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REVIEW

Environmental Justice and Health in Nigeria

Toluwalope Ogunro[1]

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Abstract

Purpose of Review The United Nations Sustainable Development Goals (SDGs) identified 17 goals to achieve by the year 2030, with many of these goals directly or indirectly linked to environmental justice. Health outcomes remain poor in Nigeria; the country ranks low in environmental quality despite supporting environmental treaties and laws. The burden of diseases in the country is in part related to poor environmental quality and is linked to environmental justice issues, such as mining, energy exploration, transport emission, poor waste management, and proliferation of slum settlement.

Recent Findings Previous studies found that living in proximity to mines and environmental degradation of land and water disrupts means of livelihood and causes poor health outcomes among children and adults. Specifically, health issues like respiratory illness, malaria, kidney disease, and high blood pressure are likely consequences of proximity to mine waste. Few published studies are available for a developing country like Nigeria, although the link between environmental justice and health in Nigeria is clear enough to require action on the part of the government and polluting industries.

Summary This paper reviewed the concept and coverage of environmental justice in the Nigerian context and its impact on health. Addressing environmental injustices related to mining and other environmental issues can accelerate health gains through conscious and concerted efforts towards preserving the environment. Also, the right of everyone to a sustainable city regardless of socioeconomic class and geographical location can only be secured through environmental justice.

Keywords Environment · Environmental justice · Health · SDG · Nigeria

Introduction

A person's level of physical, mental, and emotional wellness can be characterised as their state of health. Regional differences in mortality and morbidity rates show observable health inequities in recent years. To address this, research is extending beyond socioeconomic status, access to health facilities, and behavioural factors (smoking, exercise) to incorporate environmental variables as social determinants of health. Environmental health is responsible for 83% of illnesses and injuries [1], confirming the need to address environmental health inequality.

Environmental justice (EJ) has its roots in the United States with Black Americans' experiences serving as the inspiration for the early EJ movement. Early research found that noxious facilities were located in low-income Black communities in the United States [2–4], which is considered an injustice since they represent a minority population. In this light, EJ was conceptualised as 'fair treatment of people due to race, colour, national origin or income as regards development, implementation and enforcement of environmental laws, regulations, and policies' [5]. Nigeria is often referred to as the giant of Africa owing to its vast population and endowments of natural resources. Nigeria is the largest oil exporter in Africa and it ranked sixth among liquefied natural gas exporters in the world.

The 'Ogoni' people of Nigeria's Niger Delta began to demand EJ in 1990 as a result of the environmental damage caused by oil exploitation by Shell Corporation [6]. People were subjected to environmental threats as a result of business activities, neighbourhood activities, or federal, state, or local legislation which has serious implications on their health. While the definition of injustice reflects the voicelessness of the minority in issues affecting them, there are other forms of injustice meted out on the environment by people with negative implications on health. Although environmental justice is often proxied with air pollution from different sources [7], the term may be context-specific, extending beyond government

✉ Toluwalope Ogunro
rehobotty@gmail.com

[1] Lead City University, Ibadan, Nigeria

imposition of toxic facilities on a community to include other anthropogenic activities. Also, there are likely attributable health inequities from such exposures which can directly or indirectly impact the climate, environment, and health.

This manuscript addresses the forms of environmental injustice in Nigeria, its link to health, and the effectiveness of policies in addressing environmental injustice in the country. The paper describes energy exploration, household energy use, transport emission, waste management, proliferation of slum settlements, and their implications on health outcomes in Nigeria.

Multifaceted Forms of EJ and Health Impact

Energy Exploration

Energy was ranked as Nigeria's highest source of emissions in 2018 [8]. Conventional energy emits greenhouse gases at every stage from exploration to consumption. Even though Nigeria is well endowed with renewable and non-renewable energy resources [9], the latter is still the country's main energy source (Table 1). Considering that it is a major source of government revenue, its use might not decrease soon, thereby inflicting an environmental burden on the regions where the resources are derived (Fig. 1A).

Oil and gas exploration has taken place in the Niger Delta area since 1957 (Fig. 1B, C). The region has a population of about 31 million and it is one of the most polluted regions in the world [13, 14]. Oil exploration is linked to the release of 1300 chemicals [15], and an estimated 2300 m^3 of oil is spilled yearly in the region [13]. Chemicals released from oil activities are toxic and pose significant risks through ground and surface water contamination by benzene and environmental degradation [6]. Each of these substances has a grave impact on the health of children, women, the elderly, and low-income people, such as the carcinogenicity of polycyclic aromatic hydrocarbons, skin irritation, lung, and nasal cancer caused by nickel exposure [16–18]. For instance, pregnant women reported miscarriage and low birth weight in children as a result of exposure to heavy metals [18].

Table 1 Household cooking fuel choice in Nigeria

	2008			2018			% change		
	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural
Fuel types (share of total)									
Electricity/gas	1.6	3.7	0.5	14.7	26.8	4	8.2	6.2	7
Kerosene	25.6	51.6	11.3	15.0	24.3	6.8	−0.41	−0.53	−0.39
Wood/charcoal	67.4	41.3	83.6	67.6	47.4	85.5	0.003	0.15	0.02
Agricultural waste/dung	1.0	0.7	1.1	1	0.3	1.6	0	−0.57	0.45
Others	4.4	2.7	3.5	1.7	1.2	2.1	−0.61	−0.56	−0.45
Energy coverage in Nigeria									
Solid fuel use rate (%)	70.1	42.1	85.6	68.6	47.4	87	−0.024	0.12	0.02
Electricity coverage rate (%)	50.3	84.4	31.4	59.4	82.7	38.9	0.18	−0.02	0.24

National Population Commission various years in Nnaji (2021)

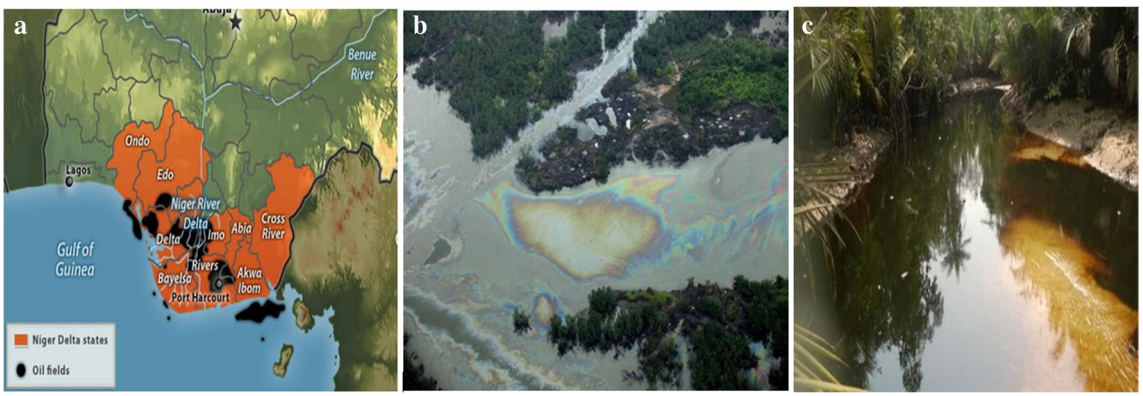

Fig. 1 **A** Map of Niger Delta [10]; **B** and **C** Environmental degradation from oil and gas activities in the Niger Delta [11, 12]

In addition to oil and gas exploration, gas flaring is a significant environmental injustice still occurring in Nigeria's Niger Delta region. There is a significant risk for global warming from the approximately 35 million tonnes of carbon monoxide and 12 million tonnes of methane released as a result of gas flaring in Nigeria [19]. Studies are unveiling forms of injustice against local communities in the Niger Delta, where energy resources are derived in Nigeria [13, 14]. Gas flaring contaminates the environment (land, water, air) which culminates in the loss of means of livelihood, mostly farming and fishing [13, 20]. There is a threat to food security, deficiency of nutrients in food, and risk of malnutrition in children [21]. Gas flaring in communities has also been attributed to both direct and indirect disturbances like anxiety and annoyance, which might have an impact on locals' mental health [22]. A study indicated that residents of gas-flaring settlements in the Niger Delta region had a higher likelihood of having hypertension due to documented incidences of increased temperature and noise pollution [23]. Gas flaring facilities in proximity to host communities is a public health concern in the Niger Delta region. According to research, exposure to volatile organic compounds (VOCs) through groundwater can harm health [17]. For instance, Srider and Bamgboye found a level of air pollution above the Federal Protection Agency's benchmark; consequently, the length of people's stay in the area can affect health outcomes as demonstrated by residents' common health issues, such as cancer, miscarriage, and respiratory complaints [24, 25].

Apart from cases of morbidity, there is a disparity in life expectancy by region or location. While the average life expectancy in Nigeria is 55 years, inhabitants in the Niger Delta region have an average life expectancy of 40 years [26]. Broadly, studies in the developed world have found that exposure to air pollutants is detrimental to human health and is a risk factor for cancer, neurological, reproductive, and developmental disorders. Kindzierski and the United Nations Environmental Programme [27, 28] found a high concentration of benzene and naphthalene in Ogoni land. More indigenous empirical research is required to examine the environmental health consequences of oil sector activities in the Niger Delta region, just as there are documented incidents of fire accidents caused by oil spills, leaks, unauthorised refining, theft, and pipeline vandalism (Fig. 1B, C).

Household Energy for Cooking and Lighting

Household energy is a basic necessity to meet other needs like cooking, lighting, pumping, and entertainment. Energy cannot be substituted, which is why in regions where modern energy is in short supply, conventional energy is mostly used for cooking. Nigeria is one of the nations with a large population reliant on biomass burning. The widespread use of conventional energy needs intervention because evidence shows it has negative effects on human health and the environment (Figs. 2 and 3) [29, 30].

Cooking practices in Nigeria can be divided into two groups: the energy-poor who depend on flammable unprocessed natural resources to cook in rural areas (Table 1) and others in urban areas using mainly modern energy. Also, the energy-poor deplete natural resources unsustainably. Reliance on firewood and other forms of biomass for cooking has endangered the environment in multifaceted ways. One such danger is deforestation, with statistics unveiling that deforestation is high in Nigeria; specifically, the country ranks as the third-highest producer of firewood, agricultural waste, and residue [8, 31, 32]. The most common way that biomass is burned is in unvented stoves, especially three-stone stoves, which produce emissions beyond WHO guidelines. Statistics

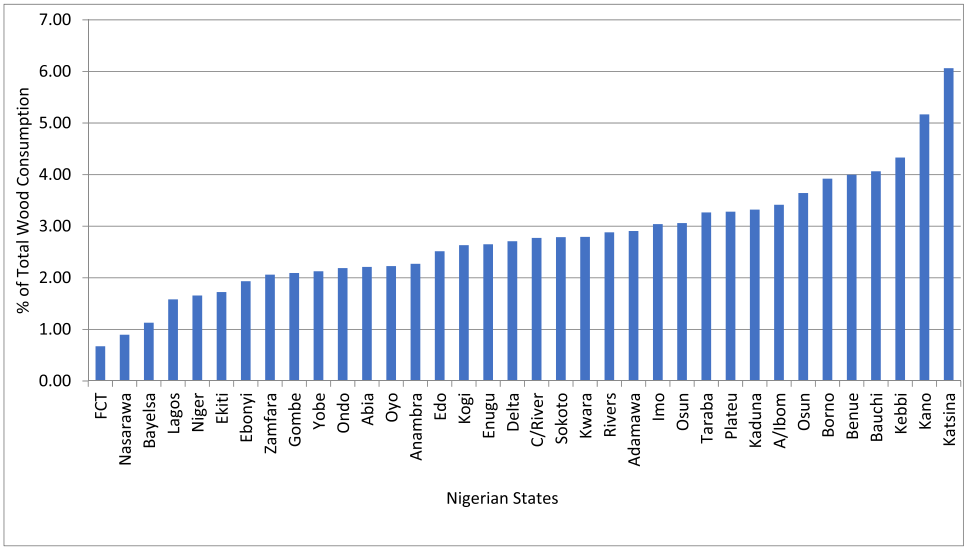

Fig. 2 Firewood used by states in Nigeria (2007)

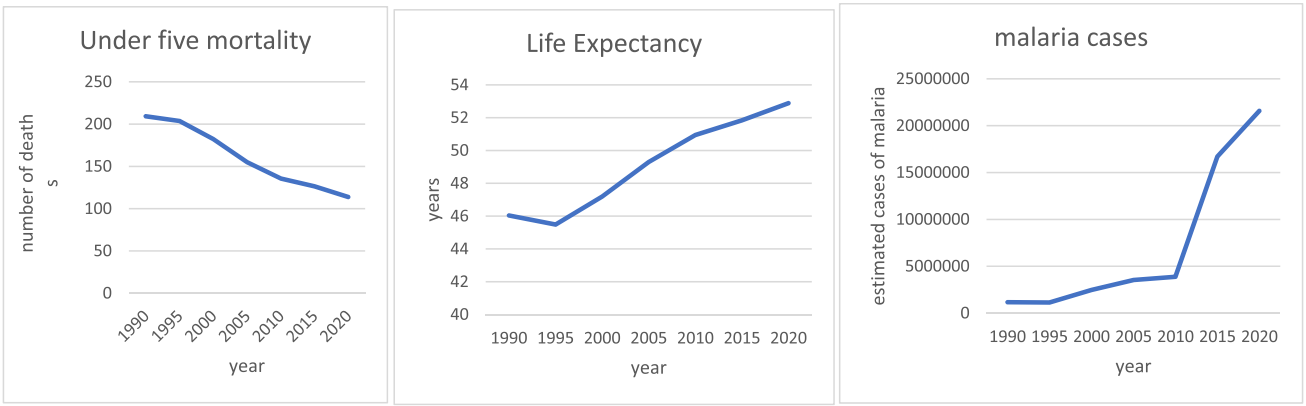

Fig. 3 Health indicators in Nigeria. Source: WDI (2022) and World Malaria Report (2021)

show that an estimated 79,000 deaths in Nigeria are attributed to indoor biomass burning, which has been connected to respiratory illnesses and death [29, 33, 34].

In the African context, groups at risk from household indoor air pollution are mostly women and children who stay with their mothers while cooking. Oluwole et al. [33] found that improved stove interventions enhanced the respiratory health of rural mothers and children in Nigeria. Therefore, those who lack access to modern energy require actions that will reduce pollution and improve energy efficiency. Access to electricity as a contemporary energy source is appalling. The electricity access rate is estimated at 55.4%; 125 kWh of electricity is consumed by households, which is about the lowest in the world when compared to Ghana and South Africa [35, 36]. Since there is a supply shortage, not all of the population uses electricity 24 h a day. To meet the shortfall, households often resort to self-generation of electricity [37–39], and the number of fossil generating sets in the country is estimated at 60 million with about $112 mn spent annually on importing generating sets [35, 40]. There are reported cases of suffocation from exposure to fumes from generating sets [41, 42].

Household fossil-generating sets are also sources of air and noise pollution causing disturbance and annoyance in a community, hence a form of environmental injustice as it lowers indoor and ambient air quality. Giwa et al. [35] discovered that CO and $PM_{2.5}$ are higher than recommended by WHO among respondents using self-power generating sets. Air pollution has been linked to cardiovascular disease and lung cancer and it is the third-highest risk factor for death globally [43–46]. Also, noise pollution is an outcome of individual fossil fuel generating sets adoption and can be a risk factor for poor health. Specifically, noise pollution is an externality that can inhibit sleep and impair hearing. Odunola et al. [37] reported the effect of household fossil-generating sets on health through stress, nausea, and respiratory issues. Compared to short-term exposure, longer-term exposure to fossil-fuel generating sets is more obvious. The literature on the impact of home generators on health is rather limited. Its impact on the environment cannot be disputed as the self-generation of electricity using fossil fuel results in emissions, triggers headaches, throat discomfort, and respiratory anomalies in the long run [37].

Transport Emission

In Nigeria, road transport dominates other forms of transport as 90% of internal goods and passengers commute using this mode of transportation. Its prominence can be justified by non-investment in the rail sector from 1958 until 2016 [47]. The need for road transport is anticipated to expand along with population growth and rapid urbanisation, which could result in continued increases in transportation-related emissions; in Nigeria, these emissions doubled as GDP increased [48]. Increased demand for road transport places strain on the infrastructure, which results in gridlock, longer commuter travel times, and higher carbon dioxide emissions.

Road transport can be provided via private or public means; currently, the total number of registered vehicles in the country is estimated at 13.9 million out of which 11.8 million are private [49], reflecting a high per capita vehicle ownership in the country. Most vehicles are imported second-hand and are fossil-fuel powered and are thus prone to high emissions of greenhouse gases [50–52]. Emission depends on age, condition, and type of vehicle. An estimated 10.6 million vehicles ply the Nigerian road daily [53] increasing its carbon footprint as studies reveal that the emission of pollutants across different cities is higher than World Health Organization guidelines [54, 55]. Twenty-three percent of energy-associated emission is linked to transport while in sub-Saharan Africa, death from ambient air pollution is estimated at 49,000 yearly [50].

Respiratory illnesses and heart conditions are among the morbidities brought on by ambient air pollution, and these

conditions can be made worse by the dense dust that permeates most of Nigeria's cities. Transport emissions are distributed unfairly since they harm the environment and those who live near road networks. The situation is also worsened by underdeveloped/unavailable transport infrastructures, causing critical challenges to liveability for different categories of people (young, old, disabled) in urban areas in Nigeria. Accessing different locations by non-motorised transport (walking, cycling) has the innate ability to lessen carbon footprint and encourage healthy living. For this to be achievable, the built environment in Nigerian cities will require supporting infrastructures (walkways, cycling lanes). Carpooling, railway, and BRT facilities are also meant to reduce transport emissions. Reducing the import of second-hand vehicles and private cars, imposing emission fees, and using low-emission vehicles (CNG) and energy-efficient vehicles (electric cars) are additional measures that can curtail transport emissions in Nigeria.

Waste Management

Since the industrial revolution, the world has witnessed uncontrolled waste generation, while the multiplier effect of industrialisation is apparent in increased income and expansion in cities. These indicators are positively associated with a growing economy, posing a challenge to the exploration of favourable means of waste management. Sustainable waste management becomes imperative owing to environmental problems resulting from improper waste disposal (gaseous, liquid, or solid). Solid waste can be biodegradable or non-biodegradable, and it can further be classified as municipal (residential and commercial), industrial, construction, or demolition wastes [56].

Environmental health is embedded in the sustainable management of solid, liquid, and gaseous wastes generated by households and industries. Nigeria generates more than 63 million tonnes of waste yearly [57]; 21% is disposed into landfills while 11% is burnt and 68% is indiscriminately dumped on land, in drainage facilities, or at sea [58, 59]. Also, an estimated 100 million Nigerians (54%) do not have access to basic sanitation and 46 million people (23%) engage in open defecation [60]. Inefficient waste management damages the environment, deteriorates aesthetics, releases an unpleasant stench, encourages the reproduction of cockroaches, flies, and mosquitoes, and allows rodents to multiply rapidly and spread diseases.

A major source of environmental injustice in this context is unsustainable waste management, as the current practices of dumping wastes around residential areas, shops, open spaces, and market places have a propensity for high disease burden, including malaria, Lassa fever, typhoid, cholera, dysentery, hepatitis, hookworm, childhood cancer, autism, learning deficiency, childhood cancer, and autism [59, 61]. There are common occurrences of flooding due to blocked drainages, as well as air and water pollution from burning wastes. Pollution of groundwater and waterways endangers human health and aquatic life through food poisoning. Studies reported health issues like cholera, skin infections, malaria, and diarrhoea as recurring among households living around dumpsites in Olusosun, Lagos state and Umuahia, Abia state in Nigeria. Also, indiscriminate disposal of wastes in rivers and streams increases the risk of cancer in children and adults in Nnewi, Nigeria [61–63].

The government has periodically implemented policies to encourage sanitary practices because it recognises the value of a clean environment. For instance, the National Environment Protection Agency advocated a reduction in solid waste of 80%; efforts such as Saturday weekly environmental sanitation were established [57, 59], but they encountered resistance because they were transient and added to the environmental burden. As a remedy to this, there is a call for a switch to a circular model in waste management [58]. Unlike developed countries that have undergone the nonconventional process of waste management through the 4Rs (reduce, reuse, recycle, and recovery), waste disposal in the country is mostly at its linear form as many communities lack proper disposal facilities and infrastructures, thereby dumping wastes in open spaces.

The mediating role of scavengers in sourcing metals, electronic waste, and reusable, recyclable objects from waste has been noted in the literature with the proposition that they can be incorporated into the formal sector since they alleviate the problem of waste and create wealth through recovery [64]. The current scale of operation is a threat to the health of scavengers. More needs to be done through a community-based participatory approach to waste management and an awareness campaign on the effect of indiscriminate waste disposal on the environment and health as a means to achieve the 'zero waste' objective of the SDGs.

Rising Slum Settlement

An estimated 3.7 billion people live in cities with this population projected to rise to 7 billion by 2050 [65]. Aside from population explosion, governments in developing countries often prioritise building world-class cities to attract foreign investment; in effect, poor people experience eviction from metropolitan areas with little or no compensation [66]. A good example of this is the city of Abuja, the federal capital territory of Nigeria, during 2003–2007 period [67].

Since the expense of housing in cosmopolitan states is logically out of reach for the poor, they tend to congregate in unofficial areas that are frequently referred to as slums. Other reasons for slum proliferation are rural–urban migration, the proliferation of the informal economy, hostility, unrest or war, natural disasters, unplanned land use, poverty, and unemployment [68,

69]. Studies are corroborating the widespread erection of structures in floodplains, along power lines, waste dumps, and landfills [68, 70]. Haphazard expansion of slums deny inhabitants access to basic amenities and where such facilities are available, congestion exerts pressure beyond the original provision by municipal authority; there are also associated environmental risks like flooding, disease outbreak, and risk of vector-borne disease, e.g. malaria and extinction of flora and fauna species [68, 70–72].

These settlements also suffer from subpar housing, overcrowding, and filthy water and sanitation [71, 73]. The estimated 1 billion people who live in slums in 1 million cities around the world lack access to sanitation, portable drinking water, energy, food, and health services, which contributes to the high prevalence of disease transmission and criminality [65, 71, 73]. Sub-Saharan African cities (Accra, Lagos, Nairobi, Addis Ababa, Ethiopia, Johannesburg, Cape Town, and Durban) have the world's largest slums estimated at 62% of urban population in comparison with 35% in South Asia, 24% in Latin America, and 13% in North America [73, 74]. In Nigeria, 79% of the population live in slums; as the commercial hub of the country, Lagos state has the highest number of slum inhabitants with an estimate of over 200 slum settlements [68, 74, 75]; others include Ibadan with an estimated 143, 15 in Abuja, 10 in Port-Harcourt, and 26 slum settlements in Jos [68, 75–77]. To achieve the SDGs of inclusive, resilient, and sustainable cities, an intervention will be required to transform slum settlements into livable and sustainable cities.

Gleaning from previous empirical studies, Masu'd et al. [78] evaluated the socioeconomic characteristics of slum residents in Ilorin. Residents of the chosen villages are described as a diverse mix of people, with the majority being over 51 years of age. They have a range of educational backgrounds, from no education to a primary school leaving certificate to a degree, and the majority of them work for themselves. Most of them make less than 50,000 Nigerian naira ($33.33 US dollars) per year, and a larger percentage reside in barrack and compound accommodations. Similar findings by another study [79] revealed that Abuja, the federal capital territory, has thirty slums. The study connected poverty and a shortage of affordable housing to the growth of slums. In actuality, these environments' open drainage, inadequate sanitation, and waste management contribute to the spread of disease.

In Badia, Lagos, slum dwellers' socioeconomic standing was investigated by Lakeman et al. [80]. The results show that there are more male residents, most of them married and between the ages of 20 and 49. Based on their educational status, 49.7% of slum residents have completed secondary school education, while 19% and 16.9% have primary and tertiary education respectively. 14.3% of the respondents have no formal education. Despite this, the bulk of them are petty traders making less than 30,000 Nigerian naira ($20 US dollars); therefore, income is a restriction. In a survey, Falade [81] evaluated the living conditions in six Nigerian slums (Abesan, Lagos; Elechi, Port Harcourt; Okpoko, Onitsha; Masaka, Karu; Dorayi, Kano; and Maukema, Bauchi) using 26 categories that are connected to the SDGs. The study's conclusions show that living in slums has negative effects on both physical and mental health because of factors including overcrowding, noise pollution, and limited access to clean drinking water (an average of seven people live in a room). For example, the study found that, as shown by earlier studies, inadequate nutrition is associated with higher rates of child mortality, typhoid, malaria, and tuberculosis. Ndukwu et al. [82] found that children from slum areas are more likely to suffer from stunting and being underweight and that these cases are due to low socioeconomic levels and environmental variables. Aliu et al. [83] characterised socioeconomic and environmental conditions of fifteen slums in Lagos. There were cases of overcrowding; social deprivation index confirmed that most slum residents are excluded from hygienic environment and improved water access and about 60% of slum inhabitants are residentially deprived. Common health issues experienced by slum inhabitants include malaria, diarrhoea, cold, and cough often linked to unhygienic conditions [84, 85].

Policies on EJ and Implication for SDG 2030 in Nigeria

One-fifth of Africans are Nigerians and by 2050, the country will be the third most populous country in Africa. Nigeria is the largest emitter of greenhouse gases in this region and is vulnerable to climatic events (Federal Ministry of Environment, 2021) [86], making the country an important driver of climate change actions in the African region. In achieving SDGs to reduce air pollution and combat climate change in Nigeria, policies are formulated across different sectors of the economy.

Nigeria's energy industry is responsible for 60% of the nation's greenhouse gas emissions, so lowering its carbon footprint in the energy sector is important for country-level reductions. The adoption of renewable energy at various levels is predicted to prevent 30,000 deaths from pollution-related causes in Nigeria [86]. Similar to the energy industry, improper handling of trash can lead to greenhouse gas emissions, air and water pollution, and environmental degradation, all of which are threats to the environment. In Nigeria, a number of illnesses are associated with environmental degradation, such as malaria, respiratory disorders, diarrhoea, TB, asthma, stroke, and paediatric pneumonia [29, 86–89] (Fig. 3).

The federal government of Nigeria in its nationally determined contributions (NDC) prioritised some sectors as imperative to achieve the Paris Agreement to reduce emissions below 1.5 °C. In the energy sector, the quantitative increase of LPG users to 26.8 million households, the adoption of improved cookstoves by 7.3 million households, and the eradication of

kerosene lighting by 2030 were proposed by the government. Also, all sectors of the economy are expected to adopt energy efficiency measures, increase the supply of bus rapid transport (BRT), zero gas flaring by 2030, and 60% reduction in methane emissions by 2031. Currently, air pollution has multiple sources in Nigeria, it was ranked as the fourth cause of death in Nigeria in 2007 but by 2017 it ranked first [43]. Environmental Performance Index (EPI) shows that Nigeria's position ranged from 86 to 96th and an average score of 40 which is a low performance compared to countries like the Netherlands with an EPI score of 75, an indication of better environmental performance. The year 2022 showed a massive deterioration in environmental quality with an EPI score estimated at 28.30, an indication that the country needs to be more committed to environmental health to reap the gains therefrom.

An examination of the national environmental policy reflects the federal government's intention to preserve the environment through earmarked strategies for each sector. However, for this to be effective, the policy needs to be updated in light of changing circumstances and events. To achieve the intended aims, communities must be acknowledged as significant stakeholders and government regulatory agencies must set targets. While the NDC proposed by the government of Nigeria captured major sectors (agriculture, energy, industry, and waste) with a gender-based approach to actualise these goals, there is a need for synergy between NDC and national environmental policy to guarantee commitment. In its NDC, the federal government states that gas flaring would halt by 2030. This is a positive development because it suggests the creation of gas for domestic use, which will solve the issue of deforestation and reliance on burning biomass for cooking and air pollution. The government can also impose the 'polluter pays principle' to ensure compliance with environmental policy. Above all, studies of the long-term effects of oil production and exploration on host communities' health ought to be iterative.

Ensuring equitable access to quality housing for all Nigerians will significantly mitigate environmental injustice. Even though the population is growing, the government can still map informal settlements, look at each one's unique characteristics, and improve them to livable conditions. The government emphasises in its policy framework the benefits of a circular economy in all sectors to promote sustainable waste management; however, since conventional waste management is still the norm, state and local governments may be better able to achieve this goal.

Conclusion

In Nigeria, the main EJ issues are energy exploration and degradation, household biomass combustion, transport emission, unsustainable waste management, and the proliferation of slum settlements. Energy exploration and production activities of oil companies across the Niger Delta region portend danger to the health of host communities. Environmental impact assessment of host communities should be done by oil companies. Also, poor waste management, household biomass burning, and rising slum settlement are threats to livability with varying impacts on physical and mental health. Since the environment and health are two sides of the same coin, the human right to habitable space must be respected and upheld at all levels. To address regional-specific environmental challenges and unequal socio-economic status that cause health inequity, community engagements across low-, middle-, and high-income locations can be instrumental in identifying and addressing EJ issues. Also, all levels of schooling should be educated on exhibiting a positive attitude towards people and the environment.

Furthermore, it is imperative to widen the scope of environmental policies in Nigeria to incorporate EJ in light of changing circumstances. In the same vein, NDC needs to be incorporated into the environmental policies being adopted by the Ministry of Environment to attain the goals of sustainable cities. Most importantly, the degree to which policies are implemented can be determined by effective institutions. There should be no lag between existing environmental laws and enforcement. Above all, meeting the demands of the present generation should not come at the expense of the ability of future generations to meet their own needs.

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Declarations

Competing interests The author declare no competing interests.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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