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MORALITY BEFORE KNOWLEDGE

Balancing industrial growth and environmental sustainability: Land use implications of cement factory operations

Oluwatoyin Olawoye Akinrogunde[1,*], Chukuma Chidi Famous[2], Rasheed Olawale Adegbindin[3], Olusola Opeoluwa Akinola[4], Rafiat Adesewa Ajibode[5], Faleti Oluyemi Oladeji[6]

[1 & 5] *Department of Urban and Regional Planning, School of Environmental Studies, Ogun State Institute of Technology, Igbesa, P.M.B 2005 Nigeria;*

[2] *Department of Architectural Technology, School of Environmental Studies, Ogun State Institute of Technology, Igbesa, P.M.B 2005 Nigeria;*

[3] *Department of Quantity Surveying, School of Environmental Studies, Ogun State Institute of Technology, Igbesa, P.M.B 2005 Nigeria;*

[4] *Department of Estate Management and Valuation, School of Environmental Studies, Ogun State Institute of Technology, Igbesa, P.M.B 2005 Nigeria;*

[6] *Department of Building Technology, School of Environmental Studies, Ogun State Institute of Technology, Igbesa, P.M.B 2005 Nigeria.*

*Correspondence: akinrogunde.oluwatoyin@ogitech.edu.ng

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ABSTRACT

Background: Accelerated industrialisation and urbanisation have reshaped rural and urban spaces, catalysing socio-spatial transformations that put a strain on agricultural land and amplify spatial and income inequalities. Cement production, being a significant driver of industrial and socio-economic transformation, is resource- and energy-demanding for the environment. This paper examines the land-use impact of cement production on sustainable development in Ewekoro, Nigeria, and offers recommendations to mitigate adverse effects while promoting sustainable livelihoods. **Methods:** Included was the use of multi-stage sampling and systematic sampling of 240 households for surveying, which involved dividing the population into clusters, with four settlements: Jagunna, Papalanto, Lapeleke, and Itori; chosen based on residential development and proximity to the cement factory. 233 of which completed questionnaires (response rate 97.1%). The Relative Importance Index (RII) was used to quantify socio-economic and environmental effects, supplemented by qualitative views on perceived community perceptions. **Findings:** Job opportunities (RII = 0.914) and social provision of facilities (RII = 0.870) were reported as the most significant socio-economic gains in Ewekoro. Health impacts arising from chronic exposure to factory effluent were highly indicated. Lafarge Cement's product technology improvements (RII = 0.7648) were claimed to enhance environmental sustainability, despite unresolved land use conflicts. **Conclusion:** The research provides policy guidelines that prioritize green practices and technologies to align cement production with the United Nations Sustainable Development Goals (SDGs). By integrating socio-economic and environmental concerns, cement factories can promote sustainable development within resource-based communities. **Originality/Novelty:** The study presents a localized adaptation of the Driver-Pressure-State-Impact-Response (DPSIR) framework for analysing cement production, land use, and sustainable development in Ewekoro. It provides a new understanding of the reconciliation between industry growth and human welfare, as well as ecological sustainability, and contributes to global discourses on sustainable industrial practices in developing world settings.

KEYWORDS: cement factory; industrial pollution; land use; mitigation; sustainable development.

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1. Introduction

The rapid acceleration of industrialisation and urbanisation has significantly transformed the rural and urban environments. The change has, over time, increased the demand for and need for cropland and other ancillary land uses, thereby generating spatial imbalances and income gaps (Rasure, 2023; Qiao et al., 2023). Urbanisation is commonly triggered by industrial development, land-use planning legislation, and environmental conservation regulations, all of which require strategic land-use planning, environmental planning, and consideration of social justice. Land-use planning becomes key in preventing the adverse effects of economic growth on the environment and human settlements (Qiao et al., 2023). Nevertheless, with technological and globalisation forces deepening production and employment systems, particularly in sub-Saharan Africa, development follows a trajectory depending on whether human activities are in harmony with environmental sustainability (Camara, Jamil, & Abdullah, 2019).

The production of cement is a principal driver of industrial development and socio-economic advancement, but also one of the most ecologically challenging sectors. It is interesting to note, according to USGS (2021), Tong et al. (2019), and Chen et al. (2022), that "globally, cement production has risen from 1.2 billion tonnes in 1990 to 4.1 billion tonnes in 2019. The industry is currently the second-largest industrial source of CO_2 globally, and is accountable for almost a quarter of total industrial emissions". The manufacturing of cement is widely considered to be among the most emission-intensive production steps, and therefore, decreasing its carbon footprint is the most challenging task. According to Czigler et al. (2020), the production of cement alone accounts for approximately 7% of global greenhouse gas emissions annually (see Figure 1). Unfortunately, the ecological impact is significantly outweighed by carbon emissions.

Cement factories are also significant emitters of nitrogen oxides (NO_x), sulphur dioxide (SO_2), and delicate particulate matter; all of which contaminate air and water, impact biodiversity, and pose grave respiratory health hazards to human beings (Pollution Prevention & Abatement, 1998; Mehraj et al., 2013; Agbede et al., 2022).

In the majority of developing countries, including Nigeria, these problems are exacerbated by a poor or weak regulatory environment. Likewise, Oyinloye (2015), the World Health Organisation (2023), and Akinrogunde (2024) also noted that "the absence of well-established buffer zones between industrial developments and residential communities increases the health hazards and environmental degradation, whereby marginalised communities end up suffering the devastating effects of polluting industrial emissions, with little protection or redress." The growth of cement manufacturing, especially in fast urbanising areas like Ewekoro, Nigeria, has become a powerful driver of land use change with lasting impacts on sustainable development. Scholarship increasingly records the environmental costs of locating cement plants in peri-urban and rural areas, where industrialisation as a land displacement process inevitably results in the loss of agricultural land, vegetative cover, and ecosystem integrity.

Dalil et al. (2017) also recorded a significant reduction in green cover, approximately 50% within ten years, in communities surrounding cement factories in Nigeria's Kogi State, resulting from large-scale land conversion to meet industrialisation needs. Cement dust and fumes have also been found to alter the chemical composition of the soil, negatively impacting fertility and resulting in land degradation and reduced agricultural output (Akinrogunde, 2024; Bilen et al., 2025). In the long run, environmental stress not only reduces the soil's capacity for recovery but also leads to massive-scale loss of biodiversity. This definitely disrupts the essential ecosystem services that are vital to human health and our climate change resilience (Dawoudian et al., 2021; Abdulwadood et al., 2024). Moreover, cement manufacturing pollution impacts both groundwater and surface water, a matter of grave concern to the water security of industrialised regions (Vázquez-Rowe et al., 2019; Habert et al., 2020).

Parallel to this, the socio-economic implications of cement factory expansions have been increasingly documented in empirical research. Land grabbing for cement production has historically disrupted agrarian economies, compelling indigenous communities to abandon agricultural activities in favour of low-paying, non-agricultural livelihoods (Harifuddin et al., 2024). It not only affects food security but also undermines indigenous knowledge systems as well as socio-cultural solidarity. Moreover, neighbouring populations consistently have higher rates of respiratory disease and other environmental health consequences of air pollution, which pose legitimate concerns for social sustainability and environmental justice (Abdulwadood et al., 2024). However, the experts have reacted with calls for far-reaching mitigation measures such as land use change spatial monitoring (Dalil et al., 2017), vegetative buffer strips and emissions control technologies (Vázquez-Rowe et al., 2019), and implementing low-carbon production methods (Barbhuiya et al., 2024; Habert et al., 2020). At the core of these measures is the critical call for genuine community participation and unbiased compensation policies. These elements can transform individuals' lives and improve local resilience. However, as cement development advances, a balance must be struck between this advancement and the pursuit of sustainability. That means accepting responsibility for the environment, improving technology, and facilitating participatory governance.

It is worth mentioning that the Ewekoro Cement Factory in Ogun State provides a prototypical example of the complex interactions between industrial development and sustainable land use. While it is playing a significant role in the economic development of Nigeria, a lot of other adverse effects are attached to it, as reported by Ojo & Ogunnusi (2019), Adekoya (2020), and Salami, Farounbi, & Muoghalu (2004); some of which are disruption of livelihoods, inter-communal conflict, and environmental degradation. Based on the above, existing studies have indicated that emissions from cement factories in Ewekoro affect air and water quality, crop yields, and the host community's resistance (Oladimeji, 2019; Roche, 2023). Although extensive research has been conducted on environmental and health consequences triggered by cement factories, their broader implications in land use planning, urban resilience, and sustainable development are underexplored and hence underreported. It is therefore crucial to bridge this knowledge gap in order to inform policies that convert economic growth into environmental sustainability and community welfare. The study location, Ewekoro, is a suitable case study because it is geographically close to Nigeria's largest cement producer, Lafarge, and represents a rapidly industrialising resource-based community. The socio-economic dependency of the region on the cement industry, along with accompanying land-use conflicts and environmental challenges, reflects broader trends in developing economies.

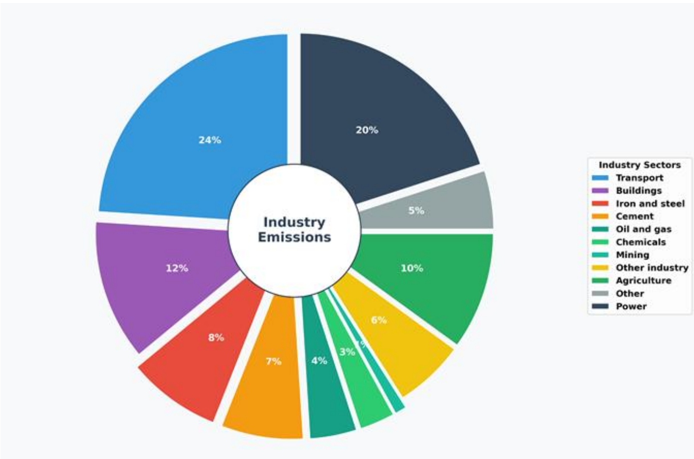


Fig 1. Cement production’s share of global CO_2 emissions
(Adapted from Czigler et al., 2020)

This research aims to assess the land-use impacts of cement factories on sustainable development in Ewekoro, Nigeria. Its broad goal is to develop strategies that counteract potential adverse effects and promote sustainable livelihoods for the people. The key research questions for this research are: What are the socio-economic impacts of the activities of the cement factory on the study area? What are the land use and health implications of the cement factory in the study area? How does the cement factory impact sustainable development in the study area? Notably, the current research makes its contribution to some of the top Sustainable Development Goals, i.e., SDG 11 (sustainable cities and communities), SDG 12 (responsible consumption and production), and SDG 15 (life on land); the research attempts to provide insights that facilitate action for synergistic and resilient urban development (United Nations, 2015). The research also promotes intersectoral dialogue among policymakers, industrial operators, urban planners, other built environment professionals, and local communities to design green technologies, participatory planning, and adaptive governance measures. Through interdisciplinary collaboration, the research promotes balanced action that facilitates sustainable industrialisation without undermining the health and well-being of host populations.

1.1 Research objectives

This study examines the land use implications of cement factories for sustainable development in Ewekoro, Nigeria. Its primary aim is to propose strategies that mitigate adverse impacts while supporting sustainable livelihoods for the local community. Therefore, in order to achieve the above aim, the following objectives needs to be pursued: 1) Examine the socio-economic impacts of the cement factory's activities in the study area; 2) Identify the land use and health implications of the cement factory in the study area, and, 3) Ascertain the influence of the cement factory on sustainable development in the study area.

1.2 Conceptual underpining

This study adopts the dual concept of the Driver-Pressure-State-Impact-Response framework (DPSIR) and Sustainable Development. The frameworks enable a better understanding of the theoretical foundation of this study (see Figs. 2 and 3). The OECD 1993 Pressure-State-Response (PSR) method, a variant of the 1979 Stress-Response model by Rapport and Friend, was a precursor to the Drivers-Pressure-State-Impact-Response (DPSIR) approach adopted by the European Environment Agency in 1999. As explained by Gari et al. (2015) and Pearson and Fippinger (2018), DPSIR provides a structured framework for analysing causal relationships between human requirements (drivers), activities they impose (pressures), resulting environmental conditions (State), ensuing ecological, social, and economic effects (impacts), and institutional or policy measures developed in response. Its applicability has been confirmed in numerous applications, including urban tourism, flood transportation systems, water surface management, marine degradation, fisheries sustainability, change in land cover and use, climate change impacts, and sand harvesting impacts. In cement production, social and economic needs for houses and infrastructure drive limestone mining and manufacturing. These activities release sulphur dioxide, nitrogen oxides, and carbon oxides. They also lead to traffic congestion, noise pollution, water shortages, and waste management problems. These stresses degrade air and water quality, threatening ecosystems. The impacts lead to job loss, poverty, ill health, poor educational outcomes, and environmental degradation. Individuals suffer from resource conflicts, economic loss, and environmental asset losses. The model provides a system to track these connections and formulate effective responses.

On the other hand, the concept of sustainability emerged in the mid-20th century and gained prominence with the publication of the Brundtland Report, which defined sustainable development as meeting present needs without compromising future generations' ability to meet their own needs. Sustainability requires working within nature's limits, eradicating poverty, conserving resources, and promoting sustainable growth. The UN's 17 Sustainable Development Goals reflect this balance through a harmonious integration of ecological, social, and economic needs. Intergenerational justice is involved. You must maintain natural systems, preserve social needs, and grow the economy together.

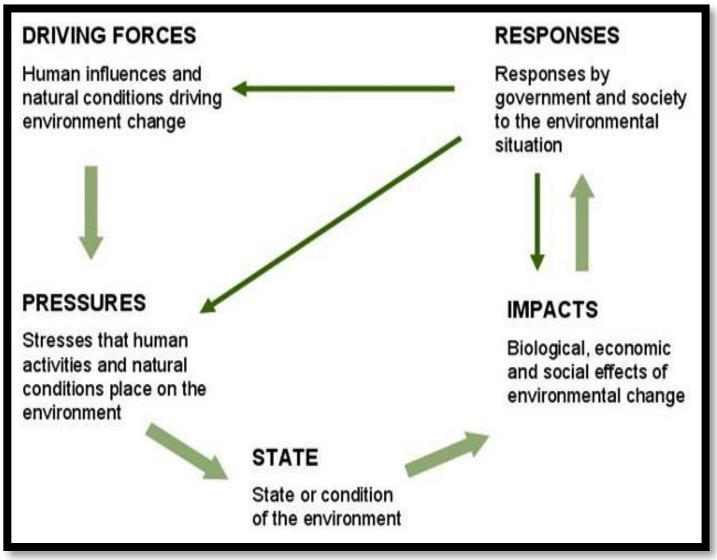


Fig. 2. The Driver-Pressure-State-Impact-Response Framework
Source: Denla, 2018.

Energy transitions, such as solar, wind, hydroelectric power, and biomass, are practical solutions. Education also introduces change through learning conservation and sustainable practices. Cities are most significant. Over half the world's population lives in cities. Sustainable cities emphasise the careful use of resources, the use of renewable energy, effective pollution management, and good governance. They aim to reduce emissions, improve air and water quality, and prepare for the climate-related dangers. Sustainability has evolved from being merely about the environment to a whole-of-government approach necessitating structural, societal, and economic changes towards balanced and resilient development.

Fig. 3(a) Fig. 3(b)
Fig. 3(a). Overview of the Sustainable Development Goals (SDGs) (UN, 2019b)
Fig. 3(b). Assignment of the Sustainable Development Goals (SDGs) to the Three Contextual Domains.
(Folke et al., 2016; Rockstrom & Sukhdev, 2014)

1.3 Past empirical studies

African scholarly literature on cement production consistently underscores the acute tensions between industrial development and environmental sustainability, particularly in relation to land-use change that triggers ecological decline and deepens socio-economic inequality. The argument has been framed primarily within the context of political ecology and environmental justice paradigms, both of which emphasise the uneven distribution of environmental costs and benefits. In the Nigerian context, Adebayo et al. (2024) observed that Lafarge Cement Factory activities in Ewekoro contribute to economic development in terms of employment creation and infrastructure provision, yet simultaneously cause extensive land degradation, pollution, and livelihood disruption. As a result of the foregoing findings, the central concern in political ecology is with asymmetric power relations in resource production, echoing environmental justice debates on the disproportionate impacts borne by marginalised communities. However, complementary evidence is provided by Tesfaye et al. (2024), who conducted a life cycle assessment of cement production in Ethiopia. Their findings demonstrate high environmental and human health risks, necessitating the adoption of cleaner technologies to minimise land-use conflicts.

This trend is similar to what happened in Ewekoro and is explained by colonial economic pathways that continue to promote extractive and environmentally unfair industrial ventures. More pertinently, Mnguni & Van der Merwe (2022) used a system dynamics modelling approach to explore the potentialities of decarbonisation policy in urbanising contexts. However, their critique of elite-led industrial policy, which rode on the back of political ecology, identified the agrarian displacements associated with cement expansion, further solidifying Ewekoro as a significant site of investigation. Miller et al. (2023) argued that African cement emissions are projected to be 1.4 to 3.8 gigatonnes by 2050. This, in turn, necessitated the need for material efficiency strategies as a means of offsetting the adverse land-use effects of industrialisation. A scenario that falls within Nigeria's trajectory towards an export-oriented cement industry, which aggravates environmental, as well as social, pressures. Besides these predictions, Abubakar & Aina (2021) and Sithole et al. (2023) also highlighted how industrialisation deepens vulnerabilities in urban and informal settlements and therefore requires inclusive and equitable land-use policies. Policy studies also highlight these concerns; in Osei-Kojo et al.'s (2024) comparative study of Nigeria and Morocco's cement industries, possible trajectories towards sustainable industrial linkages were identified but required justice-oriented reforms to avert environmental devastation.

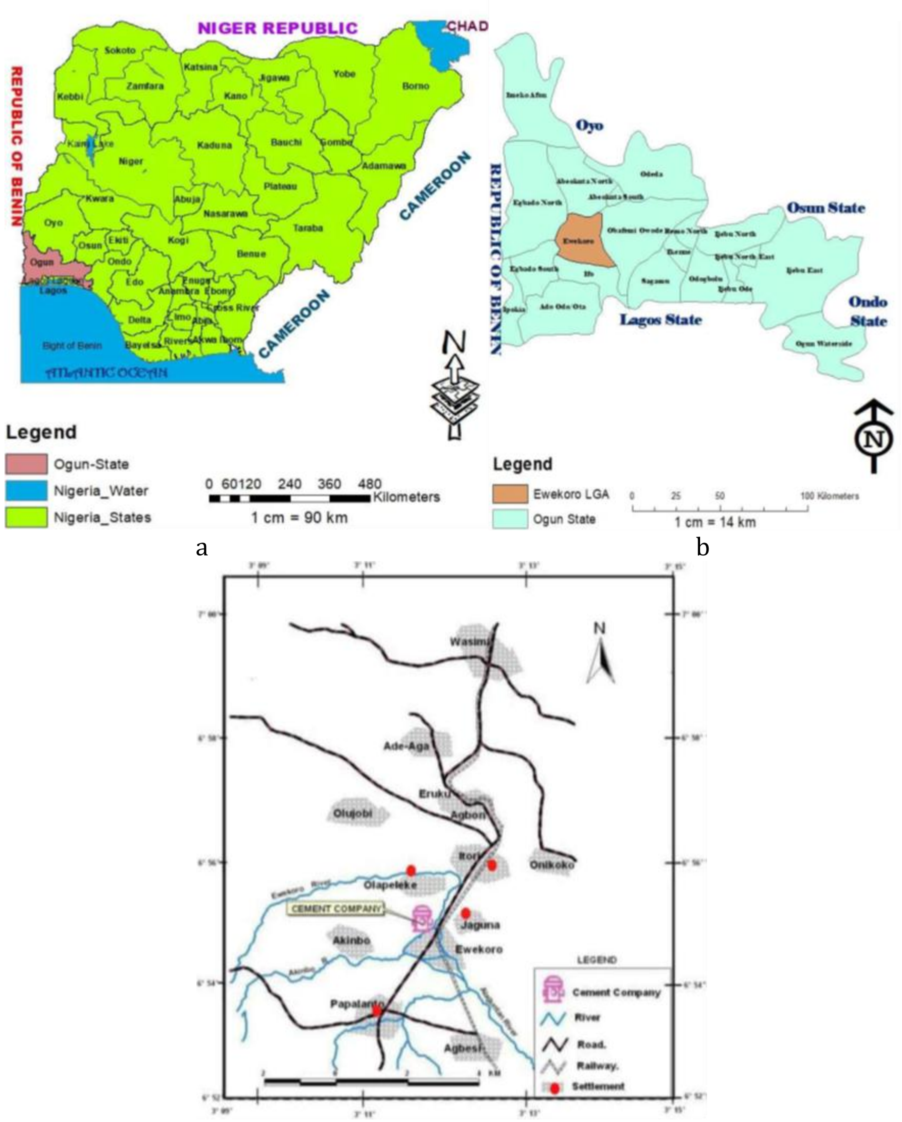
These interventions resonate with broader calls for incorporating environmental justice in industrial policy debates. In summary, this body of work positions Ewekoro as a case study representative for exploring the intersection of industrialisation, land-use transformation, and social justice in Africa. The research converges on the imperatives of green technology uptake, participatory governance, and sustainability transitions. These types of strategies align with the emancipatory agenda of political ecology, which seeks to reconcile economic development imperatives with ecologically sustainable and equitable land uses (Okereke & Agupusi, 2020).

2. Methods

2.1. Description of the study area

Ewekoro, in Ogun State, Nigeria, is prominent for the presence of the West African Portland Cement Company (WAPCO) and rich deposits of limestone. The town was created as a local government area in 1981 and is found in southern Nigeria. The town is named after the Ewekoro limestone, which is the most common natural resource of this area. It is one of the twenty Local Government Areas (LGA) in Ogun State, bordered by Abeokuta North LGA to the north, Obafemi-Owode to the east, Yewa South LGA to the west, and Ado-Odo Ota LGA to the south. According to the 2006 census, Ewekoro had a population of 55,093. The area spans approximately 594 km^2 (229 sq mi) and is positioned along the Sango-Ifo-Abeokuta expressway. Its geographical coordinates lie between Latitudes 6°49'48" N and 7°6'16" N of the Equator and Longitudes 3°2'56" E and 3°21'54" E of the Greenwich Meridian, with an average elevation of 120 meters above sea level. The Lagos-Abeokuta Expressway runs north-south through the region and links the Ewekoro LGA.

The International Highway (Ilaro/Papalanto Road) parallelly passes along the Ajegunle/Abalabi Road. Transport infrastructure consists of different types of routes and terminals, and cars, taxis, trucks, and motorbikes are the main modes of transport within the area. The Lagos-Abeokuta Highway also runs adjacent to the terminals in the area (Badejo Olasunkanmi & Ogunseye, 2020). Figures 4 a, b, and c shows the map of Nigeria showing Ogun State in its regional setting, the map of Ogun State depicting Ewekoro LGA in its local setting, and the map showing the study area and the selected settlements in Ewekoro LGA.



a b

c

Fig. 4. a) Map of Nigeria showing Ogun state in its regional setting; b) Map of Ogun State showing Ewekoro LGA in its local setting; c) Location of the selected settlements in Ewekoro LGA (Ogun State Ministry of Physical Planning and Urban Development, 2023) (Bada et al., 2013)

2.2 Methodology

The research adopted a multi-stage sampling technique to select the households for the survey in a systematic and representative manner. The population was first divided into various clusters, which were further divided using various levels of sampling. Jagunna, Papalanto, Lapeleke, and Itori settlements were selected as they were close to the cement factory and experienced a preponderance of residential development. In each community, the first sample was selected from the Random Number Generator of SPSS software, and all residential buildings were surveyed at intervals of every fifth (5th) building. A commercial, religious, or industrial building, if selected, was replaced with the closest available residential builsding. The household heads were given priority in the survey because they were the decision-makers in the Nigerian families (Adebisi et al., 2018). Where the household head could not be located, a similarly reliable adult well acquainted with the household and study area was engaged as a proxy.

The sample size was calculated using appropriate statistical methods, with 20% of the household heads, amounting to 11,988, derived from the sample frame (see Table 1). This method is supported by research from Singh and Masuku (2014), Ajayi and Ajayi (2021), and Lakens (2022), which confirmed the reliability of such sample proportions used in this study. To ensure statistical significance, 2% of the household sample (240 households) was selected, resulting in the distribution of 240 questionnaires. A reconnaissance survey helped shape the data collection schedule, ensuring maximum participation between 12 pm and 4 pm on weekends. The questionnaire was administered in English, Yoruba, and Pidgin to cross the language barrier. The responses were digitally audio-recorded, transcribed into Microsoft Excel sheets, and rated on a five-point scale rating from "extremely bad" (1), representing the lowest score, to "very good" (5), representing the highest score. To ensure data reliability and accuracy, quality control strategies like frequent supervision, monitoring, and double-entry verification were followed, which enhanced the validity of the study.

One of the various research instruments utilized for data collection and analysis of this study is a structured questionnaire, and Google Earth was specifically utilized to map out the areas that were selected and to determine the number of buildings in the area. In addition, the Geographic Information System (GIS) tool was utilized to define the selected communities in Ewekoro LGA. Moreover, observation and photography were also involved in gathering actual time data using personal observation and pictorial documentation, with the view of maintaining a balanced data collection and analysis method.

Table 1: Sample Size for the Study

Selected areas in Ewekoro	Approximate distance from the cement factory (km)	Number of buildings per unit	Sample taken @ 20% of buildings per unit	Household population	Household sample taken @ 2%
Jaguna	1.54	493	99	594	12
Papalanto	2.48	2,196	439	2,634	53
Lapeleke	2.07	82	16	96	2
Itori	3.06	7,220	1,444	8,664	173
Total	-	9,991	1,998	11,988	240

3.3. Instrument Validation and Reliability

The household survey was designed to measure the socio-economic impacts, health consequences, and sustainable gains of the Ewekoro Cement Factory, employing items tailored to the local conditions of Jagunna, Papalanto, Lapeleke, and Itori. Environmental and social science experts familiar with Nigeria's cement industry provided input to maintain content validity, refining items to capture local issues such as land loss and pollution. Table 2 presents a pilot test of 40 households in Itori, which validated item clarity and relevance, with minor modifications. Reliability was tested through Cronbach's alpha, with resulting measurements of 0.82 for socio-economic impacts (e.g., job, social services), 0.79 for health impacts (e.g., respiratory issues, skin irritation), and 0.76 for sustainability perception (e.g., green technology, community programs), all more than the minimum threshold value of 0.7 (Nunnally, 1978). Exploratory factor analysis confirmed the existence of singular constructs in alignment with the Driver-Pressure-State-Impact-Response (DPSIR) framework, thus ensuring the robustness of the instrument in land use implications analysis in Ewekoro.

Table 2: Instrument Validation Summary for Household Questionnaire

Construct	Number of Items	Cronbach's Alpha	Content Validity Notes	Factor Analysis Confirmation
Socio-Economic Impacts (e.g., employment, social services)	8	0.82	Items refined through expert consultation to reflect local concerns like job creation and infrastructure development in Jagunna, Papalanto, Lapeleke, and Itori.	Exploratory factor analysis confirmed distinct grouping of socio-economic items, aligning with DPSIR's "Impact" and "Response" components.
Health Effects (e.g., respiratory issues, skin irritation)	6	0.79	Developed with input from environmental scientists to address pollution-related health concerns specific to Ewekoro's cement factory emissions.	Factor analysis validated health effects as a separate construct, supporting DPSIR's "State" and "Impact" dimensions.
Sustainability Perceptions (e.g., green technology, community programs)	5	0.76	Items tailored to local sustainability issues, validated by social science experts for relevance to Ewekoro's context.	Factor analysis distinguished sustainability perceptions, aligning with DPSIR's "Response" and "Pressure" components.

3. Results and Discussion

3.1 Results

3.1.1 Questionnaire response rate

From the two hundred and forty (240) questionnaires administered to the respondents during the survey investigation, two hundred and thirty-three (233) questionnaires were retrieved back from the respondents. These retrieved numbers represent a 97.1% retrieval rate. However, this response rate aligns with Fincham (2008), who asserted that "survey research should achieve at least the minimum response rate of 80% to ensure reliability of findings and facilitate generalization." The subsequent analysis and discussion of results are structured according to the research objectives.

3.1.2 The socio-economic implication of the cement factory in Ewekoro

Socio-economic implications like social services, employment, income generation, infrastructure, economic effect, skill development, community programs, business growth, and property value were analysed as important to know how living standards in Ewekoro were affected by the cement. Relative Importance Index (RII) analysis was used to measure the relative impact of these variables on the respondents' living standards. RII for each factor was established as the respondents' weight added up and then divided by the number of responses. The above-calculated RII values from 0 to 1 ranged between and indicated the relative importance of each factor to the respondents. The higher the RII values, the more important they are in affecting living standards.

$$\text{Relative Importance Index (RII)} = \frac{5\,n_5 + 4\,n_4 + 3\,n_3 + 2\,n_2 + 1\,n_1}{A \times N} \qquad \text{(Eq.1)}$$

n_5 = Number of respondents for strongly agree
n_4 = Number of respondents for agree

n_3 = Number of respondents for neutral
n_2 = Number of respondents for disagree
n_1 = Number of respondents for strongly disagree
A = Highest weight on the scale (5-point Likert scale) = 5
N = Total number of respondents = 233

Table 3. The Relative Importance Index (RII) Analysis on the Socio-Economic Implication of the Cement Factory in Ewekoro

Statements	SA (5)	A (4)	N (3)	D (2)	SD (1)	Total (N)	N	A*N	RII
Social services	460	435	50	95	25	1065	233	1165	0.914163
Employment opportunities	730	212	33	30	8	1013	233	1165	0.869528
Economic multiplier	490	320	54	52	11	927	233	1165	0.795708
Income generation	405	388	57	48	12	910	233	1165	0.781116
Increased property value	425	324	45	48	28	870	233	1165	0.746781
Skill development	390	192	69	108	30	789	233	1165	0.677253
Infrastructure development	265	232	99	138	20	754	233	1165	0.64721
Social cohesion	225	280	45	182	12	744	233	1165	0.638627
Growth of Small Business	75	292	186	120	23	696	233	1165	0.597425
Community initiatives	125	304	57	150	38	674	233	1165	0.578541

Table 4. Ranked Relative Importance Index (RII) on the Socio-Economic Impact of Cement Factory

S/N	Statements	RII	Rank
1	Social Services	0.914163	1st
2	Employment Opportunities	0.869528	2nd
3	Economic Multiplier	0.795708	3rd
4	Income Generation	0.781116	4th
5	Increased Property Value	0.746781	5th
6	Skill Development	0.677253	6th
7	Infrastructure Development	0.64721	7th
8	Social Cohesion	0.638627	8th
9	Growth of Small Business	0.597425	9th
10	Community Initiatives	0.578541	10th

The Relative Importance Index (RII) analysis, as presented in Tables 3 and 4, and Fig. 5 gives the degree of importance of the various socio-economic implications and ranked values. Here, employment opportunities and social facilities were especially ranked in the first positions, at 0.914 and 0.870, respectively. The economic multiplier effects and income generation ranked second at 0.796 and 0.781, respectively, and demonstrated their important roles. Of further concern were infrastructure, social solidarity, and skill development, whose RII estimates were 0.677, 0.647, and 0.639, respectively. Note that the second-highest ranking for employment and community development cannot conceal the importance of the top drivers. The evidence indicates a substantial contribution by employment and social services to rising living standards, with policy and community development implications. This is supported by Anam et al. (2022), whose position acknowledges corporate social responsibility initiatives, such as those of Lafarge Cement, to be positively impacting the well-being of residents in the region of wealth creation and income generation.

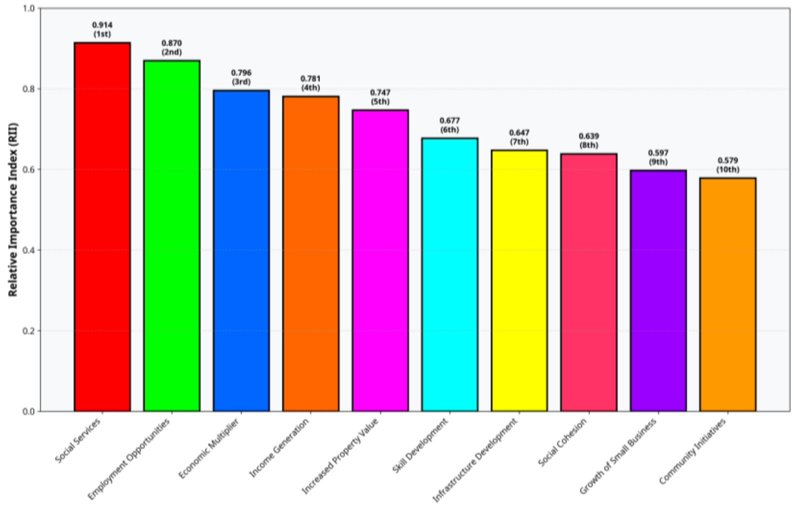


Fig 5. Ranked Relative Importance Index (RII) on the Socio-Economic Impact of Cement Factory

3.1.3 Impact of the cement factory on sustainable development in Ewekoro

This analysis Tables 5, 6 and Fig. 6 examines the Lafarge Cement Factory's contribution towards sustainable development within the host community. The research examines the contribution of the factory towards economic development, environmental conservation, and social balance. The research takes into account both the positive contribution and potential reversal of the sustainability effect of the impact of the operation of the factory on long-term development objectives and community welfare.

Using the Sustainable Industrial Indicators framework introduced by Badi et al. (2022), we can thoroughly examine how the Lafarge Cement Factory is performing in terms of sustainability. This method helps us examine key areas such as management practices, technological progress, eco-friendly supplier initiatives, innovations in product technology, social performance, and community development efforts.

The use of Relative Importance Index (RII) analysis offers more information, presenting a detailed analysis of these determinants. Relative Importance Index (RII) in Tables 5 and 6 and Fig. 6 indicates a positive orientation towards Lafarge Cement Factory in Ewekoro. Product technology innovation is the highest-valued category, with a high RII value of 0.7648. More so, community development initiatives are highly ranked (RII = 0.7502) as they have a significant role in contributing towards socio-economic development at the grassroots level. The third-ranked sustainable industrial indicator (RII = 0.7047) goes to social performance, exhibiting favourable opinions concerning ethical behaviour and responsiveness to stakeholders.

While Lafarge has performed better in some areas, there is still a need for improvement in other areas. If Lafarge improves management technological innovation and greening of suppliers, overall performance and stakeholder satisfaction can be improved. These corroborate the outcomes of Panigrahi et al. (2019), who state that Lafarge has to become more sustainable when it comes to its supply chain management and business practices. Thus, this can facilitate greener city development, expand long-term environmental stewardship, enable economic development, and enhance social well-being with these interventions while ensuring alignment of its operation with broader goals for sustainable development.

Table 5. Relative Importance Index (RII) Analysis of Lafarge Cement Factory's Impact on Sustainable Development Indicators in Ewekoro.

S/N	Statements	E (5)	G (4)	A (3)	P (2)	VP (1)	Total (N)	N	A*N	RII
1	Product Technology Innovation	280	528	39	24	20	891	233	1165	0.7648068
2	Community Development Initiatives	485	164	159	48	18	874	233	1165	0.7502145
3	Social Performance	225	352	177	52	15	821	233	1165	0.7047210
4	Management Technological Innovation	120	212	138	184	18	672	233	1165	0.5768240
5	Greening the Supplier	110	164	231	158	14	677	233	1165	0.5811158

Table 6. Ranked Relative Importance Index (RII) on Lafarge Cement Factory's Impact on Sustainable Development Indicators in Ewekoro.

S/N	Statements	RII	Rank
1	Product Technology Innovation	0.7648068	1st
2	Community Development Initiatives	0.7502145	2nd
3	Social Performance	0.7047210	3rd
4	Management Technological Innovation	0.5768240	4th
5	Greening the Supplier	0.5811158	5th

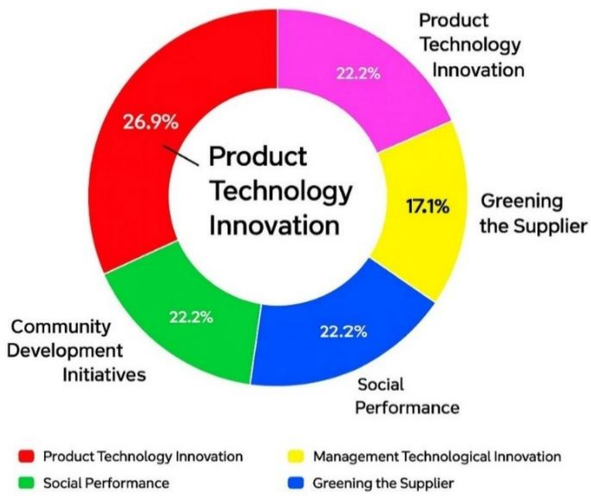


Fig 6. Ranked Relative Importance Index (RII) Analysis of Lafarge Cement Factory's Impact on Sustainable Development Indicators in Ewekoro

3.1.4 Land use implication of the cement factory on the means of livelihood of residents

Analysis in Figure 7 shows significant effects of the cement plant on the quantity of agricultural land in the host community and four prevailing categories of response supported by the variable "Completely unavailable" (9.4%), indicating a minority but considerable subgroup of respondents for whom there has been a complete loss of land suitability for agriculture. The most scored response, "Significantly reduced" (50.2%), represents a massive decline in agricultural land availability in the study area and hence reflects the extensive environmental burden of the activities of the cement factory. "Moderately constrained" (31.8%) reflects the restriction of land use to some extent, and it may imply the presence of continuing agriculture activity with operations at smaller levels of productivity. Conversely, the "Remained unaffected" category (8.6%) describes areas in which agriculture has not been directly affected by adverse impacts of the factory's presence, perhaps as a result of relative remoteness, which may have protected those areas from unwanted environmental impacts. These findings show the enormous trade-offs between industrial growth and agricultural sustainability and the necessity for state intervention through policies of land-use zoning, schemes of compensation, and environmental pollution in order to minimize adverse effects on farmers within the region.

More so, Figure 7 illustrates sudden livelihood shifts traceable to the factory's operational activities. The "Shift towards factory employment" (45.5%) clearly revealed that almost half of the respondents have moved into industrial labour, which indicates a radical shift in the local employment market. The response "Increased commercial opportunities" (38.2%) indicates the growth of a second economy, particularly in service and trade industries. The response to "Displaced traditional occupations" (13.3%) indicates the deterioration of rural and artisanal ways of life, and it can be an indicator of socio-cultural and economic destabilization. Response "No noticeable change" (3.0%) was the lowest chosen response; this may suggest either geographical remoteness (distance) from the impact of the factory or lowering sensitivity to economic change. Together, these effects form a more general transformation away from agrarian-based livelihoods in the direction of an industrial-commercial economic organization with far-reaching implications for income security, changed requirements for skills, and community identity. The study also underscores the need for vocational retraining programs and economic diversification policies aimed at minimizing occupational displacement.

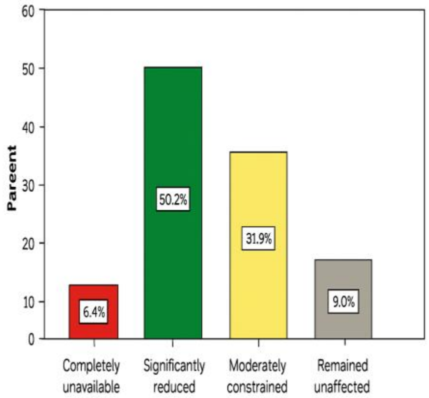


Fig. 7 (a)

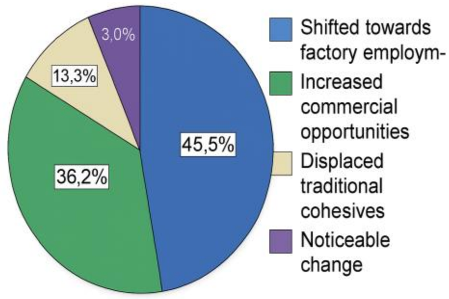


Fig. 7 (b)

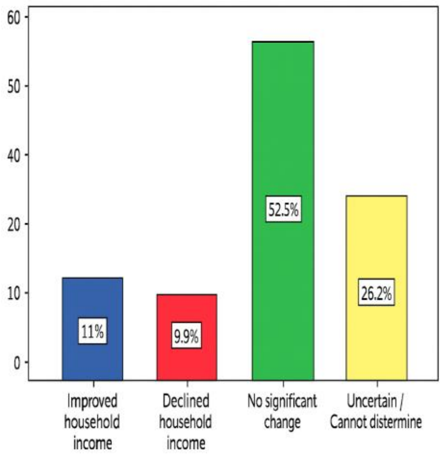


Fig. 7 (c)

Fig. 7 (a) Influence of the Cement Factory on the availability of land for agricultural activities; (b) Cement Factory altered the predominant forms of livelihood among residents; (c) Impact of land use changes associated with the cement factory on household's income

Figure 7 revealed a balanced analysis of the variation in household income as a result of land-use change surrounding the cement factory. The "Improved household income" category (11.2%) indicates a minority was economically better off through the generation of new jobs or entrepreneurial ventures on account of the existence of the factory. On the other hand, "Declined household income" (9.9%) represents the households that have been adversely impacted by farmland loss or disruption of traditional livelihoods. Most of the respondents chose "No significant change" (52.8%), which could reflect some spatial disconnection from the impact of the factory or the existence of diversified sources of income being used as a buffer against such impacts. Of particular interest is the low rate of "Uncertain/Cannot determine" answers (26.2%), an indicator of general uncertainty about the long-term economic consequence, perhaps due to lag effects or livelihood complexity. While overall, results indicate a range of economic impacts, ranging from moderate improvement to fall and uncertainty, it indicates the need for special support mechanisms covering both short-term economic dislocation and the potential for long-term adaptation.

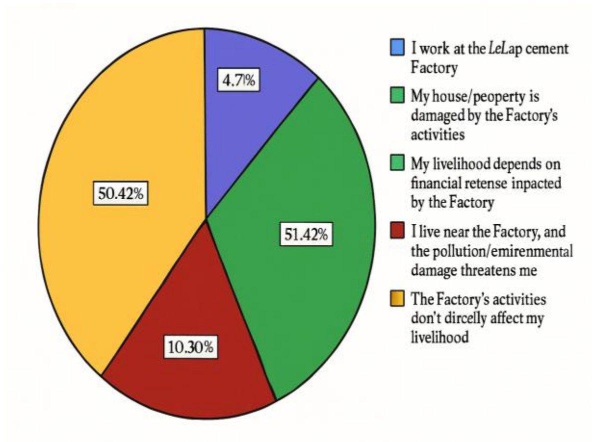


Fig. 8 (a)

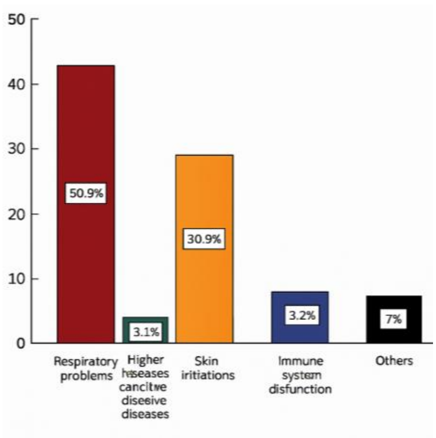


Fig. 8 (b)

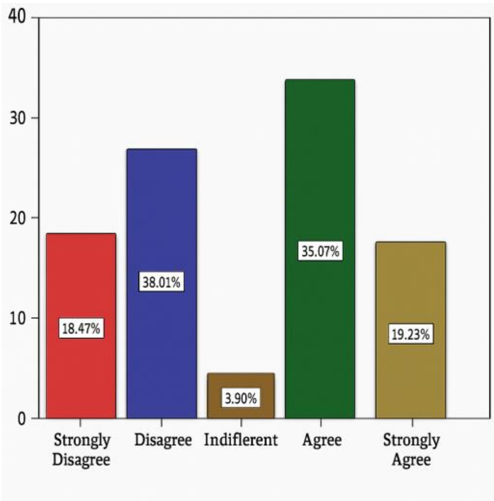


Fig. 8 (c)

Fig. 8 (a) Ways the activities of the Cement factory directly affects respondent's livelihood; (b) Perceived associated health problems due to prolonged exposure to emissions; (c) The positive influence of Cement Factory on economic development

The finding in Figure 8 depicts that 39.1% of the respondents live in immediate proximity to the cement factory and expressed grievances about environmental degradation and pollution. Additionally, 33.5% of the respondents testified that the factory's operations threatened enormous destruction to their business and/or property. More so, 13.7% of the respondents worked at the Lafarge Cement Factory, while 10.3% utilised natural resources that were harmed due to its operation. Significantly, only 3.4% of respondents claimed that the factory's activities had no direct effect on their lives. The findings are consistent with the study of Ajibade et al. (2021) in recognising environmental degradation and economic displacement as shared concerns among host communities. Such findings imply more environmental regulation, increased corporate accountability, and application of sustainable industrialisation to minimise adverse effects and promote well-being among communities. Similarly, in Figure 8, 50.6% of the respondents identified respiratory disease as the most common condition due to long-term exposure to cement factory emissions, indicating high concern with air quality and chemical inhalation. Those respondents who indicated that skin irritation is the primary health challenge were 30.9%, indicating high skin exposure to particulate matter. However, fewer respondents reported cardiovascular disease (5.6%) and immune system dysfunction (5.2%), indicators of potential long-term impacts on the body. Also, 7.7% of respondents reported other diseases, including eye and headache irritation. Overall, respondents' more certain perception about the harmful effects of long cement factory emission exposures to health is evident. Conversely, Figure 8 shows divergent views regarding the economic impact of the cement factory on development in Ewekoro. While 33% of the respondents concurred and 18% agreed strongly that the factory positively contributed to economic development, a greater percentage (45.1%) disagreed—26.6% disagreed and 18.5% strongly disagreed. A mere 3.9% of the respondents adopted a middle response. Such mixed reactions indicate that while some economic gains have been achieved through the activities of Lafarge Cement, most people in the impacted community feel that the presence of the factory is more detrimental than positive to the local economic growth. Such a perceptual difference highlights the need for inclusive and sustainable development policy alternatives that are able to satisfy the needs of industrial interests and impact local populations in an equal manner.

3.2 Discussions

3.2.1 Socio-economic implication of cement factory in Ewekoro

Relative Importance Index (RII) test indicates that employment availability (RII = 0.870) and social services (RII = 0.914) are the leading determinants of living standards within Ewekoro. In line with Anam et al. (2022), who found that corporate social responsibility drives the well-being created in rural communities, a similar finding emanates from our study. Both strong RII values of economic multiplier impacts (RII = 0.796) and income generation (RII = 0.781) equally demonstrate the contribution of the factory to economic growth at the regional level. However, growth of small businesses was lower on the agenda (RII = 0.597), followed by local projects (RII = 0.578), indicating that while the factory is at the centre of employment and income generation opportunities, there are chances for entrepreneurship stimulation as well as local projects. The same requires policy addressing specifically the rise in skill development (RII = 0.677) and infrastructure (RII = 0.647) such that long-run socio-economic benefits are reaped.

3.2.2 Impact of cement factory on sustainable development in Ewekoro

A ranking of factory contribution towards sustainable development by scale in the Sustainable Industrial Indicators model established by Badi et al. (2022) showed community development programs and product technology innovation as number one. The local people greatly esteem Lafarge's technological advancements as well as its contribution to the region's development program. In contrast, management technological innovation and greening the supplier were perceived on a low term, highlighting areas where the factory could improve its sustainability efforts. However, these findings concur with Panigrahi et al. (2019) as they highlighted green supply chain management and urban planning. To achieve more in concordance with high sustainability development objectives, Lafarge Cement should focus on increasing its green custody and institution eco-friendly modes in operations.

3.2.3. Land use implication of the cement factory on the means of livelihood of residents

Findings from this analysis highlight the dualistic impact of cement factory operations on the Ewekoro community, revealing both economic opportunities and significant socio-environmental trade-offs. While industrialisation has created employment and commercial prospects for many residents, it has concurrently displaced traditional agrarian livelihoods and degraded agricultural land, creating livelihood insecurity for vulnerable groups. The results indicate that the individuals have excellent environmental concerns that they are worried about, namely pollution and the adverse impacts on local enterprises and environmental systems. This is in line with the literature on adverse externalities of manufacturing (Ajibade et al., 2021).

Also, the findings reveal a strong perception among residents of the adverse health impacts caused by prolonged exposure to emissions from the cement factory. Most respondents identified respiratory diseases as the most prevalent condition, underscoring serious concerns about air quality and chemical inhalation. Skin irritation was also prominently noted as being among the conditions, indicating frequent exposure to particulate matter in the air. Few of them linked emissions to cardiovascular disease and failure in the immune system, which could indicate less immediate but possibly cumulative impacts on health. Other conditions like eye irritation and headache were also indicated. These, in total, confirm a common perception of the health effects of cement plant emissions, where skin and respiratory diseases appeared to be the most significant problems, consistent with the study of Raffetti et al. (2019). The research also identifies mixed perceptions about the economic gains of the cement plant in the region, as perceived benefits are not uniformly distributed among the community members. Most of the respondents continue to question the net developmental benefit of the presence of the factory, and others have even questioned the sustainability and equity of its economic effects. These findings call for increasingly sustainable industrial strategies in compliance with SDG factors, mainly in the form of greater protection of the environment, fair sharing regimes of the benefits, and niche strategies for promoting economic transition among affected farming farm workers. The research thus calls for policy frameworks that better balance industrialisation, social well-being, and environmental safeguards.

3.2.4 Comparative analysis of ewekoro cement factory study with regional and international research

The socio-economic impacts of cement manufacturing in Nigeria's Ewekoro are reflected in its high Relative Importance Index (RII) values for employment opportunity (0.870) and social amenity (0.914), which align with the results of other Nigerian and African cement-producing regions, albeit confirming the persisting issues of uneven benefit distribution and entrepreneurial activity. For instance, Anam et al. (2023) studied Dangote Cement operations in Mbayion, Benue State, Nigeria. They observed the same positive impacts on livelihoods, including job opportunities and increased income. However, they had little evidence for small business growth and assistance to local projects, which are congruent with Ewekoro's comparatively low RII scores on these indicators (0.597 and 0.578, respectively) (Anam et al., 2023). There were economic multipliers in Ethiopia, as noted by Gebremichael et al. (2024), stemming from cement factory jobs. However, tapping into the agrarian livelihood opportunity costs of land use change revealed dualistic effects of economic opportunity and agricultural displacement in Ewekoro (Gebremichael et al., 2024). Internationally, studies in the Third World, like Zimbabwe by Mutambara (2012, revised 2024), reported the same job creation benefits of cement production but reported negative externalities on agriculture in rural areas, such as lowering farm productivity and income inequality, consistent with Ewekoro's issues of skill development (RII=0.677) and infrastructural shortcomings (Mutambara, 2012). Similarly, Miller et al. (2023) quantified international cement emissions. They explained the land use conflict that shrouds livelihood uncertainty around resource-dependent people, underscoring the rationale for Ewekoro policies to encourage entrepreneurship and minimise displacement towards balanced socio-economic development (Miller et al., 2023).

High product technology innovation and community development program (RII = 0.7648) for sustainable development and health impacts in Ewekoro is balanced against low greening of suppliers and management innovation scores, a trend repeated in part in African studies but extended by international decarbonisation policy. Adebayo et al. (2024) reaffirmed the conditions in Ewekoro, Nigeria, where they noted Lafarge's socio-economic advantages but also highlighted excessive expenditure on health-related emissions, including respiratory and skin conditions, which corroborated the locals' impressions of pollution-related diseases (Adebayo et al., 2024). Tesfaye et al. (2024) conducted a life cycle assessment of cement production in Ethiopia, documenting its significant impact on human health and the environment. They recommended environmentally friendly practices, aligning with Ewekoro's call for the use of green technologies in achieving the UN Sustainable Development Goals (Tesfaye et al., 2024). Internationally, Al-Khalifa et al. (2025) advocated for circular economy approaches to cement manufacture, backed by supply greening and technological innovation, to reduce CO2 emissions by up to 30% in environments like the UAE, which offers a model for addressing the sustainability shortfall in Ewekoro (Al-Khalifa et al., 2025). Additionally, Schmidt et al. (2024) proffered four decarbonisation alternatives, including material efficiency and lower carbon fuels, that would remedy health problems of Ewekoro like respiratory disease and burning eyes, which is consistent with the finding of a South African study by Van der Merwe (2023) on the environment impact of cement (Schmidt et al., 2024; Van der Merwe, 2023). Such local and global comparisons poised Ewekoro to adopt new models of sustainability that would balance industrial growth with environmental conservation and health.

4. Conclusions

The current study assesses the land-use impacts of operations in cement factories in Ewekoro, Nigeria, and efforts towards reducing adverse impacts and promoting sustainable livelihoods. Findings indicate that Lafarge Cement Factory has a significant positive impact on the local economy, particularly in terms of employment prospects (RII = 0.914) and social amenities (RII = 0.870), driven by overall industrialisation patterns and infrastructure development. It has the benefit of generating high costs, such as the loss of farm fields, environmental pollution, and health problems like respiratory diseases, which exacerbate socio-economic exposures to farm-dependent households, as indicated by the Driver-Pressure-State-Impact-Response (DPSIR) framework. The respondents recognised the economic benefits but raised concerns about their sustainability and equity in distribution, citing concerns related to environmental justice. The limitations of the research are evident from its single-case study, cross-sectional design, reliance on preconceptions, and absence of longitudinal data. It is recommended that future studies compare various regions with cement production, employ longitudinal designs to track land degradation and changes in livelihood, and examine adaptive strategies such as alternative agriculture or vocational training, accompanied by qualitative measures for recording community attitudes. The research demands industrial planning that is ecologically sustainable, promotes social justice, and fosters economic resilience, with policy support for green technology and equitable benefit-sharing, aligning with the United Nations Sustainable Development Goals. Based on the analysis, the following recommendations are made to develop a greener, more equitable, and healthier economic industrial sector in Ewekoro and other industrial areas: a) Cement factories must invest in environmentally sound and efficient production plants that reduce emissions, waste, and environmental damage, b) Government agencies must implement and monitor stringent environmental standards, including regular environmental impact assessments (EIAs), to minimise pollution and protect biodiversity, c)

Industries should integrate CSR programmes that directly address health, education, and environmental protection, ensuring that industrial growth benefits the host communities holistically, d) Policymakers and urban planners must embrace participatory planning approaches that engage the local people in decision-making on urban planning, land use, and development to produce more equitable and sustainable settlements, e) Recast industrial planning paradigms into eco-industrial paradigms that balance environmental protection, social justice, and sustainable long-term economic development, f) Encourage product innovation by adopting eco-friendly raw materials and processes to minimise environmental footprints and promote sustainable consumption, g) Form local development forums or councils where citizens, industry players, and government representatives can meet to plan and review policies and projects to ensure inclusiveness and transparency.

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Author Contribution

Conceptualization, Akinrogunde, O.O. and Akinola, O.O.; Methodology, Adegbindin, R.O.; Software, Akinrogunde, O.O. and Faleti, O.O.; Validation, Akinrogunde, O.O., Akinola, O.O., and Adegbindin, R.O.; Formal Analysis, Famous, C.C.; Investigation, Adegbindin, R.O.; Resources, Famous, C.C.; Data Curation, Famous, C.C.; Writing – Original Draft Preparation, Akinrogunde, O.O.; Writing – Review & Editing, Ajibode R. A..; Visualization, Famous, C.C.; Supervision, Ajibode R. A.; Project Administration, Akinrogunde, O.O.; Funding Acquisition, Adegbindin, R.O. and Faleti, O.O.

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Ethical Review Board Statement

There was no requirement for ethical clearance of this research since it entailed public second-level data and non-personal responses to a questionnaire. The research posed minimal risk and complied with ethical standards for the use of anonymised and non-sensitive data.

Informed Consent Statement

Not applicable

Data Availability Statement

Not applicable

Conflicts of Interest

The authors declare no conflict of interest.

Open Access

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Biographies of Author(s)

Oluwatoyin Olawoye Akinrogunde, Department of Urban and Regional Planning, School of Environmental Studies, Ogun State Institute of Technology, Igbesa, P.M.B 2005 Nigeria.

- Email: akinrogunde.oluwatoyin@ogitech.edu.ng
- ORCID: 0000-0002-2977-8663
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A

Chukuma Chidi Famous, Department of Architectural Technology, School of Environmental Studies, Ogun State Institute of Technology, Igbesa, P.M.B 2005 Nigeria.

- Email: famouschukuma@gmail.com
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A

Rasheed Olawale Adegbindin, Department of Quantity Surveying, School of Environmental Studies, Ogun State Institute of Technology, Igbesa, P.M.B 2005 Nigeria.

- Email: adegbindinrasheed@yahoo.com
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A

Olusola Opeoluwa Akinola, Department of Estate Management and Valuation, School of Environmental Studies, Ogun State Institute of Technology, Igbesa, P.M.B 2005 Nigeria.

- Email: sola2bob@gmail.com
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A

Rafiat Adesewa Ajibode, Department of Urban and Regional Planning, School of Environmental Studies, Ogun State Institute of Technology, Igbesa, P.M.B 2005 Nigeria.

- Email: rafiatajibode@gmail.com
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A

Faleti Oluyemi Oladeji, Department of Building Technology, School of Environmental Studies, Ogun State Institute of Technology, Igbesa, P.M.B 2005 Nigeria.

- Email: tysplophic@gmail.com
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A