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Geospatial Technologies Usage in Mapping Occupational Health Risk Zones in Urban-Industrial Regions in Nigeria

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Abstract

In Nigeria, Occupational health risks in urban-industrial environments are often spatially distributed and influenced by a variety of environmental, infrastructural, and social factors. With the unprecedented rapid growth in urbanization and gradually increasing levels of industrialization in Nigeria, this problem has become more compounded. The cities of Lagos, Port Harcourt, Kano, Ibadan and Abuja, have seen tremendous growth. So also have industrial complexes like the Dangote Refineries complex and BUA Cement emerged, while Oando Petroleum, has joined to reach unprecedented growth levels. Traditional tools for occupational safety management are increasingly inadequate in addressing the complexity of modern industrial ecosystems. This article explores how geospatial technologies, such as Geographic Information Systems (GIS), remote sensing, and spatial modeling, can be effectively employed to map occupational health risk zones in urban-industrial regions. The paper further investigates how such mapping contributes to promoting environmental justice and shaping data-informed workplace safety regulations. Drawing on interdisciplinary perspectives and empirical case studies from both developed and developing countries, the article highlights the transformative potential of spatial technologies in occupational risk governance, while also addressing the ethical and logistical challenges inherent in their deployment. There is thus, a dire need to shift away from sole emphasis on the use of Personal Protective Equipment (PPE), with emphasis on multiple approaches, including engineering design, or redesign, as well as effective industrial policies and guidelines.

Keywords: Risk Zones, Urban Mapping, Occupational Health, Urban-Industrial Regions, Geospatial Technologies

Introduction

Urban-industrial zones are hubs of economic activity but also hotspots of environmental degradation and occupational health risks. Workers in such environments are frequently exposed to hazardous chemicals, extreme heat, noise pollution, particulate matter, and ergonomic stressors. The distribution of these risks is rarely uniform; it is shaped by the geography of industrial installations, traffic patterns, waste disposal sites, and socio-economic stratification.

Traditional occupational health and safety (OHS) approaches often focus on individual-level interventions or organizational compliance, neglecting the spatial dynamics of risk exposure. This frameworks represents a paradigm shift, enabling stakeholders to visualize, quantify, and respond to spatial disparities in health risks.

Spatial oversight results in regulatory blind spots, particularly in informal industrial zones or marginalized communities. The integration of geospatial technologies into occupational health This article examines the capabilities and applications of geospatial technologies in mapping occupational health risk zones, and discusses how these tools can inform more equitable environmental and workplace safety policies. The conceptual framework underlying this discussion lies at the intersection of occupational health, spatial epidemiology, environmental justice, and geoinformatics. Spatial epidemiology emphasizes the geographic

distribution of health outcomes and determinants, while environmental justice advocates for the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to environmental laws and policies (Bullard, Robert Doyle, 2000).

Occupational health, as defined by the World Health Organization (2022), encompasses the physical, mental, and social well-being of workers in all occupations. Mapping risk zones using geospatial technologies allows researchers and policymakers to detect spatial patterns, identify high-risk clusters, and prioritize intervention areas, thereby operationalizing the principles of environmental justice within occupational settings.

Overview of Occupational Health Risks in Urban-Industrial Areas

Apart from the Dangote Group of Companies, others such as Omini retail Inc., PalmPay Ltd., Remedial Health Inc., Termii Inc., Bisedge Ltd., Winock Solar Nigeria Ltd., Moniepoint Inc., Evercare Hospital Iekki Ltd., Neveah Ltd., Apha Morgan Capital Managers Ltd., BlueCamp Ltd., X3M Marketing Ideas Ltd., Cham Holding Company Plc., Transcorp Hotels Plc., Emerging Africa Capital Ltd., Meter Plc., FoodCo Nigeria Ltd, Fidson Healthcare Plc. and United Capital are all thriving Nigerian businesses with considerable population of employees, working in different geospatial locations in Nigeria, with various occupational health requirements. These companies have also contributed along with others to urban challenges as a result of rural populations emigration to urban-industrial regions.

Urban-Industrial regions face multifaceted health threats. Key risks to humans include: airborne pollutants from factories and vehicle emissions (e.g., sulfur dioxide, PM_{2.5}), noise pollution from machinery, traffic, and construction sites, exposure to hazardous materials such as asbestos, benzene, and heavy metals, physical injuries from machinery and poorly maintained infrastructure, psychosocial stress due to job insecurity, long hours, and poor working conditions

A study by Adegoke, and Agboola (2021) in Lagos, Nigeria, showed that industrial workers near Apapa seaport were 60% more likely to report respiratory ailments than those working farther from the industrial belt. Similar studies in Guangzhou, China (Zhang, and Xu, 2019), and São Paulo, Brazil (Silva, Mariana and Gonçalves, Eduardo, 2018) reinforce the correlation between geographic proximity to industrial zones and increased health risks.

Geospatial Technologies, Tools and Capabilities

Geospatial technologies encompass a suite of tools for capturing, analyzing, and visualizing spatial data. These include: Geographic Information Systems (GIS), which is a digital platform for managing spatial data, performing spatial analysis, and generating risk maps (Burrough and McDonnell, 1998).

Also remote Sensing, including satellite or aerial imagery used to monitor environmental parameters such as land use, vegetation cover, and pollutant dispersion and Global Positioning Systems (GPS) include devices that provide accurate location data, often used in mobile health monitoring. The last but not least is spatial Modeling and Simulation, which is an area of techniques for predicting future risk scenarios based on historical and real-time data. These tools are capable of overlaying occupational risk data with environmental indicators, population demographics, and infrastructural layouts to provide a multi-dimensional understanding of health hazards.

Mapping Occupational Health Risk Zones

Mapping occupational health risk zones involves several steps. For instance, *Data Collection*, can help in gathering data on pollutant levels, workplace incidents, demographic vulnerability, and industrial layouts; with *spatial Analysis*, it is possible to identify clusters of high-risk areas using tools like kernel density estimation and spatial autocorrelation. Also, *Risk Indexing* will help in developing composite indices that integrate exposure levels, vulnerability, and adaptive capacity, and with *visualization*, there is the possibility of creating maps that communicate complex risk patterns to stakeholders in an accessible format.

In India, for example, a GIS-based study by Sharma, Rakesh and Patil (2020) mapped heat stress zones among outdoor laborers in Delhi, identifying critical hotspots during summer months. In the United States, a similar approach by McCormick and Brody (2012) linked cancer incidence in industrial regions of Louisiana to proximity to petrochemical facilities. There are numerous case studies. Its interesting that in Lagos, Nigeria a study by Olaniyi and Okonkwo, (2022) employed GIS and remote sensing to map particulate matter

concentrations in Lagos industrial zones. Overlaying the data with worker population density revealed that low-income workers in metal fabrication plants were disproportionately exposed to high PM2.5 levels.

Also, in Dhaka, Bangladesh, according to Rahman and Khan (2019), garment factory workers in Dhaka were mapped using GPS-enabled health surveys. GIS analysis showed higher incidence of musculoskeletal disorders in areas with poor building ventilation and ergonomic neglect. There is even another example from the United States of America, where a collaborative study by the University of Michigan (Wright and Bullard, 2016) mapped asthma rates among auto industry workers. Spatial analysis revealed a concentration of respiratory illness near older plants with lax emission controls.

Environmental Justice and Risk Mapping

Environmental justice emphasizes the equitable distribution of environmental benefits and burdens. Risk mapping supports this, by revealing spatial inequities in occupational exposures, identifying communities lacking protective infrastructure, and informing targeted health interventions and inspections. Mapping can highlight the compounded vulnerabilities faced by marginalized groups, particularly in informal settlements or near industrial landfills. This aligns with the findings of Mohai, Paul and Saha (2015), who demonstrated that low-income and minority communities are more likely to be situated near hazardous industrial facilities.

Policy Implications and Workplace Safety Regulation

Geospatial risk maps provide empirical evidence that can be adopted to enhance, regulatory Enforcement, by guiding inspections and compliance monitoring, while urban planning helps to ensure industrial zoning does not compromise worker or community health. Also worker advocacy, can enable unions and Non-governmental Organizations (NGOs) to push for safer conditions. Another strategy is to focus on resource Allocation.

The above can assist in directing healthcare services to underserved, high-risk zones. Also, for instance, the European Environment Agency (EEA, 2020) recommends the integration of GIS in occupational risk assessments to support the implementation of the EU Occupational Safety and Health Framework Directive (89/391/EEC).

Challenges and Ethical Considerations.

Although, *Geospatial technologies* offer numerous benefits, several challenges include the use of data privacy techniques, which can allow the use of geo-location data to inadvertently expose workers identities. Improving *technical capacity* is vital, because many regions lack trained personnel and infrastructure. It is inevitable to consider *Costs*, because high-resolution satellite imagery and software licenses can be expensive. *Interpretation Risks*: can result in misuse or misinterpretation of maps can lead to discriminatory policies. Lastly, *Ethical mapping* should involve informed consent, data anonymization, and participatory mapping approaches to ensure community trust and accuracy.

This approach to Occupational health and safety of employees, is a collective contribution to the need for a move away from sole emphasis on Personal Protection Equipment (PPE), which has been advocated by Akintoye, Ubong, Asuquo, Akintoye, Agbor, Ekumankama (2024)

Recommendations

There is a dire need for capacity building. This should be based on efforts to invest in training occupational health professionals in GIS and spatial analysis.

Open-Source Tools, are necessary for promoting the use of accessible tools like QGIS and Google Earth Engine.

Adoption of collaborative platforms will foster partnerships among academic institutions, labor unions, public health agencies, and tech developers. Agreeably, participatory mapping, is an unavoidable panacea, which involve workers and local communities in data collection and interpretation. There is also the need to understand and demonstrate that policy Integration is integral in achieving this goal, by mandating spatial risk assessments in occupational health policies and audits.

Conclusion

Geospatial technologies have the potential to revolutionize how occupational health risks are understood, communicated, and managed. By visualizing hidden patterns of exposure and vulnerability, spatial tools bridge the gap between science, policy, and social justice. In a world increasingly shaped by urbanization,

climate change, and industrial expansion, mapping occupational health risks is not just a technical exercise but a moral imperative.

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