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Review Article

The interplay of forestry on human health; A holistic perspective

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ABSTRACT

This review paper explores the intricate interplay between forestry and human health, emphasizing a holistic perspective that integrates ecological, health, and social dimensions. As forests play a vital role in providing ecosystem services—such as biodiversity, carbon sequestration, and sources of food and medicine—they significantly impact public health outcomes. Despite these benefits, many communities face challenges related to health disparities, malnutrition, and mental health issues exacerbated by deforestation and habitat loss. This review highlights how forest ecosystems can mitigate climate change, enhance food security, and promote mental well-being through increased access to natural spaces. However, the ongoing threats posed by urbanization and environmental degradation limit these benefits, particularly for marginalized populations. It synthesizes existing research to identify the multifaceted ways in which forestry influences health and well-being, while also addressing the gaps in knowledge regarding the social and mental health impacts of forest loss. Ultimately, the paper advocates for integrated approaches to forestry management that prioritize public health, calling for interdisciplinary collaboration to develop sustainable practices that enhance both ecological integrity and human health. Through this comprehensive examination, the review aims to inform policymakers, stakeholders, and researchers about the critical connections between forestry and health, promoting a sustainable future for both ecosystems and communities.

K E Y W O R D S : *Bio-active compounds, Food security, Forests, Infectious diseases*

INTRODUCTION

The Food and Agriculture Organization of the United Nations (FAO) defines forestry as "the management and conservation of forests, as well as the utilization of forest resources for the benefit of present and future generations" (FAO, 2020). This involves different forms of activities which includes, forest management, afforestation, reforestation, forest conservation, etc. Directly or indirectly, forests provide important health benefits to the public. There are evident relationships between human health and well-being, healthy ecosystems, climate change, and biodiversity which has received an increasing attention in international discussion and policy processes in recent years.

The World Health Organization (WHO) defines health as "a state of complete physical, mental, and social well-being and not merely the absence of diseases or infirmity" (WHO, 2020). Public health encompasses a broad range of activities aimed not only at treating illnesses but also at preventing disease and promoting overall health and well-

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being. As defined by the World Health Organization (WHO), public health involves "the art and science of preventing disease, prolonging life, and promoting health through organized efforts" (WHO, 2019). This holistic approach emphasizes the importance of community health initiatives, health education, and policies designed to create environments that support healthy lifestyles (McKenzie *et al.,* 2016). Forests and trees provide essential ecosystem services that contribute to healthy living environments and the restoration of degraded ecosystems. By maintaining soil fertility and improving water quality, forests help filter pollutants and regulate nutrient cycling, which is crucial for both human and ecological health (Fletcher, 2018). By integrating forestry into public health strategies, we can address not only environmental sustainability but also enhance community health outcomes, ultimately supporting the United Nations Sustainable Development Goals (SDGs) aimed at combating poverty and improving health (Diaz *et al.,* 2018)

The complex interplay between forestry and human health has garnered increased interest in recent years; however, a considerable gap remains in comprehending how these areas interact in a comprehensive manner. While the numerous benefits of forests—such as biodiversity preservation, carbon sequestration, and provision of food and medicinal resources—are well-established, many communities continue to experience significant challenges, including health disparities, malnutrition, and mental health issues that effective forest management could alleviate (Rasolofoson, 2024).

Current trends in deforestation, habitat degradation, and climate change are causing a decline in forest ecosystems, which in turn negatively affects public health. As biodiversity diminishes, the availability of essential resources also declines, worsening food insecurity and increasing the risk of vector-borne diseases (Hoffmann, 2021). Furthermore, urbanization and industrial expansion are encroaching on forested regions, restricting access to these vital resources, especially for marginalized groups (Bera *et al*., 2023). This oversight highlights the urgent need for a comprehensive review that explores the diverse ways in which forestry affects human health across various contexts.

Consequently, the challenge lies in the absence of a holistic framework that combines ecological, health, and social dimensions. This gap leaves policy-makers and stakeholders without the necessary tools to implement sustainable forestry practices that can improve human health outcomes. This review seeks to fill these gaps by synthesizing current literature and emphasizing the crucial connections between forestry and human health, advocating for integrated strategies that emphasize both ecological sustainability and public health benefits.

Forest Ecosystem Services and Human Health

1. Nutritional Contributions

A major challenge to human health is nutrient deficiency. Forests provide edible foods that contain both macro-nutrients and micro-nutrients essential for healthy diets (FAO, 2020). Food biodiversity provided by forests helps to combat malnutrition in developing countries, which is crucial for ensuring a well-rounded and balanced diet. It also plays a significant role in alleviating food insecurity (Olesen *et al.,* 2022). Research indicates that forest-based foods significantly enhance dietary diversity and nutritional status, especially in rural communities (Osei *et al.,* 2023; Bera *et al*., 2023).

A study by Osei *et al.* (2023) found that households near forests had a greater intake of micro-nutrients and were less likely to experience malnutrition. Furthermore, the consumption of wild foods is associated with improved health outcomes (Kumar *et al.,* 2023).

Typical forest foods such as; fruits and nuts, acorns, wild roots and tubers, mushrooms, etc., provide carbohydrates, proteins, fats, vitamins, and minerals. It also provides phytochemicals which include phenolics and carotenoids (Hartig *et al.,* 2014). Due to the presence of phenolic compounds (flavonoids, phenolic acids, lignans, and stilbenes) in the high dietary intake of flavonoid, it provides a lower risk of some chronic diseases, such as lung and prostate cancer, asthma, heart disease, type 2 diabetes etc.

According to the Food and Agriculture Organization (FAO, 2020):

- Approximately 820 million people worldwide suffer from under-nutrition, and more than 2 billion individuals lack sufficient micro-nutrients.
- Research involving 43,000 households across 27 African countries revealed that children living near forests have a dietary diversity that is at least 25% greater than that of children not exposed to these environments.
- In a study spanning 22 countries in Asia and Africa, it was found that indigenous communities typically utilize around 120 different wild food sources per community.
- In Central Africa, wild meat and fishery products constitute 85% of the total protein consumption among forest-dwelling populations.

2. Medicinal Resources

Forests serve as a valuable renewable source of health-enhancing and medicinal products. In addition to trees, various forest elements are abundant in natural bioactive compounds, which can be utilized in the development of health-promoting products and pharmaceuticals.(Abdallah *et al.,* 2023). They are sources of medicinal plants used in traditional and modern medicine. In both underdeveloped and developed countries, at least 75%–80% of people trust the remedies of herbal origin for their healthcare, as it is the most prevalent and oldest form of medicine with a long history (Bhat *et al.,* 2021).

Recent studies have documented the use of over 50,000 plant species for medicinal purposes, highlighting the importance of biodiversity in pharmaceutical development (Asigbaase *et al.,* 2023). Trees and plant extracts contain a variety of bio-active compounds such as phytoestrogens (lignans), carotenoids, stilbenes, polyphenols (flavonoids, phenolic acids, tannins), sterols, etc. (Kumar *et al.,* 2023), which in equal time possesses biological activities which includes antioxidant potential, anticancer activity, and antiatherogenic potential. WHO estimates that at least 80 percent of the world's population depends on traditional medicine to meet primary health care needs. Local knowledge of medicinal plants constitutes a major part of traditional health care systems (FAO, 2020).

Certain forest herbs possess expectorant and bronchodilator effects, which can support respiratory health and help alleviate symptoms associated with respiratory conditions (Pourová *et al.,* 2023). This underscores the importance of forest ecosystems in providing natural remedies that contribute to overall health and wellness.

The bio-active compounds present in forest trees and plants include several important substances.

- *Taxol*, derived from the bark of the Pacific yew tree, is a crucial chemotherapy drug (Wheate, 2016)
- *Sitostanol*, used as a functional food to reduce serum cholesterol, is another significant compound (Poli *et al.,* 2021).
- *Quinine*, found in the bark of the Cinchona tree, was historically utilized to treat malaria; modern antimalarial drugs like artemisinin also have their origins in the plant *Artemisia annua* (Ceravolo *et al.,* 2021). Many antibiotics, including penicillin, tetracycline, and erythromycin, have been derived from micro-organisms found in soil and forest environments (Kumar *et al.,* 2023).
- Morphine and codeine, used for pain relief, are sourced from the opium poppy (*Papaver somniferum*) (Drug Enforcement Administration, 2021).

Additionally, macro-fungi exhibit antimicrobial effects, inhibiting the growth of bacteria, fungi, protozoa, and cancerous cells (Katarzyna Sułkowska-Ziaja *et al.,* 2023). People in rural areas often utilize a combination of traditional and modern healthcare systems. The global market for traditional medicines is expanding, with many individuals preferring forest herbs, believing that natural products are healthier alternatives to synthetic drugs (van Wyk & Prinsloo, 2020). Sustainable harvesting and conservation efforts are essential to ensure that future generations can continue to access the wealth of bio-active compounds offered by forests (Eg, 2023). It is also important to approach the use of forest herbs with caution, as some plants can have toxic effects or negatively interact with other medications. Consulting a knowledgeable healthcare provider is advised when using forest herbs for medicinal purposes (FAO, 2023).

According to the Food and Agriculture Organization (FAO, 2020):

- Humans have utilized medicinal plants from forests for at least 5,000 years, with estimates suggesting that up to 50,000 plant species may be employed for medicinal purposes.
- More than 1 billion people globally rely on herbal and home remedies to manage diarrhoea in children.
- In India, forest plants are frequently used to treat a variety of conditions, including snake bites, asthma, jaundice, dropsy, gynaecological issues, haemorrhoids, elephantiasis, bronchitis, rheumatism, leprosy, diabetes, cancer, pneumonia, paralysis, pharyngitis, ulcers, dysentery, cough, skin diseases, fever, and insufficient lactation.
- In China, nearly 5,000 of the more than 26,000 native plant species (about 19%) are utilized for medicinal purposes.
- Various pharmaceutical drugs derived from forest species include quinine from *Cinchona* spp., once the most common antimalarial; cancer treatment medications from rosy periwinkle (*Catharanthus roseus*); paclitaxel, an anticancer drug originally obtained from the bark of the Pacific yew (*Taxus brevifolia*); treatments for enlarged prostate from *Prunus africana*; forskolin from the root of *Coleus forskohlii*; and diabetes medications from *Dioscorea dumetorium* and *Harungana vismia*.

3. Climate Regulation

Forests play a crucial role in regulating the Earth's climate through various mechanisms, including carbon sequestration, influencing local weather patterns, and maintaining biodiversity. This can be further explained;

- *Carbon Sequestration*: Forests are vital carbon sinks, absorbing carbon dioxide (CO2) from the atmosphere and storing it in biomass and soil. According to the Food and Agriculture Organization (FAO, 2022), forests globally sequester approximately 2.6 billion metric tons of CO2 annually. This process is essential for mitigating climate change, as elevated CO2 levels contribute to global warming. Recent studies have shown that mature forests, particularly tropical rainforests, are exceptionally efficient at carbon storage. For instance, a study by (Artaxo *et al.,* 2022) indicated that intact tropical forests could store up to 60% more carbon than previously estimated, underscoring their importance in climate regulation.

- *Local Climate Regulation*: Forests influence local weather patterns by moderating temperature and humidity levels. They help maintain local hydrological cycles through processes like transpiration, where trees release water vapour into the atmosphere. A review by (Ekhuemelo, 2016) highlighted how trees and forests recycle moisture in the atmosphere through the process of transpiration to increase rainfall. Additionally, forests can reduce the urban heat island effect in nearby cities, helping to lower temperatures in urban areas. Research by (Fang *et al.,* 2022) found that urban areas with significant tree cover experienced lower average temperatures compared to those with less greenery.

- *Biodiversity and Ecosystem Resilience:* Forests are home to a significant portion of the world's biodiversity, which is essential for ecosystem resilience. Diverse ecosystems are better equipped to withstand climate-related stresses, such as extreme weather events. A study by (Weiskopf, 2020) emphasized that biodiversity loss due to deforestation and habitat fragmentation can diminish the ability of ecosystems to adapt to climate change, further exacerbating its impacts.

- *Albedo Effect and Surface Cooling*: Forests also affect the Earth's albedo, the reflectivity of the Earth's surface. Darker forest canopies absorb more sunlight compared to lighter surfaces like grasslands or deserts, which can lead to localized warming. However, the canopies of trees provide shade, reducing the input of short wave radiation to ground level, particularly in the summer when deciduous trees are in leaf in temperate and cold climates (Rahman *et al.,* 2020)

Mental Health Benefits of Forest Exposure.

- *Psychological Well-being*: Numerous studies emphasize the mental health benefits associated with spending time in forest environments (Oh *et al.,* 2017; Song *et al.,* 2018). Nature therapy programs are gaining traction as effective interventions for mental health issues.

- *Community and Social Cohesion*: Forests enhance community cohesion by providing spaces for social interaction and recreational activities. Participation in forest-related activities fosters social ties and community resilience, which are essential for overall well-being (None Suswadi *et al.,* 2023).

Biodiversity and Disease Regulation

- *The Dilution Effect*: High biodiversity in forest ecosystems can reduce the transmission of infectious diseases. The "dilution effect" suggests that greater species diversity can disrupt the life cycles of disease vectors, leading to lower incidence rates of diseases such as malaria and Lyme disease (Keesing & Ostfeld, 2021).

- *Zoonotic Disease Prevention*: Healthy forest ecosystems minimize human-wildlife interactions, which are crucial for preventing zoonotic disease outbreaks. Deforestation and habitat fragmentation increase the likelihood of such interactions, leading to higher risks of diseases like COVID-19 (Lawler *et al.,* 2021). Conserving forests is essential for mitigating these public health risks.

Risks Associated with Deforestation and Habitat Loss

Health Impacts of Deforestation

Deforestation poses significant threats to human health, including the loss of biodiversity and increased disease prevalence. A study by (Sekhran *et al.,* 2022) highlights that communities dependent on forest resources are more vulnerable to health risks associated with habitat destruction, including respiratory illnesses and exposure to pathogens.

Air and Water Quality

Deforestation adversely affects air and water quality, leading to severe health consequences. The removal of trees results in increased air pollution and reduced water filtration, exacerbating health problems, particularly in marginalized communities (Damania *et al.,* 2023).

Climate Change

Deforestation has profound negative effects on climate. Removing trees decreases carbon storage capacity and releases stored carbon back into the atmosphere, contributing to global warming. According to research by Hansen *et al.* (2023), deforestation is responsible for nearly 10% of global greenhouse gas emissions. Furthermore, it disrupts local climate patterns, leading to changes in rainfall and increased vulnerability to droughts and floods.

Case Studies and Evidence

- *Community Practices*: Indigenous communities often utilize forest resources sustainably, demonstrating the importance of traditional ecological knowledge in maintaining health and cultural integrity. Research shows that indigenous practices significantly contribute to the conservation of medicinal plants and biodiversity (Gadgil *et al.*, 2021).

- *Successful Forest Management Models*: Integrated forest management practices, such as agro-forestry and community forestry, illustrate how sustainable practices can enhance both ecological health and human well-being (Castle *et al.*, 2022). These models frequently lead to improved food security and health outcomes for local populations.

CONCLUSION

Forests are essential for human health, providing vital bio active compounds, nutrients, and medicinal agents crucial for treating various health conditions. Despite their importance, over-harvesting and habitat destruction pose significant threats to these resources. The global demand for natural products in traditional medicine is growing, yet the risks of toxicity and interactions with conventional drugs highlight the need for caution and professional oversight. Sustainable practices and conservation efforts are critical to preserving these bio active compounds for future generations.

POLICY IMPLICATIONS AND RECOMMENDATIONS

- *Sustainable Forestry Practices*: Policies that promote sustainable forest management can improve health outcomes by preserving biodiversity and ecosystem services. It is crucial to integrate health considerations into forestry policies to achieve holistic benefits (Gordon *et al.*, 2023).

- *Integration of Health and Environmental Policies*: A multidisciplinary approach that combines health and environmental policies is essential for addressing the complex interactions between forestry and human health. Collaborative efforts among governments, NGOs, and local communities can create effective strategies that benefit both ecosystems and public health.

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Authors' contribution

VBS was responsible for managing the writing of the manuscript, providing material support, and drafting the initial version. NNA & JII managed material support and reviewed the manuscript.

Ethics Committee's Aproval

Not applicable

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