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Environment and human health: Interlinkages of human rights, value education, women and child welfare, and information technology: A comprehensive review

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Abstract
Environmental degradation has emerged as a critical determinant of public health outcomes globally, contributing substantially to the growing burden of both communicable and non-communicable diseases. Exposure to polluted air, unsafe drinking water, toxic chemical substances, and inadequate sanitation systems disproportionately affects vulnerable populations, particularly women and children, thereby reinforcing existing health inequities (Petropoulou, 2025; Lahariya *et al*., 2025) [29, 42]. These environmental risks are closely intertwined with socioeconomic disparities and human rights concerns, underscoring the necessity for integrated and rights-based governance frameworks (Bhattacharya, 2023) [9].
Value education and environmental awareness are fundamental in fostering ethical responsibility, sustainable behaviors, and community participation in environmental protection initiatives (Agarwal, 2018) [1]. Concurrently, advances in information technology have significantly enhanced environmental monitoring, health surveillance, and risk communication, enabling more timely and evidence-based public health interventions (Topol, 2019) [57]. This review critically synthesizes multidisciplinary literature on environment and human health, with particular emphasis on human rights, value education, women's and child welfare, HIV/AIDS vulnerability, and the role of information technology. Drawing on selected Indian case studies, the paper highlights structural challenges and policy gaps while emphasizing the importance of participatory, technology-driven, and equity-oriented approaches. The review concludes that integrated policy frameworks combining environmental protection, social justice, and technological innovation are essential for advancing health equity and sustainable development.

Keywords: Environmental degradation, Public health outcomes, Communicable diseases, Non-communicable diseases, Air pollution

Introduction

Environmental conditions exert a profound and multifaceted influence on human health across the life course, beginning from prenatal development through old age. Extensive empirical evidence has demonstrated strong associations between exposure to environmental pollutants and a wide range of adverse health outcomes, including respiratory illnesses, cardiovascular diseases, neurological impairments, metabolic disorders, and developmental delays (Petropoulou, 2025; George *et al*., 2023) [15, 42]. Chronic exposure to air pollution, contaminated water, toxic chemicals, and inadequate waste management systems contributes significantly to both communicable and non-communicable disease burdens. These risks are particularly pronounced in low- and middle-income countries, where rapid urbanization, industrial expansion, weak regulatory frameworks, and inadequate public infrastructure exacerbate environmental hazards (Malik *et al*., 2023) [33].
Social and economic inequalities further intensify environmental health risks by limiting access to safe housing, clean energy, healthcare services, and environmental information. Marginalized populations often reside in environmentally degraded areas characterized by high pollution levels, overcrowding, and insufficient sanitation facilities, thereby experiencing cumulative and intergenerational health disadvantages. Children, pregnant women, older adults, and individuals with pre-existing health conditions are especially vulnerable to these exposures due to physiological sensitivity and social dependency.
Bhattacharya (2023) [9] emphasized that environmental protection constitutes a constitutional obligation in India, grounded in the fundamental right to life and personal liberty under Article 21. This legal interpretation positions environmental health not merely as a policy objective but as a matter of social justice and state accountability. At the international level, the recognition of a clean, healthy, and sustainable environment as a human right by the United Nations General Assembly (2022) has strengthened global policy commitments and reinforced the ethical responsibility of governments to safeguard public wellbeing. Despite these normative advances, persistent implementation gaps, weak enforcement mechanisms, limited institutional capacity, and fragmented governance structures continue to undermine effective environmental health management.
Against this backdrop, the present review examines the complex and dynamic interactions between environmental degradation and human health through multiple analytical perspectives, including human rights, value education, gender and child welfare, HIV/AIDS vulnerability, information technology, and community participation. By systematically synthesizing recent empirical evidence and selected Indian case studies, this paper seeks to identify structural challenges, highlight best practices, and propose integrated policy responses. The review aims to contribute to evidence-based decision-making and support the development of equitable, sustainable, and health-centered environmental governance frameworks.

Environment and Human Health

Environmental pollution remains one of the leading contributors to the global disease burden, with mounting evidence linking ambient air contaminants to adverse health outcomes. Exposure to fine particulate matter (PM2.5), nitrogen oxides, sulfur dioxide, and ground-level ozone has been consistently associated with increased mortality and morbidity from respiratory and cardiovascular diseases (Petropoulou, 2025; WHO, 2021) [42]. Mahapatra *et al*. (2023) [32] demonstrated that ambient air pollution in major Indian metropolitan cities, including Delhi, Mumbai, and Kolkata, was significantly associated with neonatal mortality and low birth weight. Similarly, Balakrishnan *et al*. (2019) reported that long-term exposure to PM2.5 contributed substantially to premature mortality across urban and semi-urban regions in India. Chowdhury *et al*. (2021) [11] further observed elevated hospital admissions for asthma and chronic obstructive pulmonary disease in cities with persistent smog episodes.

Children are particularly vulnerable to environmental hazards due to their developing physiological systems, immature immune responses, and higher inhalation rates relative to body weight (Lahariya *et al*., 2025) [29]. George *et al*. (2023) [15] documented increased incidence of acute respiratory infections among children exposed to moderate levels of particulate matter in peri-urban settlements. In a longitudinal study conducted in Delhi slums, Tiwari *et al*. (2020) reported impaired lung function growth among school-aged children living in high-traffic zones. Singh *et al*. (2022) found significant associations between indoor air pollution and childhood wheezing in low-income households. Furthermore, Gupta and Kumar (2024) [18] observed delayed cognitive development among children chronically exposed to lead and airborne toxins in industrial clusters.

Household air pollution remains a major public health concern in rural and low-income urban households. Reliance on biomass fuels such as firewood, cow dung, and crop residues exposes women and children to high concentrations of toxic smoke, thereby increasing risks of chronic respiratory disease, cataracts, and adverse pregnancy outcomes (Neira *et al*., 2017; Salve *et al*., 2024) [38, 51]. A multi-state study by Smith *et al*. (2018) reported that prolonged biomass fuel use significantly elevated the risk of chronic obstructive pulmonary disease among rural women. Purohit *et al*. (2019) documented high prevalence of childhood pneumonia in households lacking clean cooking facilities. Although government initiatives such as the Pradhan Mantri Ujjwala Yojana have expanded access to liquefied petroleum gas, Kumar *et al*. (2022) noted persistent fuel-stacking behaviors that limit sustained health benefits.

Water contamination also represents a critical public health threat in many developing regions. Industrial effluents, agricultural runoff, and inadequate sewage treatment contribute to heavy metal, nitrate, and microbial pollution of surface and groundwater sources (Krishan *et al*., 2023) [26]. Thimmadasiah and Joshi (2020) observed that unsafe drinking water remained a major driver of diarrhoeal disease in rural Karnataka. In Punjab, Sharma *et al*. (2021) [52] identified elevated arsenic and uranium levels in groundwater, linked to increased kidney and neurological disorders. Mishra *et al*. (2022) reported widespread fluoride contamination in Rajasthan, contributing to skeletal fluorosis among children and adults. Similarly, Das *et al*. (2020) [12] documented recurrent outbreaks of waterborne diseases in flood-prone districts of Assam due to compromised sanitation infrastructure.

Urban water supply systems are also vulnerable to contamination. Rao *et al*. (2023) [48] found that intermittent water supply in Hyderabad facilitated bacterial regrowth and increased gastrointestinal infections. In Chennai, Raghavan *et al*. (2021) [21] demonstrated that seawater intrusion and over-extraction of groundwater intensified salinity-related health risks. A case study from West Bengal by Mukherjee *et al*. (2019) [35] revealed chronic arsenic exposure among rural communities, leading to dermatological and cardiovascular complications.

Collectively, these case studies demonstrate that environmental exposures across air, household energy, and water systems interact cumulatively to shape health outcomes throughout the life course. The persistence of environmental hazards reflects structural challenges, including weak regulatory enforcement, infrastructural deficits, and social inequalities. These findings underscore the urgent need for integrated environmental management strategies that combine pollution control, public awareness, and equitable access to basic services in order to reduce preventable disease burdens and protect vulnerable populations.

Human Rights and Environmental Justice

The integration of human rights principles into environmental governance has gained increasing recognition at national and international levels. Bhattacharya (2023) [9] argued that environmental degradation violates fundamental rights by restricting access to clean air, safe water, and healthy living conditions, thereby undermining human dignity and social justice. International frameworks similarly emphasize the indivisibility of environmental and social rights, recognizing environmental protection as essential for the realization of economic, cultural, and political freedoms (UNEP, 2019). Knox (2018) [25] further highlighted that environmental rights strengthen legal accountability and enhance citizen participation in governance processes.

Environmental justice research consistently reveals that marginalized communities experience disproportionate exposure to pollution and environmental hazards. Malik *et al*. (2023) [33] reported that informal settlements in Indian cities face higher exposure to industrial emissions, contaminated water, and solid waste accumulation. A study by Walker (2012) [59] demonstrated that socioeconomically disadvantaged groups are systematically located near hazardous facilities. In Delhi's resettlement colonies, Ghosh and Bhattacharya (2020) [17] found elevated rates of respiratory illness linked to proximity to landfills. Similarly, Patel *et al*. (2021) [40] documented severe groundwater contamination in peri-urban Gujarat affecting low-income agricultural workers.

Several Indian case studies illustrate structural inequalities in environmental risk distribution. In Bhopal, Mishra (2019) [24] reported long-term health consequences of industrial pollution among economically disadvantaged residents. In Chennai's Ennore industrial belt, Narayanan *et al*. (2022) [37] identified high levels of heavy metal exposure among fishing communities. Banerjee *et al*. (2020) [6] observed increased cancer prevalence near coal mining regions in

Jharkhand. In Odisha's mining districts, Padhan and Nayak (2021) documented displacement-related health vulnerabilities among tribal populations. These findings underscore the intersection of environmental injustice with caste, class, and livelihood patterns.

Legal interventions have played an important role in addressing environmental injustice in India. Judicial actions by the National Green Tribunal, Supreme Court, and human rights commissions have compelled regulatory agencies to act against industrial pollution, illegal mining, and groundwater depletion (Bhattacharya, 2023) [9]. Gill (2020) [16] emphasized that public interest litigation has expanded environmental rights jurisprudence. In the Ganga pollution case, Shankar and Singh (2019) reported significant regulatory reforms following court directives. Similarly, interventions in the Sterlite copper plant controversy in Tamil Nadu resulted in temporary pollution control measures (Ramanathan, 2020) [47].

Despite these advances, weak enforcement mechanisms continue to limit long-term effectiveness. Poor inter-agency coordination, political interference, limited technical capacity, and inadequate public participation undermine regulatory compliance (Dubash *et al*., 2018) [14]. Aiyar and Mehta (2021) [3] observed that monitoring systems often lack transparency and accountability. Roy *et al*. (2023) [50] further noted that marginalized communities face legal and financial barriers in accessing justice. Consequently, while rights-based legal frameworks have strengthened environmental governance in principle, their transformative potential remains constrained in practice.

Value Education and Environmental Awareness

Value education is fundamental to developing environmental responsibility and health consciousness. Educational programs that integrate ecological ethics and public health knowledge have been shown to improve sanitation practices, waste management behaviors, and household hygiene practices (Sharma & Yadav, 2021) [52]. Sterling (2014) [54] argued that sustainability-oriented education promotes systems thinking and ethical awareness, enabling learners to recognize the long-term consequences of environmental degradation. Tilbury (2011) [55] further emphasized that transformative learning approaches foster behavioral change by linking environmental values with everyday practices.

Agarwal (2018) [1] emphasized that value-based education strengthens collective action and resource sustainability by enhancing social cohesion and participatory decision-making. In rural Maharashtra, Deshpande and Kulkarni (2019) [13] observed that women's self-help group training programs significantly improved waste segregation and water management practices. Similarly, Prakash *et al*. (2020) [44] reported that school-led sanitation campaigns in Uttar Pradesh increased handwashing compliance and toilet usage among students and their families.

School-based environmental literacy initiatives promote critical thinking and civic engagement, enabling students to become advocates for sustainable development. Rieckmann (2017) [49] highlighted that competency-based sustainability education enhances problem-solving skills and environmental leadership. In Kerala, Nair and Menon (2021) [36] found that eco-club activities improved students' environmental attitudes and community outreach participation. Bhardwaj and Singh (2022) [8] demonstrated that integrating climate education into secondary curricula increased youth engagement in conservation activities.

Community-based awareness programs further enhance public participation in environmental governance. Studies indicate that participatory learning approaches improve long-term adoption of hygienic practices and water conservation behaviors (Journal of Scientific Temper, 2025). Wals *et al*. (2014) [60] emphasized that social learning platforms strengthen community resilience and environmental stewardship. In Rajasthan, Verma and Joshi (2020) reported that village-level water literacy programs reduced groundwater overextraction. Likewise, Saha *et al*. (2023) found that participatory waste management workshops in urban slums improved recycling rates and reduced open dumping.

Overall, the empirical evidence suggests that value education functions as a critical social determinant of environmental health by shaping attitudes, norms, and collective behaviors. When embedded within formal education systems and community institutions, value-based learning enhances public accountability, supports sustainable resource management, and contributes to long-term improvements in environmental and public health outcomes.

Women and Child Welfare in Environmental Health

Women and children experience disproportionate health impacts from environmental degradation due to biological susceptibility, gendered roles, and structural social inequalities. Neira *et al*. (2017) [38] highlighted that indoor air pollution and chemical exposure significantly contribute to maternal morbidity, low birth weight, and adverse pregnancy outcomes. Balakrishnan *et al*. (2018) [5] further demonstrated that prolonged exposure to household air pollution increases the risk of preeclampsia and stillbirth among rural women. Smith *et al*. (2018) reported elevated rates of chronic obstructive pulmonary disease and cataracts among women using biomass fuels.

Household energy practices place women at increased risk of respiratory illness, cardiovascular disease, and metabolic disorders (Salve *et al*., 2024) [51]. Pope *et al*. (2021) [43] observed increased blood pressure and systemic inflammation among women exposed to indoor smoke. Jain *et al*. (2022) [23] found that limited access to clean fuels in tribal communities resulted in higher maternal hospitalization rates. Moreover, restricted access to healthcare services and environmental health information further exacerbates these vulnerabilities in rural and marginalized areas (Malik *et al*., 2023) [33].

Environmental contamination also significantly affects child growth and neurodevelopment. Child development is impaired by exposure to toxic substances such as lead, mercury, arsenic, and pesticides (Lahariya *et al*., 2025) [29]. Lanphear *et al*. (2018) [31] demonstrated that even low-level lead exposure reduces IQ scores and academic performance. Mukherjee *et al*. (2019) [35] documented widespread arsenic-related skin lesions and cognitive delays among children in West Bengal. Zhang *et al*. (2020) [62] reported associations between prenatal mercury exposure and attention deficits.

In industrial regions of Gujarat and Tamil Nadu, Patel *et al*. (2021) [40] observed higher prevalence of asthma and learning difficulties among children living near chemical plants. Bose *et al*. (2022) identified increased pesticide residues in breast milk samples, indicating intergenerational

exposure risks. Furthermore, Banerjee *et al*. (2023) [7] reported that chronic exposure to ambient air pollution was associated with stunted growth and reduced lung capacity in school-aged children.

Longitudinal evidence suggests that cumulative environmental exposures during early life stages have lasting consequences for physical, cognitive, and emotional wellbeing. Hertz-Picciotto *et al*. (2018) [19] emphasized that early-life exposure to multiple pollutants contributes to developmental disorders and mental health challenges. These findings underscore the importance of preventive strategies, early screening programs, and gender-responsive environmental policies to safeguard women's and children's health.

Role of Information Technology in Environmental and Human Health

Information technology has significantly transformed environmental monitoring and public health surveillance, enabling more efficient data collection, spatial analysis, and early warning systems for environmental hazards and disease outbreaks. Digital platforms such as geographic information systems (GIS), remote sensing, and mobile applications allow researchers and policymakers to monitor air and water quality in near real-time, model environmental exposures, and make data-driven decisions (Topol, 2019) [57]. Advanced machine learning algorithms and artificial intelligence (AI) further enhance predictive capabilities, allowing for early detection of pollution spikes and potential health risks before they escalate.

In India, the Integrated Disease Surveillance Programme (IDSP) has leveraged digital reporting tools to improve the detection and response to infectious disease outbreaks, demonstrating the utility of IT in strengthening public health infrastructure (IDSP, 2025). Studies by Bhatt *et al*. (2023) [10] showed that digital dashboards and mobile reporting significantly reduced reporting delays for vector-borne diseases in rural districts. Likewise, the eSanjeevani telemedicine platform expanded digital consultation access for underserved populations, improving patient follow-up and reducing health system burdens (Singh & Kumar, 2021) [53].

Mobile health (mHealth) initiatives have notably enhanced maternal and child health communication. Lalan *et al*. (2024) [30] reported that mobile messaging platforms improved adherence to antenatal care visits and immunization schedules in remote areas. Similar findings were observed in the Kilkari program, where targeted health messages led to increased uptake of postnatal care services (Kumar *et al*., 2020).

GIS and remote sensing tools have also been widely applied to map environmental risks. Patel *et al*. (2022) [41] used GIS to identify urban heat islands in Indian megacities and guide heat action plans. In Chennai, satellite data integrated with machine learning was used to forecast dengue outbreaks based on seasonal rainfall and temperature patterns (Ramesh *et al*., 2021) [46]. In addition, real-time air quality monitoring networks supported by IoT sensors have been established in several Indian cities, providing granular pollution data for community alerts (Sharma & Jain, 2023) [23].

Environmental informatics platforms have facilitated community engagement as well. The 'Swachhata App' enables citizens to report sanitation issues directly to municipal authorities, improving municipal responsiveness and accountability (Verma & Singh, 2022). AI-powered water quality prediction models have been developed to anticipate contamination events in rural water systems, allowing for proactive interventions (Roy *et al*., 2023) [50].

Artificial intelligence and satellite-based monitoring systems are increasingly used to integrate large environmental datasets, improve predictive modeling of pollution and climate risks, and inform preventive policy measures. These approaches leverage remote sensing data and machine learning algorithms to identify pollution patterns, forecast changes in air and water quality, and provide decision-support tools for policymakers (Islam, 2025) [22]. However, despite these technological advances, inequitable access to high-quality data and digital infrastructure can limit equitable implementation and may widen gaps between resource-rich and resource-poor regions (Shukla *et al*., 2025). Despite these advances, digital divides remain a barrier to equitable access. Areas with limited internet connectivity and digital literacy face challenges in leveraging these technologies fully, highlighting the need for inclusive digital infrastructure investments and capacity building.

Selected Indian Case Studies

- Studies from Punjab and Chandigarh revealed elevated levels of lead and uranium in children's blood and groundwater, prompting regulatory interventions (Times of India, 2025).
- Norm-based sanitation programs in Tamil Nadu significantly improved community participation and willingness to invest in hygienic environments (Ashraf *et al*., 2023) [4].
- Pandey *et al*. (2024) [39] demonstrated uneven child health transitions in Empowered Action Group states, reflecting persistent regional disparities.
- Ahmedabad's Heat Action Plan illustrates the effectiveness of IT-enabled early warning systems in reducing heat-related mortality (Petropoulou, 2025) [42].
- Indore's decentralized waste management model further demonstrates the role of community engagement and digital monitoring in improving urban health(Indore Solid Waste Management Case Study, 2023) [21].

Punjab and Chandigarh: Lead and Uranium Exposure

Studies conducted in Punjab and Chandigarh revealed abnormally high concentrations of lead and uranium in children's blood samples and in local groundwater sources (Times of India, 2025). These contaminants were primarily linked to industrial waste disposal, agricultural chemical use, and natural geological deposits. Prolonged exposure to lead is associated with impaired cognitive development, behavioral disorders, and reduced academic performance in children, while uranium exposure increases risks of kidney damage and carcinogenic effects. The findings prompted interventions by state authorities and human rights commissions, including water quality monitoring, provision of alternative drinking water sources, and stricter regulation of industrial effluents. This case highlights the urgent need for systematic surveillance of environmental toxins and preventive public health strategies.

Tamil Nadu: Norm-Based Sanitation Programs

Ashraf *et al*. (2023) [4] evaluated norm-based sanitation interventions in peri-urban and rural regions of Tamil Nadu

aimed at reducing open defecation and improving hygiene practices. The study demonstrated that community-level behavioral change strategies, such as public commitment, social recognition, and collective monitoring, significantly increased residents' willingness to invest in household toilets and sanitation infrastructure. By emphasizing social norms and shared responsibility rather than financial incentives alone, the program strengthened long-term adherence to hygienic practices. These findings indicate that culturally sensitive and participatory approaches are effective in improving sanitation-related health outcomes.

Empowered Action Group States: Child Health Transitions

Pandey *et al*. (2024) [39] analyzed district-level data from India's Empowered Action Group (EAG) states, which are characterized by low socioeconomic development and poor health indicators. The study found uneven progress in reproductive and child health outcomes, with persistent gaps in immunization coverage, maternal care utilization, and nutritional status. Environmental factors such as unsafe water, poor sanitation, and high pollution levels were identified as major contributors to these disparities. The research highlights the need for region-specific policies that address both environmental and social determinants of child health.

Ahmedabad: Heat Action Plan and IT-Based Early Warning

Petropoulou (2025) [42] examined the Ahmedabad Heat Action Plan as an example of climate-adaptive public health policy. The plan integrates meteorological data, health surveillance systems, and mobile communication platforms to issue early warnings during heatwaves. Public advisories, hospital preparedness measures, and community outreach programs have significantly reduced heat-related mortality and morbidity. The use of information technology enabled real-time risk assessment and rapid dissemination of preventive information. This case demonstrates how digital tools can enhance climate resilience and protect vulnerable populations.

Indore: Decentralized Waste Management Model

Indore's waste management system represents a successful model of community-driven environmental governance. The city implemented decentralized waste segregation, door-to-door collection, composting units, and digital monitoring platforms to track waste disposal practices. Active involvement of local residents, self-help groups, and municipal workers strengthened compliance and accountability, resulting in significant reductions in open dumping and associated environmental health risks (Indore Solid Waste Management Case Study, 2023) [21]. The model has also been recognized internationally as a benchmark for urban waste management and sanitation, demonstrating how integrated municipal planning and strong community participation can improve urban environmental health (Indore has become a global model for solid waste management, 2018).

Conclusion

Environmental health is influenced by intricate interactions among ecological processes, socioeconomic conditions, institutional governance structures, and technological advancements. Degradation of natural resources, rapid urbanization, industrial expansion, and climate change collectively intensify environmental risks, particularly in low- and middle-income countries. These risks are unevenly distributed, with women, children, older adults, and economically marginalized populations experiencing disproportionate exposure to polluted air, unsafe water, hazardous waste, and inadequate sanitation facilities. Structural inequalities, limited access to healthcare, and weak regulatory enforcement further exacerbate these vulnerabilities, resulting in persistent environmental injustice.

Rights-based governance frameworks provide an essential foundation for addressing these challenges by recognizing access to a healthy environment as a fundamental human right. Such approaches promote accountability, transparency, and public participation in environmental decision-making processes. At the same time, value education and environmental literacy strengthen ethical responsibility and collective awareness, enabling individuals and communities to adopt sustainable behaviors and actively engage in environmental protection initiatives. Educational interventions foster long-term attitudinal change, which is critical for sustaining public health improvements.

Technological innovations, including digital surveillance systems, geographic information platforms, mobile health applications, and artificial intelligence–based predictive models, have significantly enhanced environmental monitoring and health risk management. These tools facilitate early detection of environmental hazards, improve data-driven policy formulation, and strengthen healthcare service delivery, particularly in resource-constrained settings. However, digital disparities and limited technical capacity remain barriers to equitable access and effective implementation.

Integrated policy frameworks that combine human rights principles, educational strategies, community participation, and technological innovation are therefore essential for advancing environmental health in India. Such frameworks should prioritize intersectoral collaboration among environmental agencies, health departments, educational institutions, and local governments. Emphasis on equity, sustainability, and inclusive governance will ensure that development initiatives do not compromise ecological integrity or public wellbeing. By adopting holistic and participatory approaches, India can strengthen environmental resilience, reduce health disparities, and promote sustainable development for present and future generations.

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