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Safety by Design: Embedding Ergonomic Thinking into Facility and Equipment Management Systems

Author: Kazeem Abiodun Adekunle[1], Juba Idowu David[2]
Affiliation: Texas A&M university, Kingsville, USA[1], HSE Department, Acciona Agua Qatar[2]
Email: Kazeemite01@yahoo.com[1], juba.idowu@acciona.com[2]
ORCID iD: 0009-0002-2365-3285[1]

Abstract

The primary aim of this research is to provide a thorough and up-to-date analysis on the importance and benefits of ergonomic principles in the management of facility and equipment systems. Ergonomics, also known as human factors engineering, is a multidisciplinary approach that goes beyond compliance and focuses on the human-centered design of work systems that are tailored to the physical, cognitive, and organizational requirements of workers. The study methodology involved a systematic review of the current literature and the synthesis of the evidence supporting the benefits of ergonomic integration into work systems. The results of this research reveal that the implementation of ergonomics not only leads to a reduction in the incidence of work-related musculoskeletal disorders (MSDs), absenteeism, and costs, but also contributes to improvements in worker well-being, motivation, and productivity. Additionally, the study highlights the emerging trends in ergonomics in the era of Industry 4.0, including the use of wearable technology, the Internet of Things (IoT), and artificial intelligence (AI) to enable real-time monitoring and predictive analytics of human factors. In conclusion, this study demonstrates that the integration of ergonomic thinking is not an optional extra but a strategic investment for creating a resilient, sustainable, and high-performing work environment, and provides recommendations for the effective implementation of ergonomic programs as an integral part of a safety and excellence culture.

Keywords: Ergonomics, Human Factors, Safety by Design, Facility Management, Equipment Management, Musculoskeletal Disorders (MSDs), Productivity, Industry 4.0, Occupational Health.

1. Introduction

Today's industrial organizations face the challenge of handling the complexity of advanced systems and technological devices along with the need for sustainable operational practices as interactions between people and machines increase. In all these conditions, the human operator continues to be the most valuable resource and the foundation of any organization's performance. Ergonomics is a dynamic and multidisciplinary science whose main goal is to optimize human well-being and the total performance of the system through an in-depth adaptation of the work system to the worker's characteristics (Garosi et al., 2025; Santos et al., 2017).

Ergonomics is based on the concept that the human operator, or the user in general, is the most important and most decisive element in any design and management process and his/her actions, behavior, physical and psychological characteristics and limitations, and needs are to be the main reference in every stage of a work system development (Hasanain, 2024). The ergonomic approach to human activities and workspaces goes far beyond simply "reacting" to safety incidents and regulations, and it advocates proactively including human-centric principles into the DNA of facilities and equipment management systems (Garosi et al., 2025). The "Safety by Design" principle is to integrate these human-centered concepts in order to effectively eliminate all latent hazards and actively manage risks, errors and residual effects in ways that sustainably deliver operational excellence.

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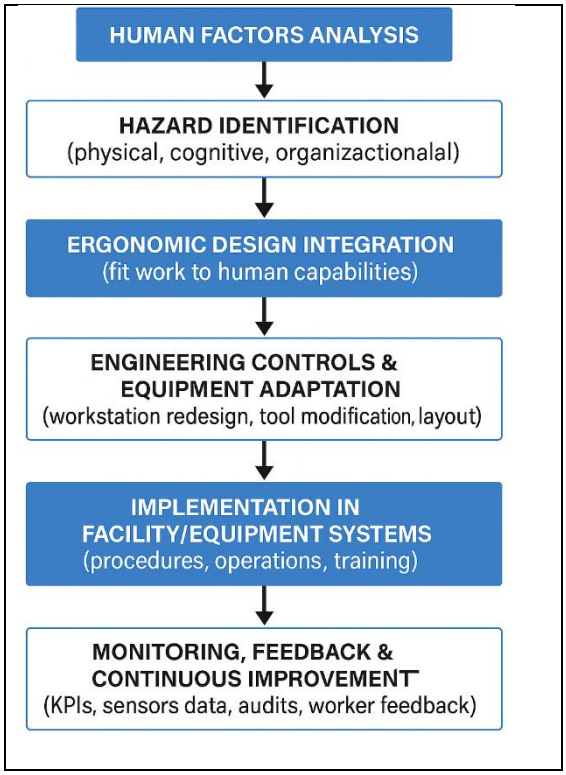

Figure 1: Ergonomics in Facility Management: Safety-by-Design Workflow

The purpose of this paper is to show that a strategic and systematic application of ergonomics thinking is an inherent component of any contemporary management system. It will present the key principles of the ergonomic approach, describe its numerous benefits, examine new methods that are relevant to its application in the context of the fourth industrial revolution, and outline steps for its implementation.

2. Literature Review

2.1. The Foundational Principles of Ergonomics

Ergonomics is also referred to as the "Human Factors" and is defined as the scientific discipline dealing with the understanding of interactions among humans and other elements of a system. Ergonomics is the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance (International Ergonomics Association, cited in Marras & Karwowski, 2006). Ergonomics can simply be described as a science that designs the workplace to fit the talents, abilities and limitations of people in order to reduce the wasteful expenditure of human energy and to achieve maximum productivity, efficiency, and effectiveness (Boatca & Cirjaliu, 2015).

Ergonomics has a broad scope, and it includes three main categories:

• Physical Ergonomics: It focuses on human anatomical, anthropometric, physiological and biomechanical characteristics as they relate to physical activity. It includes the design of workstations, tools, and equipment to prevent MSDs.

• Cognitive Ergonomics: It focuses on mental processes, such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system. It includes mental workload, decision-making, and human-computer interaction.

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• Organizational Ergonomics: It focuses on optimizing sociotechnical systems, including their organizational structures, policies, and processes. It includes teamwork, communication, and work design.

In this regard, the main objective is to fit the work to the human, not the other way around. To this end, one should consider the close connection between people, machines, and the environment, collectively known as the "ergonomic triad" (Montoya-Reyes et al., 2020).

2.2. Documented Benefits and Organizational Impact

Extensive research has been conducted to determine the ROI associated with ergonomic interventions. The existing literature overwhelmingly indicates that ergonomic programs can lead to significant increases in productivity and efficiency while also significantly reducing work-related injuries (Heller-Ono, 2009). The reasons for this are multifaceted:

• Increased Safety and Health: Ergonomic interventions are effective in reducing the occurrence of WMSDs, which are the leading cause of industrial injuries (Garosi et al., 2025; Selamat et al., 2021). By designing work that is consistent with human capabilities and limitations, organizations can reduce absenteeism, lower healthcare costs, and decrease injury-related compensation claims (Faez et al., 2021; Patil & Patil, 2023).

• Enhanced Productivity and Quality: By reducing fatigue and errors and streamlining processes, well-designed work environments can lead to improved productivity and quality. Ergonomic interventions can help increase worker motivation and productivity and enhance the quality of products and services (Faez et al., 2021). The existence of a positive ergonomics climate is associated with increased organizational performance (Faez et al., 2021).

• Increased Job Satisfaction and Morale: When workers feel that their safety and well-being are a priority, they are more likely to be satisfied with their jobs, leading to a more positive organizational culture, lower turnover, and higher morale (Boatca & Cirjaliu, 2015).

Table 1: Comparative Benefits of Ergonomic Interventions

Benefit Category	**Description**	**Evidence From Literature**
Reduced Injuries	Lower MSD rates, fewer incidents	Heller-Ono (2009); Faez et al. (2021)
Cost Savings	Reduced compensation claims, lower absenteeism	Patil & Patil (2023)
Productivity Gains	Reduced fatigue, fewer errors	Montoya-Reyes et al. (2020)
Better Morale & Culture	Higher job satisfaction & retention	Boatca & Cirjaliu (2015)
Improved Quality	Fewer defects, improved performance	Faez et al. (2021)

2.3. The Evolution of Ergonomics in the Digital Age

Ergonomics as a discipline is not static and can be adjusted to the challenges of Industry 4.0. New models based on the use of wearable sensors, virtual reality (VR), or the Internet of Things (IoT) are being developed to offer solutions for physical and cognitive tasks at work (Garosi et al., 2025). The adoption of machine learning and artificial intelligence (AI) is shifting ergonomics from reactive to predictive, enabling real-time posture monitoring, fatigue analysis, and environmental feedback, as well as predictive analysis and early interventions (Garosi et al., 2025; Marková et al., 2025). In this way, ergonomics has

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become the primary tool to manage the more complex human-technology interaction in automated and roboticized work systems (Marková & Škurková, 2023).

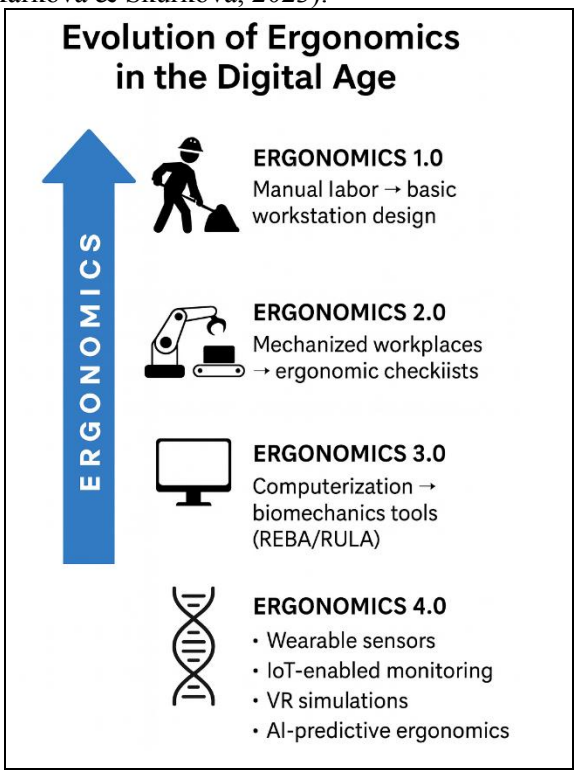

Figure 2: Evolution of Ergonomics in the Digital Age (Industry 1.0 to 4.0)

3. Methodology

This study uses a literature review methodology to provide an in-depth examination and summary of existing research on the role of ergonomics in facility and equipment management. The stages of the methodology are as follows:

1. Search and Identification of Research: A systematic search was conducted across multiple databases such as Google Scholar, PubMed, ScienceDirect, and Scopus. Keywords and phrases used in the search included "ergonomics", "human factors", "facility management", "equipment design", "musculoskeletal disorders", "safety by design", "productivity", and "Industry 4.0", often in combination.
2. Screening and Selection: The search was restricted to peer-reviewed journal articles, books, and conference proceedings, with a preference for recent publications within the last two decades to ensure contemporary relevance, although seminal papers from earlier periods were also included. Titles and abstracts of articles were screened, followed by a full-text assessment for their direct relevance to the research topic.
3. Data Analysis and Synthesis: The included literature was analyzed by themes. Key themes, findings, and methodologies from the studies were extracted and synthesized to form a cohesive overview. The analysis aimed to identify consistent findings related to benefits, successful implementation strategies, and emerging trends, especially in technology integration.
4. Limitations: The main limitation of this study, as a literature review, is that its findings are limited to the existing body of published research. It does not include new empirical data but rather interprets and synthesizes the information that has already been published.

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4. Findings and Results

The Findings synthesized from the literature on this topic include:

4.1. Documented Injury and Cost Reduction

The clearest and most replicated finding is that a well-implemented ergonomic program, embedded into management practices, has been shown to significantly reduce work-related injuries, particularly MSDs. Several studies across diverse industries, from manufacturing to healthcare, indicate that targeted ergonomic interventions can decrease MSD risk factors by over 50% in many cases (e.g., Heller-Ono, 2009). This directly translates into cost savings, with documented reductions in expenses related to medical treatment, worker compensation claims, and absenteeism. For example, Faez et al. (2021) found a direct relationship between a positive ergonomics climate and self-reported pain reduction and performance metrics.

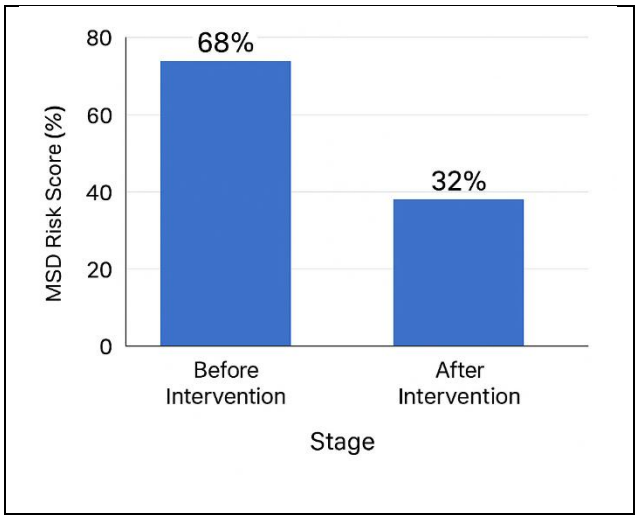

Figure 3: MSD Risk Reduction After Ergonomic Improvements

4.2. Ergonomics Improvement Metrics Directly Correlate with Productivity Increases

The second key finding is that improvements in ergonomics do indeed translate to productivity gains. This is achieved by reducing unnecessary motions, minimizing fatigue, optimizing workflow, and lowering error rates. One case study used a novel ergonomic triad model to calculate a Sustainable Work Index (SWI) (Montoya-Reyes et al., 2020). This work not only documented pre and post improvement WMSD potential but also postulates a method of looking at human well-being and process sustainability in the same index. After ergonomic improvements were made, the index for a particularly stressful job was shown to improve from 63.6% to 73.9%.

4.3. The Necessity of a Proactive, Systems-Based Approach

The literature reviewed strongly points to the most effective ergonomic programs being those that are proactive and system-based, integrated into the design phase of a process or system rather than being reactive changes made after implementation. The concept of “Safety by Design” is crucial. It is also shown that isolated changes, while potentially beneficial, are less effective than a comprehensive approach that considers the physical, cognitive, and organizational aspects of ergonomics together

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(Selamat et al., 2021).

4.4. The Rise of Technological Enablers

A notable and emerging trend identified is the increasing role of technology in ergonomic practice. Recent research (Garosi et al., 2025) and others have begun to explore the use of wearable technology for continuous biomechanical monitoring, IoT sensors for environmental conditioning, and VR for safe simulation and training. These tools are pushing the field toward a more data-driven, predictive model where interventions can be made before an injury occurs or a process inefficiency becomes critical.

5. Discussion

The evidence presented in this review unambiguously supports the thesis that integrating ergonomic thinking is a strategic necessity. Several points of interpretation are necessary.

5.1. From Cost Center to Strategic Investment

The literature clearly demands a reframing of ergonomics from a perceived cost center to a strategic investment with an expected return on investment (ROI). The direct savings in health care and compensation costs, the indirect gains in productivity, quality, innovation, and the overall positive impact on the bottom line and competitive advantage are compelling reasons to invest in ergonomics. Worker well-being and system performance are not trade-offs, but mutual drivers of success, as evidenced by the studies reviewed in section 2 and the synergistic model of Montoya-Reyes et al. (2020).

5.2. Implementation Challenges and Solutions

The literature is equally clear that the path to implementation is strewn with challenges, the most common being a lack of awareness, training, and resources, especially in SMEs and rural industries (Patil & Patil, 2023). Solutions include strong leadership, employee involvement, top-down commitment, and bottom-up participation. It also requires a culture of continuous improvement, not a project-based approach. Ergonomics is an ongoing process of assessment, intervention, and evaluation, not a one-time checklist.

5.3. Ergonomics of the Future is Human-Centric and Digital

The emerging trend of Industry 4.0 is a challenge and an opportunity for ergonomics. The higher levels of automation, integration, and complexity of the system pose new demands on human-machine interaction. The ergonomician of the future will be less of a problem-solver of discrete physical issues and more of a designer of holistic cognitive and organizational systems. The potential of AI and big data analytics for predictive, adaptive, and personalized ergonomic management is enormous. The smart facility of the future will have fully integrated ergonomic management, monitoring, and control systems that adjust the work environment in real-time to the needs of the workforce.

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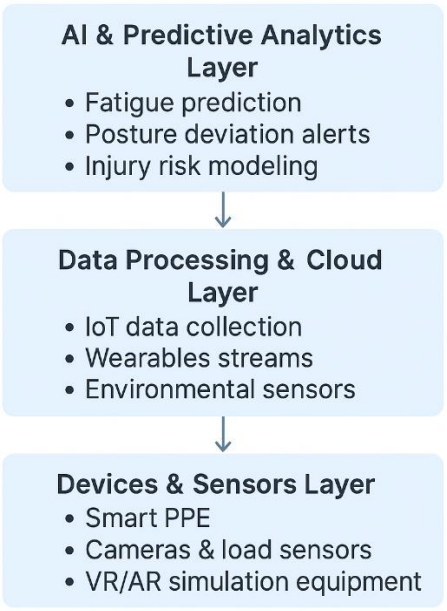

Figure 4: AI-Enabled Ergonomics Architecture (Industry 4.0 Model)

5.4. Limitations and Research Gaps

This review is not without its limitations. While the evidence is strong, the literature could benefit from more longitudinal studies that measure the long-term ROI of comprehensive ergonomic programs, and not just individual projects or interventions. Research on the application of the higher levels of cognitive and organizational ergonomics in facility management is less developed than research on the physical aspects of ergonomics. The ethical considerations of continuous monitoring and data collection via wearables and other sensors also need more attention.

6. Conclusion and Recommendations

In summary, the integration of ergonomic principles into facility and equipment management systems is an essential pillar of modern operational excellence. It is a proactive, holistic discipline that seeks to optimize the relationship between people and their work to create safer, healthier, more efficient and productive environments. By adopting a "Safety by Design" approach and prioritizing human factors from the beginning, we can prevent ergonomic hazards instead of trying to fix them after the fact.

From this review of findings and discussion, a set of recommendations is listed as below for the organization's general information:

1.Adopt a proactive, systems-based framework for ergonomics management, which incorporates ergonomics thinking and principles throughout the project life cycle, including design, procurement, daily operations, and ongoing management.
2.Invest in education and training to close the gap in ergonomics awareness and ensure that managers, engineers, and frontline employees have a clear understanding of their roles and responsibilities in promoting and sustaining well-being.
3.Explore and invest in emerging technologies (wearable sensors, real-time monitoring, and data analytics platforms) that will enable predictive and personalized ergonomics interventions.
4.Foster a culture of participation and empowerment where employees are actively engaged in the

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ergonomic assessment and solution process. Their experience and insights are an invaluable resource for identifying issues and developing effective, practical solutions.
5.Measure and communicate the success of ergonomic interventions in terms of key performance indicators related to safety (e.g., MSD incidence rates), productivity (e.g., output, error rates), and well-being (e.g., absenteeism, satisfaction surveys) to demonstrate the value of these initiatives and gain ongoing organizational support.
Business success depends on maintaining proper ergonomic standards. By designing systems for people, we can unlock human potential, build resilient operations, and achieve sustainable excellence.

References

1) Boatca, M. E., & Cirjaliu, B. (2015). A proposed approach for an efficient ergonomics intervention in organizations. *Procedia Economics and Finance, 23*, 54-62. https://doi.org/10.1016/S2212-5671(15)00411-6
2) Faez, E., Zakerian, S. A., Azam, K., Hancook, K., & Rosecrance, J. (2021). An assessment of ergonomics climate and its association with self-reported pain, organizational performance and employee well-being. *International Journal of Environmental Research and Public Health, 18*(5), 2610. https://doi.org/10.3390/ijerph18052610
3) Garosi, E., Sheikh, F., & Goodarzi, M. A. (2025). Ergonomic interventions in risk reduction. In *IntechOpen eBooks*. https://doi.org/10.5772/intechopen.1008463
4) Hasanain, B. (2024). The role of ergonomic and human factors in sustainable manufacturing: A review. *Machines, 12*(3), 159. https://doi.org/10.3390/machines12030159
5) Heller-Ono, A. (2009). 21st century ergonomics: A lean approach to ergonomics process design and management. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 53*(16), 1013-1016. https://doi.org/10.1177/154193120905301603
6) International Ergonomics Association. (n.d.). *What is ergonomics?* Retrieved October 28, 2024, from https://iea.cc/what-is-ergonomics/
7) Korhan, O. (2023). Introductory chapter: Contemporary topics in ergonomics. In *IntechOpen eBooks*. https://doi.org/10.5772/intechopen.108643
8) Knowledge gaps and research challenges in the contemporary ergonomics. (2015). *Journal of Ergonomics, 5*(1), 1000e134. https://doi.org/10.4172/2165-7556.1000e134
9) Marková, P., & Škurková, K. L. (2023). The impact of ergonomics on quality of life in the workplace. *System Safety: Human - Technical Facility - Environment, 5*(1), 121-129. https://doi.org/10.2478/czoto-2023-0014
10) Marková, P., Vrecková, D., Míková, P., Szabo, Ž., & Čambál, M. (2025). The impact of ergonomic rationalisation on the efficiency and productivity of the production process. *Administrative Sciences, 15*(2), 62. https://doi.org/10.3390/admsci15020062
11) Marras, W. S., & Karwowski, W. (Eds.). (2006). *Fundamentals and assessment tools for occupational ergonomics*. CRC Press. https://doi.org/10.1201/9781420003491
12) Montoya-Reyes, M., Gil-Samaniego, R., Ramos-Palomera, I., Mendoza-Muñoz, I., & González, C. R. N. (2020). Novel ergonomic triad model to calculate a sustainable work index for the manufacturing industry. *Sustainability, 12*(20), 8316. https://doi.org/10.3390/su12208316
13) Patil, A. S., & Patil, P. H. (2023). Comparative study of ergonomics among manufacturing industry workers in rural and urban industries. *International Journal of Biomedical and Healthcare Science, 13*(2), 95-102. https://doi.org/10.37622/IJBHS/13.2.2023.95-102
14) Santos, M. S., Fonseca, M. V., Soares, M. M., da Fonseca, B. B., Aguiara, M. V. C., & Alves, A. H. F. (2017). HSE management for a sound work environment: Strategies for improving health safety and environmental indicators through ergonomic design thinking. In *InTech eBooks*. https://doi.org/10.5772/66650

ISSN E: 3006-1466
ISSN P: 3006-1458
CONTEMPORARY JOURNAL OF SOCIAL SCIENCE REVIEW
CJSSR

15) Selamat, M. N., Abd Aziz, S. F., Mukapit, M., Baker, R., & Jaafar, A. H. (2021). The analysis of ergonomic task demand and psychosocial work factors towards occupational safety and health. *International Journal of Academic Research in Accounting, Finance and Management Sciences, 11*(3), 1087-1099. https://doi.org/10.6007/IJARAFMS/v11-i3/10870
16) Adeojo, O. S., Egerson, D., Mewiya, G., & Edet, R. (2021). The ideology of baby-mama phenomenon: Assessing knowledge and perceptions among young people from educational institutions.
17) Orugboh, O. G. (2025). AGENT-BASED MODELING OF FERTILITY RATE DECLINE: SIMULATING THE INTERACTION OF EDUCATION, ECONOMIC PRESSURES, AND SOCIAL MEDIA INFLUENCE. NextGen Research, 1(04), 1-21.
18) Orugboh, O. G., Ezeogu, A., & Juba, O. O. (2025). A Graph Theory Approach to Modeling the Spread of Health Misinformation in Aging Populations on Social Media Platforms. Multidisciplinary Journal of Healthcare (MJH), 2(1), 145-173.
19) Orugboh, O. G., Omabuwa, O. G., & Taiwo, O. S. (2025). Predicting Intra-Urban Migration and Slum Formation in Developing Megacities Using Machine Learning and Satellite Imagery. Journal of Social Sciences and Community Support, 2(1), 69-90.
20) Orugboh, O. G., Omabuwa, O. G., & Taiwo, O. S. (2024). Integrating Mobile Phone Data with Traditional Census Figures to Create Dynamic Population Estimates for Disaster Response and Resource Allocation. Research Corridor Journal of Engineering Science, 1(2), 210-228.
21) Orugboh, O. G., Omabuwa, O. G., & Taiwo, O. S. (2024). Predicting Neighborhood Gentrification and Resident Displacement Using Machine Learning on Real Estate, Business, and Social Datasets. Journal of Social Sciences and Community Support, 1(2), 53-70.
22) Daniel, E., Opeyemi, A., Ruth, O. E., & Gabriel, O. (2020). Understanding Childbearing for Households in Emerging Slum Communities in Lagos State, Nigeria. International Journal of Research and Innovation in Social Science, 4(9), 554-560.