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Contribution of women engineers towards sustainable building construction in Nairobi City County, Kenya

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Abstract

While the construction industry is committed to increasing women's participation in sustainable building construction, their contributions remain largely misunderstood, undefined, and undervalued throughout various phases of building construction. This study assessed the contribution of women engineers towards sustainable building in Nairobi City in Kenya. Qualitative methods were used to gather data for this research. Women engineers in Nairobi constituted the target population of the study. This research used a purposive sampling method to select sixteen (16) participants, among them eight (8) were women engineers from La Femme Engineering Services Ltd (LFE), four (4) others from outside LFE, and four (4) male engineers, key informants who held potential knowledge in the building construction industry. Data was collected through an interview guide, a checklist observation, a key informant guide, and a content analysis guide. The Qualitative Data Analysis (QDA) Miner Lite software was utilised to create codes and perform data analysis based on thematic and content analysis. The findings illustrated the lived experiences of participants across three worksites, including the head office of LFE, Zimmerman, and Ruiru apartments. The results revealed that women significantly contribute to innovation and creativity, eco-friendly materials and energy efficiency, and leadership and management. The research concluded that women engineers contributed significantly to sustainable building construction in terms of... The research ends with recommendations including institutionalising mentorship programs, leadership roles and gender sensitive policy.

Keywords: Contribution; Sustainable Building Construction; Women engineers

1. Introduction

Historically, the construction sector has been perceived as a labour-intensive, male-dominated environment, with women often confined to administrative roles due to societal prejudices that limited their participation in technical and leadership capacities [1]. The industry encompasses different sectors, including building structures, mechanical, electrical, and water systems, as well as infrastructure such as roads and bridges [2]. Building construction is divided into different stages, such as pre-design, design, procurement, construction, oversight, and post-construction [3]. Similarly, it involves coordinated planning, financing, and management to deliver durable projects [4]. In this study, sustainable building is defined as a construction process designed and monitored to minimise environmental harm, promote social well-being, and ensure human economic sustainability [5]. This process engages multiple actors, including architects and engineers, with women playing a vital role in innovation, eco-friendly materials, and energy efficiency.

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Although the present landscape concerning female engineers within the domain of sustainable building construction showcases significant progress, it is accompanied by enduring challenges. Globally, the participation of women in the construction sector remains inferior to that of their male counterparts. UNESCO reports that women constituted approximately 28% of the workforce in the overall engineering field, with an even smaller fraction engaged in construction [6]. This underrepresentation has adversely impacted the involvement of women engineers in New Zealand's construction industry [7]. Karakhan et al. (2021) reported that the National Association of Women in Construction presented that women constituted roughly 9.1% of the construction workforce in the United States in 2020. Similarly, the number of women engineers working in construction engineering is still relatively low in North America [8]. In Canada for example, women account for approximately 12 % of the construction workforce in different phases of building [9]. Similarly, the US has a relatively low percentage of women working in construction engineering about 9% [10]. However, according to Miller et al. (202) in countries like Canada and the United States have seen gradual improvements due to efforts by industry associations and educational institutions to promote engineering careers to women through scholarships, mentorship programs, and public awareness campaigns. Moreover, corporate policies promoting diversity and inclusion are gradually helping to bridge the gender gap [11].

Shifting the focus to Africa, the representation of women in construction engineering is notably low, yet varies across the continent. The African Development Bank (ADB) (2021) reported that women make up less than 10% of the construction workforce in many African countries [12]. Some studies mentioned that the construction industry in many African countries is influenced by several barriers, including culture, societal expectations, nature perception of the sector, etc. In a nation such as South Africa, the construction industry remains predominantly male, with men constituting the majority of individuals involved in this sector [13]. In addition, South African industrial companies, such as mining companies were characterised by the low presence of females compared to other sectors. There was a persistence in integrating women in engineering jobs that led to women's underrepresentation [14].

The contribution of women engineers in sustainable building entails their participation and representativity in various phases of the building, namely pre-designing, designing, procurement, construction and monitoring, and post-construction phase [5]. Also, the involvement of women engineers in sustainable building construction is pivotal for advancing the industry's commitment to environmental, economic, and social sustainability. In this perspective, Manzoor et al. (2021) argued that sustainability in the construction sector necessitates the attainment of equilibrium among economic, environmental, and social dimensions during the phases of design, construction, utilisation, and maintenance of structures [15].

Researchers, including Iyer-Raniga et al. (2021), have demonstrated that women engineers bring diverse perspectives and innovative approaches that enhance the design and implementation of sustainable construction practices. Their participation ensures that sustainability is integrated at every stage of the building process, from initial planning and design to construction and post-occupancy management. In India, women play a crucial role in household and water management, promoting sustainable water practices in construction and ensuring access for all [16]. Similarly, Nigerian women, long regarded as custodians of the environment, actively participate in conservation, advocate for sustainable materials, and encourage recycling [17].

In the Kenyan context, Women engineers play pivotal roles throughout the five key phases of building construction, each of which is crucial for ensuring the sustainability and quality of building projects [18]. Likewise, in some communities in Kenya, older women pass construction knowledge from generation to generation. For instance,

Women in the Maasai community, with the exclusion of the expectant and the elders in the society, are responsible for the design and construction of family houses. The concept of design and building of manyatta houses gives elderly women an opportunity to teach and give directives to the younger generations on the process of developing good, stable structures. This key information in the design and construction of Manyatta housing ensures that the semi-permanent structures use natural resources such as cow dung, water, mud, small branches, and poles, among others (Edna, 2023, p 140).

According to Eglin (2023), in the pre-design phase, women engineers are involved in the initial planning and feasibility studies. They conduct site analyses, assess environmental impacts, and engage in community consultations to understand the specific needs and challenges of the project area. Their involvement ensures that the project starts with a strong foundation of sustainability principles, considering factors such as site selection, resource availability and advocating for green site practices and inclusive planning; women engineers help to set the stage for a sustainable construction process from the very beginning [19].

In Nairobi, emerging research and practice highlighted how women engineers contribute to integrating sustainability at various phases of construction. Studies have shown that women-led engineering teams are more inclined to adopt eco-friendly materials, green technologies, and inclusive decision-making processes that enhance resilience in urban infrastructure [20, 21]. Moreover, associations such as the Association of Women Engineers in Kenya (AWEK), the Society of Women Engineers, WomEng Kenya, and the Association of Kenya Women in Construction (AKEWIC) have been instrumental in promoting visibility, mentorship, and advocacy for women professionals in the sector.

Despite different efforts, limited empirical evidence exists on the specific contributions of women engineers in sustainable building within Nairobi’s unique socio-economic and cultural context, resulting in misunderstanding, undefined, and undervalued contributions of women engineers throughout various phases of building construction. Given the landscapes of women engineers and their possible contribution to building construction, this study sought to assess the contribution of women engineers towards sustainable building in Nairobi City in Kenya.

2. Materials and methods

This study assessed the contribution of women engineers towards sustainable building construction. The research was conducted in Nairobi City County. This County was selected as it is Kenya’s major urban hub with numerous construction projects, offering a diverse setting to assess women engineers’ contributions to sustainable building. Its commitment to sustainable development aligns with the study, particularly in pursuing SDG 11 on inclusive, safe, resilient, and sustainable cities. Nairobi also hosts La Femme Engineering Services (LFE), founded in 2006 by Engineer Jane Mutulili, which constituted the study’s focus. As a recognised construction and consultancy firm, it is located at the Allamano Centre.

2.1. Research design, target population, sample size, and sample technique

This study used a qualitative approach with a case study research design targeting women engineers in different construction departments, including managerial, technical, and financial departments in Nairobi. It also involved male key informants who held important knowledge in the construction. Using purposive sampling, a total of sixteen (16) participants were selected until data saturation was reached.

2.2. Data collection and data analysis

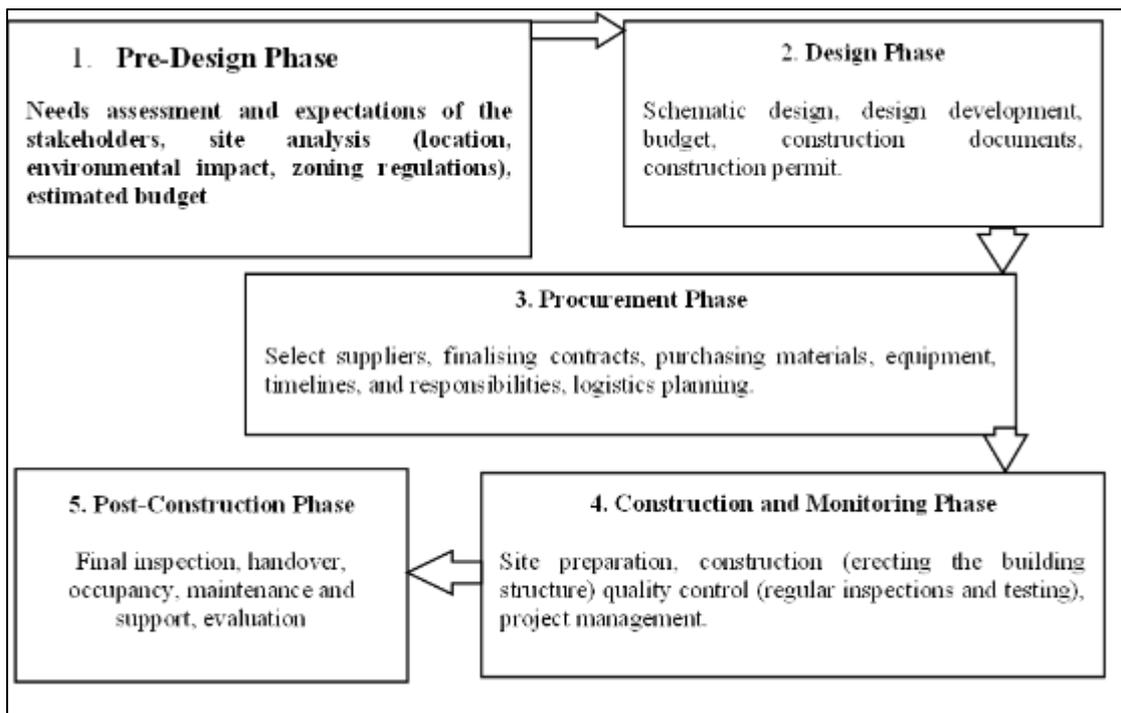


Figure 1 Diagram of building construction stages

Data were collected through interview guides, checklist observation guides, and key informant guides, while secondary data employed content analysis, focusing on building construction phases. The coding and data analysis involved the

Qualitative Data Analysis (QDA) Miner Lite software. Information was collected focusing on detailed building construction phases above.

In this study, triangulation was used to improve credibility and trustworthiness by combining data from various methods and sources. Using purposive sampling, information was gathered through interview guides, key informant guides, checklist observations, and a content analysis guide. In addition, triangulation was achieved by involving different participant groups and employing customised interview techniques. The combined use of these tools provided a structured and systematic assessment of the research question, ensuring comprehensive insights into the role of women engineers during different stages of sustainable building construction.

3. Results of the study

The study looked at the experiences of participants at different work sites with a close consideration of the head office of LFE, Zimmerman, and Lamaison apartments (Ruiru). The first apartment was still being constructed, while the second was finished. These sites enabled the researcher to evaluate women's contributions across all five phases of the project, with a particular focus on the fourth stage (construction and monitoring). Female engineers demonstrated a great sense of creativity and innovation through their work. Examining the completed Lamaison apartment project, the results revealed that women contribute to innovation and creativity throughout all phases of building construction in different ways. Likewise, the data from the respondents unveiled that innovation and creativity encompass different themes described in the figure below, including social aspect (19.6%), the design aspect (17.4%), unique perspectives (30.4%), and value (32.6%).

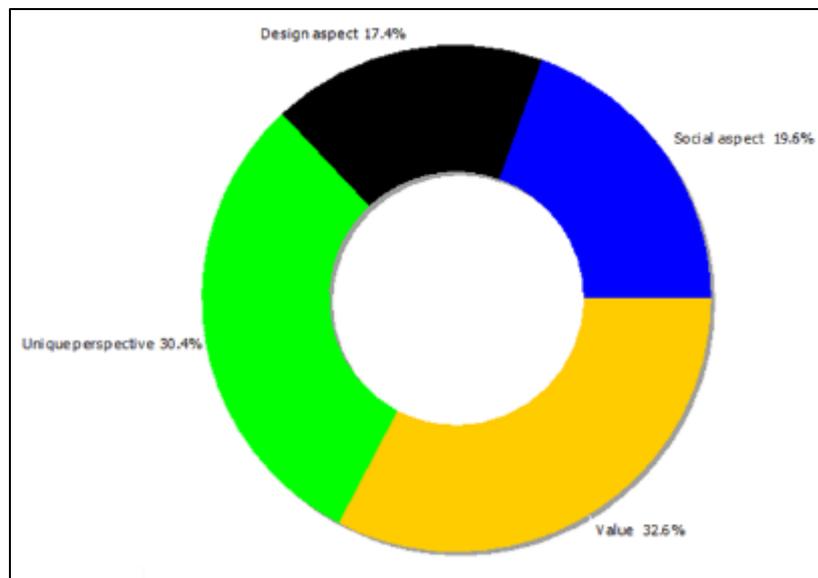


Figure 2 Innovation and Creativity

3.1. Theme 1: Value

To implement sustainable building construction, women engineers in Nairobi demonstrate different values through their leadership, competence, and advocacy for ethical standards. The results revealed that women not only impacted the construction with technical skills but also with the value (32.6%). This value was cited at a high rate (15 cases, 93.8% of participants). Respondents reported, their engagement in the industry enhanced gender balance or equality, transparency, and integrity in the five stages of building construction.

For instance, respondents, including A7, indicated that women engineers foster equity, marking a significant shift in the traditionally male-dominated realm of engineering. She noted that women advocate for inclusive design, community engagement, and social sustainability, ensuring that buildings meet social and sustainable human needs. Similarly, regarding integrity, interviewee A3 remarked that women engineers often lead with a strong sense of ethical responsibility, transparency, and accountability because most are often honest and not easily corrupted. All these values contributed to project delivery and the integration of sustainability principles throughout construction phases.

Furthermore, the KIF1 said that there is more balance between the male and female genders, although it is not yet complete. It is not completely 50-50, but at least there is an improvement in terms of gender consideration. Likewise, participant KIF4 and key informant KIM3 affirmed that when we are involved in the project, we do not only look at the technical aspect of the project. But we build teamwork, we make sure everybody is engaged to deliver the best of herself or himself.

3.2. Theme 2: Unique Perspective

A remarkable group of responses (30.4%) and a notable portion of participants (14 cases, 87.5%) highlighted the unique perspectives women engineers bring to sustainable building projects. Their problem-solving techniques, informed by a broad spectrum of life experiences and training, allow them to propose creative and context-specific solutions, especially in the design phase. This capacity led to innovation with the emphasis on designing private places such as breastfeeding rooms, changing rooms.

Participants noted that women often see beyond conventional limits and apply inclusive and empathetic thinking to engineering challenges. Women bring in construction perspectives that are meaningless to males. They are detail-oriented in their approach to engineering. One participant (A4) said: Let us even talk about ablution blocks and toilets. As a man, once you put open ones (toilets) and everything else, you are fine. For women, we want privacy, we need water, we need just little things that do not look significant to anybody else. But for us, it means a lot (A4).

Women always sought to respond to the challenge of maternity leave by providing some facilities on the site. A4 clarified this, saying that now our young women want to have their babies breastfeeding throughout the six months. Nobody gives you six months' leave. And therefore, you need somewhere to be able to keep milk for the babies, and safety, just the normal working atmosphere. The participant KIF1 summarised the perspectives that women engineers bring to sustainable building in women's touch which is human, environmental, and technical interdependence.

3.3. Theme 3: Social Aspect

Women engineers contributed significantly to the social dimension of sustainable building construction by fostering inclusivity and community engagement. This was seen in the fourth stage, where women involved the community to respond to the need at the construction site. Based on the findings in Figure 14, 19.6% of responses (9 cases or 56.2% of participants) reported that, in terms of innovation and creativity, women impact the sustainable building industry with social aspects.

In the post-construction phase, social aspects were noted in terms of easier accessibility. In other words, their contributions extended to improving user satisfaction, accessibility, and participatory design processes. For instance, participants emphasised how female engineers ensure that projects meet the needs of people through active collaboration with local communities. In addition, women integrate social decisions into technical decisions (A3&A4). Their ability to consider diverse social needs results in construction projects that better serve varied user groups, particularly in marginalised communities (KIM1).

3.4. Theme 4: Design Aspect

The design phase is crucial in the construction process. It is a moment to roadmap the project for proper implementation. The design Aspect accounted for 17.4% of responses (8 cases or 50.0% of the participants). The design input of women engineers emphasised functionality (optimise spaces), aesthetic balance, and environmental consciousness, which introduced nuanced approaches that blend structural with user-friendly layouts. These designs often accounted for practical usage patterns, local climate conditions, and future adaptability.

According to respondents, women engineers frequently innovated in optimising space and considering its effects on the environment. One interviewee stated, I contribute to creativity in sustainable building construction in the designs that I do. The designs that I do, where I am now employed in La Femme, every decision that I make, I have to see how it is going to impact the environment (A1). Likewise, this integrative design approach enhanced sustainability and usability as it was reported by A7: women are details-oriented, there are many aspects that men overlook at like the design of the cabinet in the kitchen, men will not consider the height, while if women are the ones to design, they will keenly consider small aspects, because they are the one who use mostly the house. These ideas were supported by the key informant two (KIM2) stated, I have seen very innovative designs brought forth by women. They design better living spaces beyond normal bricks and mortar. Evolution has endowed them with the skills to visualise better living spaces.

4. Discussion of the findings

The results of this study indicated that women engineers contributed highly to innovation and creativity in bringing in specific aspects like value (32.6%), unique perspective (30.4%), social aspect (19.6%), and design aspect (17.4%). The results revealed a value almost not spoken about in the industry as a new element that women bring to the sector. These findings aligned with several studies, including the study of Galea et al., (2022b) in Australia on when following the rules is bad for wellbeing: The effects of gendered rules in the Australian construction industry [22] and the study of Edna in Kenya on Enhancing Sustainable Housing Through Women's Cultural Skills, Experiences, and Knowledge [23]. These research studies noted that in the first phase of construction women participation fostered creativity and innovation through their design approaches. Their unique perspectives contributed to developing environmentally friendly construction design projects.

In addition, the research of Manzoor et al., (2021) that sought to establish strategies for adopting building information modelling (BIM) in sustainable building projects and the research on Engineering: Issues, Challenges and Opportunities for Development carried out by the UNESCO, (2010), reported that in the Malaysian buildings women engineers not only brought the technical aspects of the construction but also social aspect based on community needs in the industry in terms of innovation and creativity leading to a holistic women approach to construction industry [24].

5. Conclusion

This study assessed the contribution of women engineers to sustainable building construction in Nairobi City County. The findings revealed that women significantly impact sustainability through innovation and creativity, adding value, unique perspectives, social aspects, and design aspects. Under eco-friendly materials and energy efficiency, they promoted green energy, conservation, waste management, and recycling. In leadership and management, women advanced advocacy for sustainability, inclusion, and decision-making.

Recommendations

Based on the study's findings, targeted recommendations emerge for leaders at La Femme Engineering Services Ltd (LFE), employees, government bodies, and stakeholders.

- For LFE leaders and engineers at LFE, institutionalise mentorship and leadership programs promoting women in decision-making, especially in sustainability, while adopting gender-sensitive policies.
- For government bodies, given women's high contributions to advocacy (51.9%) and inclusion (29.6%), promoting gender parity in management is essential, ensuring equal access to training, promotions, and policymaking.
- For internal and external stakeholders, strengthen partnerships with academic institutions to enhance internships, mentorship, and research collaborations on sustainable building construction.

Suggestion for further research

Based on the study's findings, future research should include other construction companies in Kenya and Africa to assess the contributions of women engineers under diverse cultural, economic, and regulatory environments. Explore the long-term impact of women-led innovations: A longitudinal study could examine how women-led projects perform over time across environmental, economic, and social sustainability indicators.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

The researcher observed ethical considerations by ensuring the safety of participants during and after the study. Participants were informed of the nature of the study, and the confidentiality of the information obtained was emphasised.

Statement of informed consent

Informed consent was obtained. Once consent was given, participants had the right to withdraw from participation in certain aspects of the research, including the right not to respond to questions or inquiries regarding the provision of requested data.

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