of noncommunicable diseases.[13]

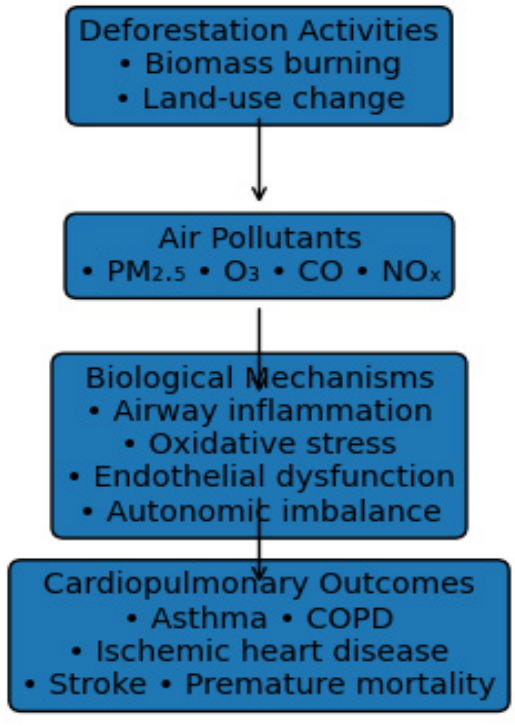

Fig 1: Conceptual framework illustrating the causal pathway linking deforestation-related activities to air pollutant emissions, subsequent biological responses, and adverse cardiopulmonary health outcomes

Longitudinal and cross-sectional studies also link climate-sensitive environmental stressors—such as altered pollen distribution, increased aeroallergens, and intensified air pollution—to rising respiratory and allergic conditions. Tropical forest loss has been implicated in worsening asthma prevalence and severity, particularly among children and sensitized populations.[9] Cardiovascular epidemiology similarly demonstrates that chronic exposure to polluted air increases systemic inflammation,

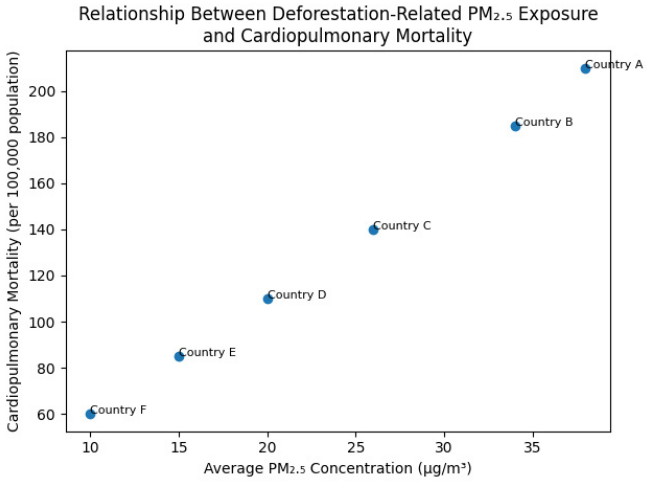

Fig 2: Deforestation contributes to increased fine particulate matter ($PM_{2.5}$) in the atmosphere through biomass burning and land-use change, leading to significant public health impacts. The graph illustrates a clear positive relationship between deforestation-related $PM_{2.5}$ exposure and cardiopulmonary mortality across countries. Regions with higher deforestation rates exhibit elevated $PM_{2.5}$ concentrations and correspondingly higher mortality rates, while low-deforestation regions show lower exposure and risk. This dose–response pattern is consistent with epidemiological findings, reinforcing evidence that deforestation-driven air pollution is an important and preventable contributor to cardiopulmonary disease burden (Reddington et al., 2015; Heald & Spracklen, 2015).

endothelial dysfunction, and atherosclerotic risk, contributing to higher rates of hypertension, myocardial infarction, and stroke.[6]

Macro-level analyses integrating environmental and health data show that deforestation, carbon emissions, and declining forest cover are statistically associated with poorer population health indicators. Empirical evidence from China indicates that reduced forest activity and increased emissions correlate with higher mortality and morbidity from cardiopulmonary diseases, even after controlling for socioeconomic factors.[12] Broader reviews of environmental degradation consistently position deforestation-related air pollution as a critical pathway linking ecological change to adverse health outcomes.[1,2,15] Overall, the epidemiological literature provides robust evidence that deforestation contributes to air quality degradation, which in turn elevates cardiopulmonary disease risk across diverse populations. These findings reinforce the need to integrate forest conservation into public health and noncommunicable disease prevention strategies.[8,11]

Public Health and Policy Implications

The interconnections between deforestation, air quality degradation, and cardiopulmonary diseases present substantial challenges for public health systems and environmental governance. Deforestation-driven emissions, particularly from biomass burning and land-use change, contribute significantly to ambient air pollution, increasing population-level exposure to harmful pollutants such as fine particulate matter and ozone. Evidence demonstrates that reducing deforestation-related fires can yield measurable improvements in air quality and corresponding reductions in morbidity and mortality, underscoring the preventable nature of these health burdens.[3,4]

From a public health perspective, deteriorating air quality linked to forest loss exacerbates noncommunicable diseases, especially cardiovascular and respiratory conditions, which already account for a growing share of global disease burden. Air pollution interacts with broader environmental stressors, including climate variability, to intensify inflammation, oxidative stress,

Table 3: Key Epidemiological Studies Linking Deforestation, Air Pollution, and Cardiopulmonary Health

Study	*Region*	*Study Design*	*Key Exposure*	*Main Health Outcomes*
Reddington et al. (2015)[4]	Brazil	Modeling & population exposure analysis	$PM_{2.5}$ from deforestation fires	Reduced cardiopulmonary mortality with fire reduction
Heald & Spracklen (2015)[3]	Global	Review & atmospheric modeling	Land-use change pollutants	Increased respiratory and cardiovascular risk
D'Amato et al. (2017)[9]	Tropical regions	Review	Air pollution, aeroallergens	Increased asthma and allergic diseases
Farooq et al. (2019)[12]	China	Econometric analysis	Carbon emissions, forest activity	Higher cardiopulmonary mortality

Table 4: Cardiopulmonary Conditions Associated with Deforestation-Related Air Pollution

Disease Category	Associated Pollutants	Epidemiological Evidence
Asthma & COPD	$PM_{2.5}$, ozone	Increased prevalence and hospital admissions[7,9]
Ischemic heart disease	$PM_{2.5}$, NO_2	Elevated mortality and morbidity[6]
Stroke & hypertension	$PM_{2.5}$, CO	Higher incidence in polluted regions[13]

and cardiopulmonary dysfunction, thereby increasing hospital admissions and premature deaths.[6,8,13] These effects are particularly pronounced among vulnerable populations, including children, older adults, urban residents, and communities in low- and middle-income regions where regulatory capacity and health infrastructure may be limited.[5,10]

Policy implications point to the necessity of integrating forest conservation into public health and air quality strategies. Land-use policies that limit deforestation, regulate agricultural expansion, and control open burning can produce co-benefits for climate mitigation and cardiopulmonary health.[12] Strengthening air quality monitoring in deforestation-prone regions is essential for early detection of pollution episodes and for informing health advisories and preventive interventions.[7] Additionally, health impact assessments should be systematically incorporated into environmental and land-management decision-making to better capture the long-term health costs of environmental degradation.[1,11]

At the governance level, addressing deforestation-related health risks requires cross-sectoral collaboration between environmental agencies, public health institutions, and urban and agricultural planners. Policies focused solely on economic development without accounting for environmental degradation may inadvertently intensify health inequities and long-term healthcare costs.[3,15] Promoting sustainable land-use practices, protecting tropical forests, and reducing pollutant emissions can therefore be viewed not only as environmental imperatives but also as cost-effective public health interventions with significant cardiopulmonary health benefits.[9,14]

CONCLUSION

The evidence reviewed demonstrates that deforestation is not solely an environmental concern but a significant public health challenge mediated through air quality degradation and its cardiopulmonary consequences. Forest loss alters land–atmosphere interactions by increasing biomass burning, reducing natural filtration of pollutants, and intensifying emissions of fine particulate matter and gaseous pollutants. These processes contribute to sustained deterioration of ambient air quality, with measurable impacts on respiratory and cardiovascular health across exposed populations.[3,4]

The link between degraded air quality and increased cardiopulmonary diseases is well established, with epidemiological and mechanistic studies showing associations with asthma, chronic obstructive pulmonary disease, ischemic heart disease, hypertension, and premature mortality. Biological pathways such as systemic inflammation, oxidative stress, endothelial dysfunction, and autonomic imbalance provide plausible explanations for these outcomes.[6,7] These health burdens are amplified in low- and middle-income regions where deforestation rates are high and healthcare systems face structural constraints, exacerbating existing inequities.[10,11]

Importantly, reductions in deforestation-related fires have been shown to yield immediate improvements in air quality and prevent avoidable morbidity and mortality, underscoring the potential health co-benefits of forest conservation and sustainable land-use policies.[4] The intersection of deforestation, air pollution, and noncommunicable diseases also highlights the broader context of global environmental change, where climate dynamics, urbanization, and environmental degradation collectively shape cardiopulmonary risk profiles.[8,13]

In conclusion, addressing deforestation represents a critical upstream intervention for improving air quality and reducing the growing burden of cardiopulmonary diseases. Integrated strategies that align environmental protection with public health planning are essential to mitigate these risks. Strengthening environmental governance, promoting sustainable forest management, and incorporating health considerations into land-use and climate policies can deliver substantial and enduring benefits for population health.[1,9,12]

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