Effect of Construction Mechanization on the Quality of Work Life of Construction Workers in Kenya

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Abstract

Mechanization has emerged as a cornerstone of modern construction, promising significant improvements in operational efficiency, cost management, and overall project quality. However, its influence on the Quality of Work Life (QWL) for construction personnel remains a subject of intense debate, especially within the context of developing economies like Kenya. This research provides a critical examination of the relationship between construction mechanization and QWL, specifically focusing on high-rise building projects in Nairobi. QWL was investigated through a multidimensional lens, encompassing four key constructs: fairness of compensation and reward systems, physical and psychological working conditions, occupational health and safety, and worker welfare and social integration. Utilizing a quantitative survey design, the study targeted 125 registered construction projects. Data were meticulously gathered from accredited site supervisors to assess mechanization levels across seven core work categories, while QWL indicators were evaluated using established Likert-scale constructs. Statistical reliability and validity tests confirmed a high degree of internal consistency, with a Cronbach's alpha exceeding 0.95. The correlation analysis produced complex, mixed outcomes. While mechanization was found to positively influence general working conditions ($r = 0.274$, $p < 0.01$), it demonstrated a significant negative impact on worker compensation ($r = -0.219$, $p < 0.05$) and health and safety standards ($r = -0.241$, $p < 0.05$). Furthermore, regression analysis highlighted that while mechanization in scaffolding improved QWL, mechanization during site preparation actually reduced it. Overall, the chosen mechanization variables accounted for 15% of the total variation in worker QWL. These findings emphasize mechanization's paradoxical nature: while it acts as a catalyst for modernization, it simultaneously introduces new vulnerabilities for the workforce. To harmonize technological advancement with worker well-being, the study recommends comprehensive policy reforms, mandated technical training, equitable wage frameworks, and the implementation of more robust site safety protocols.

Keywords: Construction Mechanization, Construction Workers, Quality of Work Life, Survey

Introduction

Mechanization, in a broad sense, is the process of adopting the use of machines in carrying out tasks that would otherwise be done by manual labour (Hwang *et al.*, 2020). From this perspective, mechanization can be understood as the process of substituting or complementing human labour with machines to make work easier. Mechanization thus implies a complete or partial replacement of human labour with machines that could either be automated or operated by just one or a few experts. Where the machine is automatic, a computerized system is used to instruct the machine on which operation to undertake (Vadukkumchery and Myneni, 2023). While the level of mechanization depends on the extent to which machines have been incorporated to replace human labour, automation is a dimension of mechanization, which means the total replacement of human labour with machines that use Artificial Intelligence (AI) to perform an activity (Kamaruddin, Mohammad, and Mahbub, 2016). Automated machines work, but under the instruction of a programme that controls the behaviour of the machines. Understandably, therefore, mechanization can be applied at the design level, and in actual construction processes such as digging trenches, earth moving, paving, lifting, and hoisting, bar cutting machines, bar straightening machines, concrete making machines, core drilling, plastering and painting, and 3D printing (Calvetti *et al.*, 2020).

Though mechanization is known to have its disadvantages, the majority of researchers seem to agree that the potential advantages, such as the ability to handle tough activities, cost savings in large quantities of work, better quality of work, adherence to project schedules, better prediction of behaviour, and ease of supervision and control, far outweigh the disadvantages. (Vishwakarma et al., 2022; Kamaruddin et al., 2018; Sharmila et al., 2018; Grover & Solanki, 2023; Iheama et al., 2017; Calvetti et al., 2021; Kamaruddin et al., 2016; Vadukkumchery & Myneni, 2023). This study investigates the effect of mechanization on the Quality of Work Life (QWL) of construction workers in high-rise building projects in Nairobi, Kenya.

Literature Review

Concept of Construction Mechanization

Technology is changing and developing around the world at a rate and pace never experienced before. The construction industry is one of the largest industries in both developing and developed countries in terms of investment, mechanization, employment, and contribution to GDP. Its impact on the environment is considerable across a broad spectrum of its activities. In this matter, construction organizations have aggressively embraced new technology to remain competitive in the current market (Alshawi et al., 2010).

Mechanization has long been defined as the process of shifting from working largely or exclusively manually to working with hand tools or powered equipment. (Willis, 1875). In an overall sense, mechanization as used in this study comprises mechanization itself, automation, and robotization.

Mechanization in Construction

Mechanization can be described as the process of applying the use of mechanical power to carry out a task. It can also be defined as the act of implementing the control of equipment with advanced technology, usually involving electronic hardware. According to Kamaruddin et al. (2016), it is the method of employing mechanical equipment in the performance of a job. The level of mechanization is defined as the number of plants and equipment employed or the number of activities carried out by mechanical plants in an operation (Hwang *et al.*, 2020). Machines have been employed in many phases of construction, including excavation, earthworks and piling works, structural steel works, filing, demolition and site clearance, concrete works, formwork, building component assembly, flooring and pavement works, plumbing and drainage works, masonry works, painting and finishing works, and roof works. Most of these activities were, for a long time, fully carried out by manual labour, but with time they gradually got mechanized.

Automation in Construction

According to Muro et al. (2019)Automation can be defined as the substitution of human labour with machines, or the automatic operation of a machine or equipment, either autonomously or via remote control. Automation is described as a self-regulating process executed by programmable machines to conduct a sequence of tasks without requiring human presence. Automation surpasses mechanization by not just utilizing machines but also enabling these machines to operate according to a programmed system that governs their behaviour, so granting them the capacity for "cognition and reasoning." (Mahbub, 2008). A report by Muro et al. (2019) described that automation is recognized as the technology related to the implementation of intricate mechanical, electronic, or computer-based systems for the operation and regulation of production or manufacturing.

It should be understood that the concept of automation has emerged from mechanization. The construction processes presently exhibit a minimal level of automation due to several factors. The primary cause is the conventional nature of the construction work, which hinders and obstructs the progress and implementation of automated systems for executing these tasks. (Brosnan, 2023). The distinctive nature of the structures and the absence of standardization in their components are another significant concern. For a uniform ultimate result, such as a skyscraper constructed in various locations, the duties and their execution may differ markedly between two distinct construction sites. This sense of rootedness in a specific location introduces ambiguity and differentiation (Muro et al., 2019).

Robotization in Construction

The domain of construction robotization is incorporated into the automation of construction. This concept pertains to the integration of robots into an automated system or the establishment of a fully automated system, as observed in Japan (Muro et al., 2019). The primary impediment to the integration of robotics in the construction industry is the inconsistency of operations and the fluctuating conditions of the construction environment (Idoro, 2011). Considering this, the application of robots in construction is increasingly shifting from rigid programming and fixed task sequences to a more adaptive type of utilization, enabling them to effectively perform changeable tasks. The integration of robots into the building site serves as an optimal environment for testing and validating advancements in robotics. (Hwang *et al.*, 2020).

Another issue is the limited payload of the existing robot technology. The manufacturing sector handles light to medium-weight components, whereas the construction sector deals with large loads and equipment. The correlation between payload and positional accuracy is another significant element. (Calvetti *et al.*, 2020). An increase in payload results in diminished positional precision at the robot's tip. The utilization of robots, as part of the automation domain, encompasses both the benefits and drawbacks previously outlined. Robots can do more intricate manipulation and processing activities than traditional systems. One advantage of a robotic system is its ability to perform manipulation tasks that would often need multiple machines, thereby consolidating the function into a single device. (Calvetti *et al.*, 2021).

Concept of Quality of Work Life (QWL)

Throughout history, man has always looked for ways to make tasks easier and improve his well-being. However, it was not until the 18th century that the scientific study of work conditions and their impact on productivity and worker morale began. This was when concepts such as task division, systematic production methods, specialized steps, centralized production, use of specialized tools and equipment, and quality control were introduced. (Camarini *et al.*, 2020). Thus, there was a major shift in industrial processes and technological advancements. On the other hand, workers' basic needs were disregarded as they endured poor living conditions, inadequate remuneration, and workdays lasting up to 18 hours. (Sinval *et al.*, 2020).

Though previous studies and experiments had explored human behaviour and needs at the workplace, the expression "*Quality of Work Life*" appeared in the early 1950s in England, when research on the work organization was developed based on the socio-technical approach, which takes into account social relations in the workplace, work conditions, worker satisfaction, and technological requirements. (Camarini *et al.*, 2020). However, according to Shanmugam and Ganapathi (2017)The concept of QWL was born in the 1960s, and since then, the idea has become increasingly significant in almost all economic sectors. (Jayaraman *et al.*, 2023). According to Walton (1973), who was a major contributor during the early years, QWL refers to the human and environmental values that industries neglect in favour of technological development, productivity, and economic growth. Jerome (2013) describes QWL as a process through which organizations respond to employees' needs by developing mechanisms to include them in the decision-making process of issues that affect their lives at work. It has been defined by Vetrimani and Maheswari (2014) as the quality of the relationship between workers and the total working environment. According to Ganapathi (2016)QWL is a philosophical approach that holds people to be the most significant resource in an organization, as they are reliable, responsible, and make valuable contributions, and therefore should be treated with dignity and respect. It is therefore clear from these definitions that QWL is generally the extent of favourableness of a job environment for people. It is all about enhancing the human dimensions at the workplace by introducing inclusive problem-solving, work restructuring, improving the work environment, and introducing innovative reward systems.

QWL can be conceived as a set of methods, such as job enrichment, autonomous work groups, and high worker involvement, aimed at boosting both the productivity and satisfaction of workers (Soundarya and Anandh, 2024). It requires the commitment of workers to the organization and a working environment in which this commitment can prosper. Therefore, QWL could be seen as a comprehensive construct that not only includes an individual's job-related well-being but also the extent to which the job experience is fulfilling, rewarding, and free of stress and other negative consequences.

QWL is a highly significant issue in almost all industries. The success of any industrial sector is not just dependent on the adoption of contemporary methods; it also requires having quality workers. The concept of QWL is primarily focused on the influence of employment on the health and welfare of workers. Nowadays, every industry seeks to provide enhanced working conditions for its employees, both financially and non-financially. Their main aim is to retain employees for longer working durations and achieve the organization's goals. There is also an understanding that workers perform their jobs better when they are permitted to contribute to managing and being involved in the decision-making process in their work.

The working conditions of construction workers in developing countries have been termed subpar. Shanmugam and Ganapathi (2017) argue that though the construction industry in developing countries continues to grow in leaps and bounds, the working conditions of construction workers have not drastically improved. Further, according to Samuel et al. (2022)The industry faces a number of challenges, including high levels of accidents and health problems, and it is one of the most hazardous sectors. Ganapathi (2016) pointed out that construction workers in developing countries remain the most exploited.

During the 1960's and the early 1970's, great progress was made in QWL studies due to the increased awareness of workers' and companies' social responsibility, resulting in them focusing their efforts on internal research on the organization and different ways to accomplish the work. During those early years of the development of the idea of QWL, Walton (1973) established a model for analyzing organizational experiments based on contributions from human development theories such as Maslow's Hierarchy of Needs theory. The model introduced eight conceptual categories together with their respective criteria relating to aspects of physical and mental health, social development, and integration, as shown in Table 1.

Table 1: Conceptual categories for analyzing organizational experiments

No.	Category	Criteria
1	Fair and adequate compensation	Internal and external equity, fair compensation, sharing productivity earnings, and proportionality of salaries
2	Safe and healthy working conditions	reasonable working times, a safe and healthy physical environment, and the absence of insalubrity
3	The opportunity to use and develop human capabilities	autonomy, relative self-control, multiple qualities, information on the whole work process
4	Opportunity for continued growth and employment assurance	possibility of career, personal growth, perspective of advancing wages and job security
5	Social integration into the organization	equality, mobility, relationship, sense of community, and absence of prejudices
6	Constitutionalism in the organization	rights of worker protection, personal privacy, freedom of speech, fair treatment, and labour rights
7	Work and the total space in an individual's life	balanced role at work, stability of schedules, and a few geographical changes and time for leisure activities with the family
8	Social relevance of work	image of the company, corporate social responsibility, liability for products, and employment practices

Modified from Camarini et al. (2020)

Over the years, QWL, which was previously understood as a simple reaction to work, evolved to a new way of enhancing the work environment, of increasing productivity and worker satisfaction. Sirgy (2001) proposed that QWL involves the satisfaction of workers' basic (lower-order) and growth (higher-order) needs based on Maslow's framework. The basic needs include health and safety needs, such as protection from injury and job-related health benefits, and economic and family needs, such as adequate compensation, job security, and work-life balance. On the other hand, higher-order needs include social needs such as leisure time and social interactions at work, esteem needs such as recognition of job performance, actualization needs such as the realization of one's potential within the organization and work field, knowledge needs such as learning for continuous professional development, and aesthetic needs such as creativity at work. Further, current studies on QWL emphasize, mainly, the worker's well-being and satisfaction, valuing workers' participation in the decision-making process, and the humanistic perspective of thinking about people, work, and organization. Koonmee et al. (2010) suggested that company rules and standards that govern workers' conduct, such as incentive systems, corporate culture, promotion policies, valued behaviours, and management behaviour, are some of the factors that determine QWL. It is true that, currently, companies need to be increasingly competitive and, therefore, to care about the people, as it is through their commitment to the organization's proposals that the results will be achieved successfully (Tolfo and Piccinini, 2011). The most important aspects of work life for construction workers are working conditions and environment, compensation, professional growth, and social integration (Shanmugam and Ganapathi, 2017). According to Ganapathi (2016), factors that are relevant to workers' QWL include the physical work environment, the task, the administrative system, the social environment within the organization, and the work-life balance. The author further states that QWL consists of the opportunities for active employee involvement in problem-solving or group work arrangements that are of mutual benefit to both the workers and their employers, based on labour-management cooperation.

Some of the published instruments designed to measure QWL over the years include the Quality of Work Life Questionnaire. (Elizur and Shye, 1990), the Quality of Work Life Scale (QWLS) (Sirgy, 2001), the Quality of Work Life Measure (Zin, 2004), Quality of Working Life Systemic Inventory (Martel and Dupuis, 2006), Nurses' Quality of Working Life Questionnaire (Hsu, 2016), and the Work-Related Quality of Life Scale (Easton and Van Laar, 2018). After careful analysis of these published tools, the researcher broke down the concept of QWL into four constructs, namely compensation and reward, working conditions, health and safety, and welfare and social integration. These have been discussed in the following sections.

Compensation and Reward Systems

Salary and wages are the output of the input of labour for their effort and work. This not only includes the physical but also the mental work done by employees (Yadav, Khanna, and Panday, 2019). Salaries and wages are known as remuneration and cover all the amenities offered by the employer, such as holidays, paid vacations, and sick leave, as well as other fringe benefits. According to Vetrimani and Maheswari (2014), QWL is associated with job satisfaction, which in turn is linked to wages, working conditions, and working hours. Swathi (2017) lists the basic elements of a good QWL as impartial wages, a safe workplace, and equal opportunities for career advancement. It is clear from these discussions that remuneration is a recurring factor in the QWL discussion. Further, many authors have also explained the importance of remuneration as a key dimension of QWL (Sharma, Ghuman, and Kumar Sharma, 1970; Sirgy, 2001; Royuela, López-Tamayo, and Suriñach, 2008; Vetrimani and Maheswari, 2014; Swathi, 2017; Yadav, Khanna, and Panday, 2019; Sinval *et al.*, 2020). According to Shanmugam and Ganapathi (2017), salary and remuneration affect employees' work satisfaction and performance. Workers seek to achieve secure jobs with justified salaries, which makes them feel relaxed at the workplace (Samuel *et al.*, 2022). According to Janmohammadi et al. (2015), there should be an equitable balance between effort and reward. The pay should be able to help the worker maintain a socially desirable standard of living and should also be comparable to the reward and compensation for similar work elsewhere. Some of the factors considered for determining such compensation are the ability of the employer to pay, cost of living, labour productivity, demand and supply of labour, and job evaluation, among others (Yadav, Khanna, and Panday, 2019).

Working Conditions

The working conditions in any workplace determine the job satisfaction of employees, which in turn affects not only their productivity but also their overall performance. Issues such as opportunities to use and develop human capacities, continued growth, job security, merit-based promotions, involvement in decision-making, and open communication, among others, need to be considered in the workplace (Vetrimani and Maheswari, 2014). The job should contain a sufficient variety of tasks to not only provide a challenge but also to ensure the utilization of talents. In the modern day, work has become repetitive and mechanical, such that the worker has little control over it. (Vishwakarma, Sushil and Solanki, 2022). The work should therefore provide opportunities for the career development of new abilities and the continuous growth of existing skills. Seniority should be considered during the promotion of employees, and merit should be used for the advancement of managerial personnel. (Yadav, Khanna and Panday, 2019). This means that the promotion policy should be fair and just. Further, communication should be two-way. This means that as employers give orders, employees should also be allowed to present their grievances and suggestions. This participatory approach helps organizations to grow at a fast pace. (Zhu *et al.*, 2024). Participation has been widely recognized as a means of improving the quality of work life and increasing workers' productivity. (Bamfo-Agyei, Thwala and Aigbavboa, 2022b). In theory, participation releases creative energy and provides workers with a sense of accomplishment. (Camarini *et al.*, 2020).

Health and Safety

Construction activities tend to be labour-intensive. Due to the critical negative impacts, such as safety accidents, injuries, and fatalities, safety in construction sites is crucial to the sustainable development of the construction industry. (Zhu *et al.*, 2024). Most construction workers are at risk, with a considerable number of fatalities reportedly caused by falls. (Workplace Health and Safety Queensland, 2023). The high incident and accident rates in the construction industry have brought detrimental effects not only on construction companies but also on the entire industry, including losses in productivity and financial consequences. (Hasan *et al.*, 2018).

The quality of work life cannot be considered adequate unless the work environment is free from all hazards that may be detrimental to the health and safety of workers. Some of the main elements of a good physical environment for work include reasonable hours of work, a pollution-free atmosphere, cleanliness, and risk-free work, among others (Sinval *et al.*, 2020). Working conditions that are unsafe cause problems for both the organization and employees (Liu, Zhong, and Li, 2025). There may be little advantage to the employer in the short term, but in the medium and long term, it adversely affects the productivity within the organization (Swathi, 2017). Therefore, adequate investment should be made to ensure the working conditions are both safe and healthy for employees.

Welfare and Social Integration

It is crucial for workers to feel a sense of identity with the organization and develop a feeling of self-esteem, trust, openness, the scope for upward mobility, a sense of community feeling, and equitable treatment. (Camarini *et al.*, 2020). The concept of constitutionalism in the workplace is very important. It is related to organizational norms that influence the freedom of employees. Efforts should be made to ensure the right norms are implemented at the workplace. Such should be able to accommodate the privacy of individual workers, equity, freedom of speech, and dissent on some aspects. (Easton and Van Laar, 2018). QWL provides constitutional protection to the employees, such that management can be challenged in times when it attempts to exploit the workers. Further, there should be a proper balance between work life and workers' personal lives. The demands of work, such as frequent travel, late hours, and quick transfers, are not only psychologically but also socially very costly and detrimental to the quality of work life of employees. (Faatih Suwandi and Tentama, 2020).

Work should not only be a source of material and psychological satisfaction but also a means of social welfare. An organisation that has a greater concern for social causes like pollution, national integration, consumer protection, and employment, among other issues, can improve the quality of work-life. (Hsu, 2016). When organizations allow their employees to raise work grievances and represent their problems, employees feel more confident and secure, as they are cared for by management as part of a family. (Jerome, 2013). According to Swathi (2017)Relationships between and among the workers are an important indicator of a healthy work organization. Therefore, opportunities should be provided to enhance both formal and informal interactions. All kinds of religions, classes, crafts, races, and designations must be treated equally.

Theoretical Framework

Human Capital Theory

Human capital theory posits that investments in education, training, and skills development enhance productivity and worker well-being. (Becker, 1993). Mechanization, however, challenges this premise by substituting manual labour with machines, potentially devaluing human capital. In Kenya, limited training opportunities for workers to operate advanced machinery exacerbate this tension, leading to skill mismatches and reduced compensation. (O. Adebowale and Agumba, 2023). Empirical evidence shows that mechanization improves efficiency but often sidelines unskilled workers, undermining the expected returns on human capital investments. (Iheama, Alinta-Abel and Ezeokoli, 2017).

Theory of Capitalism

From a capitalist perspective, mechanization reflects firms' drive to maximize profit by reducing labour costs and increasing output (Marx, 1990). While this enhances competitiveness, it commodifies labour, often at the expense of worker welfare. Evidence from Kenya indicates that mechanization in cost-intensive trades such as concreting is closely monitored to safeguard margins, but this often results in wage suppression and reduced bargaining power for workers (Murianka, Njuguna, and Wachira-Towey, 2025). Thus, mechanization embodies capitalism's dual logic: efficiency gains for firms but precarious conditions for workers.

Theory of Induced Innovation

The theory of induced innovation suggests that technological adoption is driven by relative factor scarcities and cost pressures (Ruttan and Hayami, 1984). In Kenya's construction industry, where labour is abundant but mechanization remains uneven, firms are incentivized to adopt innovations that enhance labour productivity. Lean construction practices, digital monitoring tools, and prefabrication methods are increasingly being introduced to reduce non-productive time and optimize resource utilization. (Kulakov, Orlov and Kankhva, 2023). The study's emphasis on activity-measuring techniques reflects this dynamic, showing how firms respond to rising project costs and competitive pressures by innovating in labour management.

Sociotechnical Systems (STS) Theory

STS theory emphasizes the interdependence of social and technical subsystems (Trist and Bamforth, 1951). Construction projects exemplify sociotechnical systems, where worker skills, teamwork, and organizational culture interact with mechanization, tools, and processes. Recent research emphasizes that successful construction projects require holistic interventions that balance human and technical dimensions, ensuring that technology adoption complements rather than substitutes human labour. (Bamfo-Agyei, Thwala and Aigbavboa, 2022a).

Conceptual Framework

The conceptual framework (Figure 1) for this study illustrates the hypothesized relationship between construction mechanization and the quality of work life of construction workers in Kenya. The independent variable in this study is the extent of construction mechanization (CM). This refers to the integration of machines, automated tools, and robotics into project delivery processes. It was evaluated across the various work elements found in a typical building construction project. These included site preparation and earthworks, scaffolding and formwork, concreting, walling, plastering and flooring, tiling and painting, and building services. The relationship between this variable and the study's outcomes is represented by continuous (solid) lines. These solid arrows indicate a direct causal path, suggesting that construction mechanization has a significant, positive influence on the quality of work life of construction workers.

Conversely, the quality of work life of construction workers (QWL) serves as the dependent variable. Given its complexity, QWL was viewed as a multidimensional construct. In this framework, the dependent variable is decomposed into four critical dimensions: Fairness of compensation and reward systems (CRS), quality of working conditions (WC), quality of health and safety (HS), and quality of welfare and social integration (WSI). The link between the core concept of QWL and these four constructs is illustrated using dotted (dashed) lines. These lines signify a representational relationship, indicating that the four constructs are the specific indicators used to measure the overarching construct of QWL. Unlike the solid lines, these do not represent a causal flow but rather show how the dependent variable is composed.

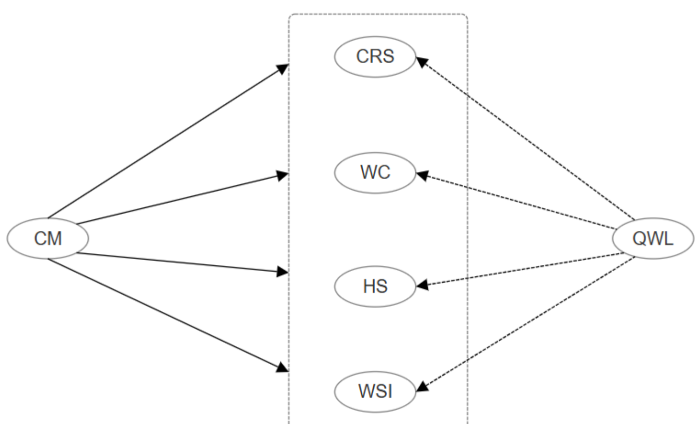

Figure 1: Conceptual Framework
Source: (Author formulation)

Methodology

This study adopted a quantitative approach since it sought to sample a population, study the sample, and make generalizations about the population. Further, this study adopted a survey research design. The method involves collecting data from a sample drawn from a target population to identify the extent and nature of relationships between variables. This research is normally conducted, especially when the population is too large and therefore too costly and impractical (Sekaran, 2003). This method made it possible for data to be collected effectively without any manipulation of the research context.

The unit of analysis for this study was the construction site workers. The respondents for the survey, however, comprised accredited construction site supervisors who were required to answer questions regarding the construction project and the site workers. The target population was based on the number of registered construction projects. This enabled the researcher to visit construction sites to confirm the extent of mechanization in the construction projects. A sample size of 125 construction projects was established using formulae from Cochran (1977) and Bartlett et al. (2001). Since simple random sampling ensures that all the target participants get an equal opportunity to participate in the study, it was used to select the construction projects from the target population. The study chose the site agent or clerk of works (whoever was first available) as the accredited construction site supervisor to respond to the questionnaire.

The extent of construction mechanization (M) was evaluated across the various work elements found in a typical building construction project. This evaluation was based on a tool developed by Hwang et al. (2020). This tool has been presented in Table 2, which shows the definition for each level of mechanization and examples. This table was also shared with the respondents so that they could fully understand the meaning and description of every mechanization level. This helped ensure the collected data had validity.

Table 2: Level of Mechanization Scale

Mechanization Level	Definition	Example
Completely Manual	Workers are on-site and use non-mechanized or *simple tools* without mechanisms to work.	Shovel, saw, and hammer, etc.
Hand tool	Workers are on site and use equipment with mechanisms (but not machines)	Hand winch, claw hammer, and spirit level, etc.
Automated hand tool	Workers are on site and use machinery to work on the construction project	Electric laser leveler, electric drill, electric bolt wrench, etc.
Machine/Workstation	Workers operate a machine/workstation to complete the construction task	Crane, excavator, and pump, etc.
Completely Automated/Robotized	Workers are not required to operate or monitor the machine, and the machine will complete the work activities by itself.	Robotic tiling machine, bricklaying robot, etc.

Adapted from: (Hwang et al., 2020)

The dependent variable, Quality of Work Life (QWL), was broken down into four constructs, namely, Fairness of Compensation and Reward Systems (CRS), Quality of Working Conditions (WC), Quality of Health and Safety (HS), and Quality of Welfare and Social Integration (WSI). The independent variable, the Extent of Construction Mechanization (M), was evaluated across the various work elements found in a typical building construction project.

Table 3: Operational Definitions of Quality of Work Life

Variable	Operational Definition
Y_2: Quality of Work Life (QWL)	The overall satisfaction and well-being of construction workers while at work. This was measured based on the following;
$Y_{2.1}$: Fairness of Compensation and Reward Systems (CRS),	The degree to which construction workers perceived their pay, benefits, and recognition to be equitable, competitive, and aligned with their skills, experience, and contributions to the construction project. This was measured based on six (6) indicators and a 5-point Likert scale
$Y_{2.2}$: Quality of Working Conditions (WC),	The physical, social, and psychological environment in which construction workers operated. This was measured based on nine (9) indicators and a 5-point Likert scale.
$Y_{2.3}$: Quality of Health and Safety (HS),	The degree to which construction workers were protected from physical, mental, and emotional harm while performing their duties on site. This was measured based on eight (8) indicators and a 5-point Likert scale.
$Y_{2.4}$: Quality of Welfare and Social Integration (WSI).	The extent to which construction workers' basic needs, such as food, water, shelter, and sanitation, were met, and the degree to which they felt socially connected, supported, and included within the organization. This was measured based on eight (8) indicators and a 5-point Likert scale

(Own Formulation)

Table 4: Operational Definitions of Construction Mechanization

Variable	Operational Definition
X: Extent of Construction Mechanization (M)	The degree to which construction processes and activities were mechanized, automated, or robotized, replacing traditional manual labour with machines and technology.
X_1: Site Preparation and Earthworks (M_{SPE})	The extent to which construction processes and activities associated with Site Preparation and Earthworks were mechanized, automated, or robotized.
X_2: Scaffolding and Formwork (M_{SF})	The extent to which construction processes and activities associated with Scaffolding and Formwork were mechanized, automated, or robotized.
X_3: Concreting (M_C)	The extent to which construction processes and activities associated with Concreting were mechanized, automated, or robotized.
X_4: Walling (M_W)	The extent to which construction processes and activities associated with Walling were mechanized, automated, or robotized.
X_5: Plastering and Flooring (M_{PF})	The extent to which construction processes and activities associated with Plastering and Flooring were mechanized, automated, or robotized.
X_6: Tiling and Painting (M_{TP})	The extent to which construction processes and activities associated with Tiling and Painting were mechanized, automated, or robotized.
X_7: Building Services (M_{BS})	The extent to which construction processes and activities associated with Building Services were mechanized, automated, or robotized.

(Own Formulation)

Results and Discussion

Response Rate, Reliability, and Validity Tests

Response Rate

A total of 125 questionnaires were administered physically to the randomly selected construction sites. A total of 116 questionnaires were received back. However, three of the questionnaires were discarded due to incompleteness. Two of these questionnaires had large sections left blank. Therefore, the number of usable questionnaires was 113, which was equivalent to a response rate of 90.4%. In these questionnaires, the number of missing values was negligible. Notably, Part 1 (Background Information) of the questionnaire was completely filled out. The highest recorded number of missing values in a single questionnaire was three (3). In all cases, the missing values were replaced with the mean of the available responses.

Table 5: Response Rate

Distributed	Total returned	Non-usable	Usable	Response rate	Remark
125	116	3	113	90.4%	Acceptable

(Fieldwork, 2025)

Reliability Results

The reliability of the collected data was established using Cronbach's alpha values obtained using SPSS version 25. The aim of this was to determine the internal consistency of the data. The results have been presented in Table 6 All the variables recorded values exceeding 0.9, which were deemed excellent. The overall Cronbach Alpha value was 0.958.

Table 6: Reliability Test Results

	Variables	N of Items	Cronbach Value	Remarks
Y	Quality of Work-Life of Construction Workers	31	0.957	Excellent
	Y_1) Compensation and Reward Systems	6	0.984	Excellent
	Y_2) Working Conditions	9	0.969	Excellent
	Y_3) Health and Safety	8	0.969	Excellent
	Y_4) Welfare and Social Integration	8	0.991	Excellent
X	Level of Mechanization	88	0.958	Excellent
	X_1) Site Preparation and Earthworks	11	0.857	Good
	X_2) Scaffolding and Formwork	18	0.951	Excellent
	X_3) Concreting	15	0.934	Excellent
	X_4) Walling	7	0.859	Excellent
	X_5) Plastering and Flooring	11	0.667	Acceptable
	X_6) Tiling and Painting	13	0.929	Excellent
	X_7) Building Services	13	0.654	Acceptable
NB: The highlighted cells are a summation/average of the factors below				

(Fieldwork, 2025)

Validity Results

The construct validity of the collected data was checked using Pearson's Product-Moment Correlation as advocated by Karras (1997). The validity test was conducted by correlating each variable with a newly computed variable (Total), which was the sum of all the variables under consideration. Significant relationships are an indication of the presence of validity. (Ahrens, Lirani and de Francisco, 2020). As presented in Table 7, all the variables were found to have construct validity.

Table 7: Construct and Criterion Validity Test Results

Variable		**Total (Sum of the Variables)**
Fairness of Compensation and Reward Systems (CRS)	Pearson Correlation	0.627^{**}
	Sig. (2-tailed)	0.000
Quality of Working Conditions (WCs)	Pearson Correlation	0.830^{**}
	Sig. (2-tailed)	0.000
Quality of Health and Safety (HS)	Pearson Correlation	0.540^{**}
	Sig. (2-tailed)	0.000
Quality of Welfare and Social Integration (WSI)	Pearson Correlation	0.537^{**}
	Sig. (2-tailed)	0.000
Level of Mechanization (M)	Pearson Correlation	0.042*
	Sig. (2-tailed)	0.046
	Sig. (2-tailed)	
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).		

(Fieldwork, 2025)

Background Information

Three aspects were included in the background information section. These included professional experience, project value, and project duration. Their results have been analyzed and discussed in the following sections.

Professional Experience

The professional experience was grouped into five categories, namely: 1-5, 6-10, 11-15, 16-20, and above 20 years. The results are presented in Table 6. The highest frequency was recorded between 6-10 years (n=48, 42.5%), while the lowest was reported for the group above 20 years (n=9, 8%). Those with minimal professional experience of between 1-5 years were not considerably high, as they only had a frequency of 13 (11.5%). Since an overwhelming majority (n=100, 88.5%), it is evidently clear that the respondents had adequate experience and exposure in the construction industry to provide results rich in "validity".

Table 8: Background Profile

Demographic	Category	Frequency	%
Professional experience (years) (n=113)	1-5 Years	13	11.5
	6-10 Years	48	42.5
	11-15 Years	31	27.4
	16 -20 Years	12	10.6
	Above 20 Years	9	8.0

Projects value (KShs) (n=113)	101 – 300million	28	24.8
	301 – 500million	43	38.1
	501 – 700million	21	18.6
	701 – 900million	11	9.7
	Above 900million	10	8.8
	101 – 300million	28	24.8
Projects duration (weeks) (n=113)	Up to 36weeks	7	6.2
	37-72weeks	24	21.2
	73-108weeks	57	50.4
	109-144weeks	16	14.2
	Above 144weeks	9	8.0

Source: (Fieldwork, 2025)

Project Value

In this section, the researcher enquired about the current project value. The aim of this was to better understand the context and provide an explanation for the reported levels of mechanization, since high-value projects are expected to embrace machines and technology more than smaller projects. In this regard, the study only considered projects that were worth more than KShs 100 million. This is to avoid skewed results since very small projects would record negligible levels of mechanization and thus need a study on their own. The majority of the projects (n=103, 91.2%) had their contract sums between KShs 100 and 900 million, with only 10 (8.8%) being worth over KShs 100 million. As shown in Figure 4.2, the highest frequency (n=43, 38.1%) was reported in “KShs 301-500 million”, followed by “KShs 101-300 million” (n=28, 24.8%)

Project Duration

The project duration was measured in weeks based on intervals of 36 weeks. As seen in Figure 4.3, the results were fairly distributed, demonstrating a bell curve with the majority of the projects (n=97, 85.8%) lying between 37 and 144 weeks. Projects with durations below 36 weeks and above 144 weeks recorded frequencies of 7 (6.2%) and 9 (8.0%), respectively. The highest frequency was reported between 73-108 weeks (n=57, 50.4%).

Effect of Mechanization on the Quality of Work Life of Construction Workers

This study used ANOVA, correlations, and multiple regression to establish the effect of mechanization on the Quality of Work Life (QWL) of construction workers on project sites. The findings have been presented and discussed in the following sections.

ANOVA results

The ANOVA results in Table 9 indicate that the level of mechanization does not significantly affect any of the four QWL constructs. While mechanization may offer operational benefits, its influence on worker welfare, compensation, safety, and social integration is limited or inconsistent.

Table 9: ANOVA between Mechanization and QWL

		Sum of Squares	df	Mean Square	F	Sig.
CRS	Between Groups	56.978	110	.518	4.662	.193
	Within Groups	.222	2	.111		
	Total	57.201	112			
WCs	Between Groups	56.909	110	.517	6.705	.138
	Within Groups	.154	2	.077		
	Total	57.063	112			
HS	Between Groups	15.493	110	.141	3.606	.242
	Within Groups	.078	2	.039		
	Total	15.571	112			
WSI	Between Groups	26.275	110	.239	.764	.726
	Within Groups	.625	2	.313		
	Total	26.900	112			

(Fieldwork, 2025)

In Compensation and Reward Systems (CRS), although the F-value suggests some variation, the p-value (.193) indicates that the mechanization level does not significantly influence perceptions of compensation and reward. This implies that wage structures and recognition systems are not systematically tied to how mechanized a project is. Working conditions (WC) show moderate variation ($F(110,2) = 6.705$, $p = .138$) across mechanization levels, but the difference is not statistically significant. Mechanization may improve physical conditions (e.g., reduced manual strain), but this effect is not strong or consistent enough to be confirmed statistically. Health and safety (HS) outcomes vary slightly ($F(110,2) = 3.606$, $p = .242$) with mechanization, but the relationship is not statistically significant. This suggests that safety improvements may depend more on management practices and compliance than on mechanization alone. 4. Welfare and Social Integration (WSI) presents the weakest association ($F(110,2) = 0.764$, $p = .726$). Mechanization level has no significant impact on welfare provisions or social integration. Welfare outcomes appear to be shaped more by project policies and duration than by the presence of machines.

Correlations

Table 10 presents a Pearson's correlation matrix between Mechanization (M) and the four variables of Quality of Work Life (QWL), namely, Fairness of Compensation and Reward Systems (CRS), Quality of Working Conditions (WC), Quality of Health and Safety (HS), and Quality of Welfare and Social Integration (WSI). All the relationships were generally weak, and three out of the four correlations were statistically significant. The results indicate that the effect of mechanization on CRS (-0.219, p=0.02) and HS (-0.241, p=0.01) was negative. This means that increased mechanization tends to be accompanied by reduced remuneration and worsened health and safety conditions on construction sites. This could be attributed to the fact (or perception) that mechanization replaces human labour and also causes injuries, as it has been observed in many cases. However, the effect of mechanization on WC (0.274, p=0.003) was positive, meaning that increased mechanization led to improved working conditions for construction workers. The relationship between mechanization and WSI was not statistically significant. Also, all but one (CRS/WSI) of the correlations among the four aspects of QWL were positive. This is expected since the four variables explain the same construct.

Table 10: QWL of Construction Workers vs. Mechanization Correlation Matrix

		M	CRS	WC	HS	WSI
M	Coefficient	1	-.219*	.274**	-.241*	-.174
	Sig. (2-tailed)		.020	.003	.010	.066
CRS	Coefficient	-.219*	1	.475**	.305**	.151
	Sig. (2-tailed)	.020		.000	.001	.111
WC	Coefficient	.274**	.475**	1	.216*	.409**
	Sig. (2-tailed)	.003	.000		.022	.000
HS	Coefficient	-.241*	.305**	.216*	1	.345**
	Sig. (2-tailed)	.010	.001	.022		.000
WSI	Coefficient	-.174	.151	.409**	.345**	1
	Sig. (2-tailed)	.066	.111	.000	.000	
*. Correlation is significant at the 0.05 level (2-tailed).						
**. Correlation is significant at the 0.01 level (2-tailed).						

(Fieldwork, 2025)

Table 11 presents a summary of the correlation between Mechanization and QWL. The results indicate that though there is a statistically significant relationship, it is negative and very weak (-0.083, p=0.008), tending towards negligible. This means that only a large increase in mechanization would have some recognizable effect on QWL. This effect would, however, be negative, meaning that extensive use of mechanization would lead to a slight decrease in the QWL of construction workers in the construction industry of Kenya.

Table 11: Overall Correlation between Mechanization and QWL

		QWL	M
QWL	Pearson Correlation	1	-.083
	Sig. (2-tailed)		.008
M	Pearson Correlation	-.083	1
	Sig. (2-tailed)	.008	

(Fieldwork, 2025)

Multiple Regression (QWL versus Mechanization)

In the multiple regression, the four aspects of QWL were aggregated to create a single variable, which was regressed on the levels of mechanization in different work categories. The results have been presented in Tables 12, 13, and 14.

As noted in Table 13, the R, R-squared, and Adjusted R-squared values for the regression model were 0.44, 0.194, and 0.140, respectively. This means that Mechanization accounts for 15% of the variation in the QWL of construction workers in Kenya. Consequently, it means that 85% of the QWL is explained by factors other than Mechanization.

Table 12: Model Summary

Model	R	R Square	Adjusted R-Square	Std. Error of the Estimate
1	.451[a]	.204	.151	.37712
a. Predictors: (Constant), MBS, MW, MSF, MSPE, MC, MPF, MTP				

(Fieldwork, 2025)

The ANOVA test presented in Table 4 shows that the achieved regression model was statistically significant (p=0.001), and the model was fit to explain the relationship between QWL and the various levels of Mechanization in different work categories.

Table 13: ANOVAa

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.820	7	.546	3.837	.001[b]
	Residual	14.933	105	.142		
	Total	18.753	112			
a. Dependent Variable: QWL						
b. Predictors: (Constant), MBS, MW, MSF, MSPE, MC, MPF, MTP						

(Fieldwork, 2025)

Table 13 showed that only two predictors had a statistically significant relationship with QWL. These were Mechanization in Site Preparation and Earthworks (SPE) and Scaffolding and Formwork (SF). However, one of these was found to have a negative relationship with QWL. This means that an increase in the mechanization of SPE resulted in decreased QWL. The relationship between QWL and the Mechanization of SF works was positive, meaning that an increase in the mechanization of SF works would improve the QWL. Mechanization in Concreting, Walling, Finishes (Plastering, Flooring, Tiling, and Painting), and Building services was found to have no statistically significant effect on the QWL.

Table 14: Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.349	9.639		.555	.618
	MSPE	-.512	.160	-.280	-3.190	.002
	MSF	.310	.101	.309	3.060	.003
	MC	-.217	.113	-.193	-1.919	.058
	MW	-.022	.101	-.019	-.216	.830
	MPF	.201	.234	.077	.860	.392
	MTP	-.240	.242	-.091	-.991	.324
	MBS	-.523	.278	-.172	-1.880	.063
a. Dependent Variable: QWL						

(Fieldwork, 2025)

The following regression model, comprising only the statistically significant predictors, was formulated;

$$QWL = 5.349 - 0.512M_{SPE} + 0.310M_{SF}$$

Discussion of Findings

Background Information

The study revealed that the majority of respondents (42.5%) had between 6 and 10 years of professional experience, while only 8% had more than 20 years. This distribution suggests that Kenya's construction workforce is relatively youthful, with most supervisors possessing moderate experience. The finding aligns with Wachira (1999) who noted that the Kenyan construction industry is dominated by mid-career professionals rather than long-tenured experts. Similarly, Adebowale and Agumba (2023) observed that in Sub-Saharan Africa, construction site supervisors often fall within the 5–15-year experience bracket, reflecting both high labour mobility and limited long-term retention.

Critically, while moderate experience ensures familiarity with mechanization and modern practices, the relatively low proportion of highly experienced supervisors may constrain knowledge transfer and mentorship. This contrasts with studies in developed economies, where longer tenures are associated with better integration of mechanization and safety protocols. (Kapliński *et al.*, 2002).

The majority of projects surveyed (91.2%) had contract sums between KShs 100–900 million, with the largest concentration (38.1%) in the KShs 301–500 million range. This reflects the dominance of medium- to large-scale projects in Nairobi's construction landscape. Previous studies confirm that mechanization is more prevalent in high-value projects, where capital investment justifies the use of cranes, excavators, and automated formwork. (Hwang *et al.*, 2020). Iheama et al. (2017) similarly found that in Nigeria, mechanization adoption was significantly higher in projects exceeding local cost thresholds, as smaller projects relied on manual labour to minimize upfront expenses.

The Kenyan results, therefore, corroborate global evidence that project value is a strong determinant of mechanization. However, the concentration of mechanization in high-value projects raises equity concerns, as smaller contractors and informal projects remain excluded from technological modernization.

Most projects (85.8%) had durations between 37 and 144 weeks, with the highest frequency (50.4%) in the 73–108-week range. This bell-curve distribution suggests that mechanization is most commonly deployed in projects of medium duration, where timelines are tight enough to necessitate efficiency but not so short as to preclude investment in machinery. Comparatively, Jang et al. (2016) found that mechanization significantly reduces project duration in Asian contexts, particularly in concreting and scaffolding tasks. In Kenya, Wachira (1999) Also reported that mechanization was most effective in reducing delays in medium-scale projects, while very short projects often relied on manual labour due to cost constraints.

Critically, while mechanization appears to align with medium-duration projects, its impact on welfare is mixed. Longer projects may expose workers to prolonged machinery noise and safety risks, while shorter projects may deny them opportunities to benefit from mechanization's ergonomic advantages. This duality underscores the need for context-specific strategies that balance efficiency with worker welfare.

Taken together, the background information results highlight a workforce dominated by moderately experienced supervisors, projects concentrated in medium- to high-value ranges, and durations that favour mechanization deployment. These findings are consistent with regional studies in Nigeria (Idoro, 2011) and Ghana (Bamfo-Agyei, Thwala and Aigbavboa, 2022a), which emphasize that mechanization adoption is shaped by project scale, value, and duration. However, the Kenyan context reveals unique challenges: limited long-term retention of experienced supervisors, inequitable distribution of mechanization across project sizes, and welfare concerns in longer projects.

Effect of Mechanization on the Quality of Work Life of Construction Workers

The analysis of the effect of mechanization on the Quality of Work Life (QWL) for construction workers in Kenya's construction industry posted mixed results. The correlation analysis in Table 4.29 showed both positive and negative effects. While the working conditions of construction workers were positively affected, their remuneration, health, and safety conditions were negatively affected. This consequently led to the overall effect of mechanization on QWL (Table 4.30) being negative, though the relationship was very weak, tending towards negligible. Regression results (Table 4.33) showed that the QWL of construction workers was only affected by variation in the mechanization of SPE and SF works, even though one of these relationships was found to be negative.

While there is agreement between the current and previous research on the effects of mechanization on various aspects of QWL, there exists some contrast. For example, the current study established that mechanization positively affects the quality of working conditions (WC) of construction workers in Kenya, Sharmila et al. (2018) notes that the introduction of machinery to construction projects has led to a surge in noise and air pollution. However, it could be argued that this is an aspect of health and safety that was established by this study to be negatively affected. The findings of this study agree with those of Kapliński et al. (2002) Who assert that mechanization and automation significantly improve the working conditions of the builders.

Just as found in this study, previous research indicates a negative influence on health and safety by mechanization. For example, Idoro (2011) notes that mechanization is associated with hazards because the use of construction plant and equipment is prone to accidents and injuries. The author reports that increased mechanization in excavation and concreting works leads to increased numbers and severity of injuries, which adversely affect health and safety in construction sites. However, there have also been contrasting findings indicating that increased mechanization leads to reduced accidents and injuries on construction sites. (Sharmila, Devadoss and Mathew, 2018). Kapliński et al. (2002) Also point out that mechanization and automation significantly improve the safety of construction workers.

Implications, Conclusions and Recommendations

Implications

Policy

- Labour Standards: Regulators should establish QWL benchmarks that balance efficiency with worker welfare.
- Training Mandates: The National Construction Authority should require certification for machine operators to align mechanization with human capital development.
- Safety Regulations**:** Policies must strengthen occupational health and safety frameworks to mitigate mechanization-related risks.

Practice

- Balanced Mechanization: Firms should selectively mechanize tasks, prioritizing worker safety and welfare alongside efficiency.
- Participatory Management: Workers should be involved in mechanization decisions to reduce alienation and resistance.
- Compensation Reform: Mechanization gains should be shared with workers through fair wages and benefits.

Methodological

- Mixed Methods: Future studies should integrate qualitative interviews to capture worker perceptions of mechanization.
- Longitudinal Analysis: Tracking QWL over time would reveal the mechanization's evolving impact.
- Comparative Studies: Cross-country analyses could contextualize Kenya's experience within broader global trends.

Conclusion

Mechanization in Kenya's construction industry exerts a complex influence on the QWL of workers. While it improves working conditions by reducing physical strain, it negatively affects compensation and health/safety, leading to an overall weak negative correlation with QWL. Regression analysis shows that mechanization in scaffolding enhances QWL, whereas mechanization in site preparation reduces it. These findings highlight the duality of mechanization: a driver of efficiency and modernization, but also a source of worker vulnerability.

Recommendations

The study makes the following recommendations;

- Policy reform: Establish QWL indices as part of project approval processes to ensure mechanization does not erode worker welfare.
- Training and certification: Mandate structured training programs for machine operators to align mechanization with human capital development.
- Safety protocols: Strengthen site safety standards and monitoring to mitigate mechanization-related hazards.
- Equitable compensation: Develop frameworks for sharing mechanization gains with workers through fair wages and benefits.
- Sociotechnical integration: Promote holistic approaches that align human skills with technological systems, ensuring mechanization complements rather than replaces labour.
- Future research: Expand studies to include qualitative insights and comparative analyses across different regions and project types.

References

Adebowale, O., & Agumba, J. (2023). Labour productivity in construction SMEs: Perspectives from South Africa. *Acta Structilia, 30*(1), 62–89. https://doi.org/10.38140/as.v30i1.7211

Adebowale, O. J., & Agumba, J. N. (2023). A scientometric analysis and review of construction labour productivity research. *International Journal of Productivity and Performance Management, 72*(7), 1903–1923. https://doi.org/10.1108/IJPPM-09-2021-0505

Ahrens, R. D. B., Lirani, L. D. S., & de Francisco, A. C. (2020). Construct validity and reliability of the work environment assessment instrument WE-10. *International Journal of Environmental Research and Public Health, 17*(20), 1–19. https://doi.org/10.3390/ijerph17207364

Bamfo-Agyei, E., Thwala, D. W., & Aigbavboa, C. (2022a). Performance improvement of construction workers to achieve better productivity for labour-intensive works. *Buildings, 12*(10), 1–18. https://doi.org/10.3390/buildings12101593

Bamfo-Agyei, E., Thwala, D. W., & Aigbavboa, C. (2022b). The effect of management control on labour productivity of labour-intensive works in Ghana. *Acta Structilia, 29*(1). https://doi.org/10.18820/24150487/as29i1.1

Bartlett, J. E., Kotrlik, J. W., & Higgins, C. C. (2001). Organizational research: Determining appropriate sample size in survey research. *Information Technology, Learning, and Performance Journal, 19*(1), 43–50.

Becker, G. S. (1993). *Human capital: A theoretical and empirical analysis, with special reference to education* (3rd ed.). Edited by C. U. of C. Press. https://doi.org/http://dx.doi.org/10.7208/chicago/9780226041223.001.0001

Brosnan, L. (2023). *Heavy equipment site preparation for construction.*

Calvetti, D., et al. (2020). Worker 4.0: The future of sensored construction sites. *Buildings, 10*(10), 1–22. https://doi.org/10.3390/BUILDINGS10100169

Calvetti, D., et al. (2021). Mechanization of construction tasks: Level assessment and craft workforce awareness. In *Proceedings of the European Conference on Computing in Construction* (pp. 342–349). https://doi.org/10.35490/EC3.2021.172

Camarini, G., et al. (2020). Quality of work life: A study on civil construction workers. *International Journal of Social Science Studies, 8*(4), 66–81. https://doi.org/10.11114/ijsss.v8i4.4820

Cochran, W. G. (1977). *Sampling techniques* (3rd ed.). John Wiley & Sons. New York.

Easton, S. A., & Van Laar, D. L. (2018). *User manual for the Work-Related Quality of Life (WRQoL) scale: A measure of quality of working life* (2nd ed.). University of Portsmouth All. https://doi.org/10.17029/EASTON2018

Elizur, D., & Shye, S. (1990). Quality of work life and its relation to quality of life. *Applied Psychology: An International Review, 39*(3), 275–291. https://doi.org/10.1111/j.1464-0597.1990.tb01054.x

Faatih Suwandi, G., & Tentama, F. (2020). The quality of work life scale: A psychometric study and its application for the employee. *International Journal of Sciences: Basic and Applied Research (IJSBAR), 50*(1), 68–81. http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

Ganapathi, R. (2016). A study on quality of work life of workers in construction industry in Madurai district. *Journal of Management Research and Analysis, 3*(2), 63–66. https://doi.org/10.5958/2394-2770.2016.00010.7

Grover, P., & Solanki, S. K. (2023). Effects of mechanization on resource productivity. *Journal of Engineering Analysis and Design, 5*(1), 1–17.

Hasan, A., et al. (2018). Factors affecting construction productivity: A 30-year systematic review. *Engineering, Construction and Architectural Management, 25*(1), 916–937.

Hsu, M.-Y. (2016). A quality of working life survey instrument for hospital nurses. *Journal of Nursing Research, 24*(1), 87–99. https://doi.org/10.1097/JNR.0000000000000098

Hwang, B. G., et al. (2020). Mechanization in building construction projects: Assessment and views from the practitioners. *Production Planning & Control, 31*(8), 613–628. https://doi.org/10.1080/09537287.2019.1667547

Idoro, G. I. (2011). Effect of mechanisation on occupational health and safety performance in the Nigerian construction industry. *Journal of Construction in Developing Countries, 16*(2), 27–45.

Iheama, N. B., Alinta-Abel, U., & Ezeokoli, O. (2017). Evaluation of mechanization in building production as a way of cost reduction: A study of some construction sites in Enugu South Local Government Area. *British Journal of Environmental Sciences, 5*(2), 14–30.

Jang, H., et al. (2016). Labour productivity model for reinforced concrete construction projects. *Construction Innovation, 11*(1), 92–113. http://www.emeraldinsight.com/doi/abs/

Janmohammadi, B., et al. (2015). Study of the dimensions of quality of work life and organizational productivity of the staff of Tax Organization of Alborz Province. *Indian Journal of Fundamental and Applied Life Sciences, 5*(1), 297–308.

Jayaraman, S., et al. (2023). Quality of work life as a precursor to work–life balance: Collegiality and job security as moderators and job satisfaction as a mediator. *Sustainability, 15*(13), 9936. http://www.ncbi.nlm.nih.gov/pubmed/25926610%5Cnhttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC4492060%0Ahttp://www.sciencedirect.com/science/article/pii/S0160738315000444

Jerome, S. (2013). A study on quality of work life of employees at Jeppiaar Cement Private Ltd: Perambalur. *International Journal of Advance Research in Computer Science and Management Studies, 1*(4), 49–57. https://doi.org/10.52783/tjjpt.v44.i4.1966

Kamaruddin, S. S., et al. (2018). The mechanisation and automation of the IBS construction approach in Malaysia. *Asian Journal of Environment-Behaviour Studies, 3*(10), 167–177. https://doi.org/10.21834/aje-bs.v3i10.324

Kamaruddin, S. S., Mohammad, M. F., & Mahbub, R. (2016). Barriers and impact of mechanisation and automation in construction to achieve better quality products. *Procedia - Social and Behavioral Sciences, 222*(1), 111–120. https://doi.org/10.1016/j.sbspro.2016.05.197

Kapliński, O., et al. (2002). Current state and perspectives of research on construction management and mechanisation in Poland. *Journal of Civil Engineering and Management, 8*(4), 221–230. https://doi.org/10.1080/13923730.2002.10531282

Karras, D. J. (1997). Statistical methodology: II. Reliability and validity assessment in study design, Part A. *Academic Emergency Medicine, 4*(1), 64–71. https://doi.org/10.1111/j.1553-2712.1997.tb03646.x

Koonmee, K., et al. (2010). Ethics institutionalization, quality of work life, and employee job-related outcomes: A survey of human resource managers in Thailand. *Journal of Business Research, 63*(1), 20–26. https://doi.org/10.1016/j.jbusres.2009.01.006

Kulakov, K., Orlov, A., & Kankhva, V. (2023). Evaluation of lean manufacturing tools and digital technologies effectiveness for increasing labour productivity in construction. *Systems, 11*(20), 570. https://doi.org/10.3390/systems11120570

Liu, Q., Zhong, Z., & Li, Y. (2025). Research on construction workers' job well-being and unsafe state: From the perspective of Maslow's hierarchy of needs. *Medicine, 104*(31), e43605. https://doi.org/10.1097/MD.0000000000043605

Mahbub, R. (2008). *An investigation into the barriers to the implementation of automation and robotics technologies in the construction industry* (Unpublished doctoral dissertation). Queensland University of Technology.

Martel, J.-P., & Dupuis, G. (2006). Quality of work life: Theoretical and methodological problems, and presentation of a new model and measuring instrument. *Social Indicators Research, 77*(2), 333–368. https://doi.org/10.1007/s11205-004-5368-4

Marx, K. (1990). *Capital: A critique of political economy*. Penguin Classics. (Original work published 1867)

Murianka, S. ole, Njuguna, M., & Wachira-Towey, N. (2025). Enhancing construction project labor productivity in Kenya. *Journal of the Kenya National Commission for UNESCO, 5*(1), 1–17. https://doi.org/10.62049/jkncu.v5i1.219

Muro, M., et al. (2019). *Automation and artificial intelligence: How machines are affecting people and places*. https://www.brookings.edu/wp-content/uploads/2019/01/2019.01_BrookingsMetro_Automation-AI_Report_Muro-Maxim-Whiton-FINAL-version.pdf

Royuela, V., López-Tamayo, J., & Suriñach, J. (2008). The institutional vs. the academic definition of the quality of work life. What is the focus of the European Commission? *Social Indicators Research, 86*(3), 401–415. https://doi.org/10.1007/s11205-007-9175-6

Ruttan, V. W., & Hayami, Y. (1984). Toward a theory of induced institutional innovation. *The Journal of Development Studies, 20*(4), 203–223. https://doi.org/10.1080/00220388408421914

Samuel, J., et al. (2022). Factors influencing quality of work life: An analysis on registered construction workers in Tirunelveli District of India. *Seybold, 17*(10), 666–674. https://doi.org/10.5281/zenodo.7220713

Sekaran, U. (2003). *Research methods for business: A skill-building approach* (2nd ed.). John Wiley & Sons, Inc. New York.

Shanmugam, B., & Ganapathi, R. (2017). A study on quality of work life and job performance of construction workers in Chennai. *International Journal of Scientific Research and Modern Education, 2*(1), 68–72. https://doi.org/10.18843/ijms/v6si5/04

Sharma, H., Ghuman, K., & Kumar Sharma, D. (1970). Quality of work life & its key dimensions: A cross-sectional analysis of private, public sector and foreign banks in India. *Amity Journal of Management, 4*(1).

Sharmila, S., Devadoss, R. S., & Mathew, F. (2018). Impact of mechanisation in construction projects in India. *International Journal of Civil Engineering and Technology, 9*(13), 1998–2008.

Sinval, J., et al. (2020). The quality of work life scale: Validity evidence from Brazil and Portugal. *Applied Research in Quality of Life, 15*(5), 1323–1351. https://doi.org/10.1007/s11482-019-09730-3

Sirgy, M. J. (2001). *Handbook of quality-of-life research: An ethical marketing perspective*. Springer Netherlands. https://doi.org/10.1007/978-94-015-9837-8

Soundarya, P. M. G., & Anandh, K. S. (2024). Exploring the determinants of quality of work life in the construction industry: A quantitative approach. *Buildings, 14*(6). https://doi.org/10.3390/buildings14061607

Swathi, R. (2017). A study on dimensions of quality of work life of employees. *International Journal and Magazine of Engineering, Technology, Management and Research, 4*(9), 187–196.

Tolfo, S. R., & Piccinini, V. C. (2011). Quality of work life in the best companies to work for in Brazil: Mismatches between theory and practice. In A. S. Sant'Anna & Z. M. Kilimnik (Eds.), *Quality of work life: Approaches and fundamentals* (pp. 85–112). Elsevier.

Trist, E. L., & Bamforth, K. W. (1951). Some social and psychological consequences of the longwall method of coal-getting: An examination of the psychological situation and defences of a work group in relation to the social structure and technological content of the work system. *Human Relations, 4*(1), 3–38. https://doi.org/10.1177/001872675100400101

Vadukkumchery, A. S., & Myneni, K. K. (2023). Assessment of impact of mechanization in construction projects in India. *Indian Journal of Science and Technology, 16*(10), 727–743. https://doi.org/10.17485/ijst/v16i10.1467

Vetrimani, M., & Maheswari, K. K. (2014). A study on quality of work life among the employees of cement industry. *Journal of International Academic Research for Multidisciplinary, 4*(12), 184–186.

Vishwakarma, K., Sushil, & Solanki, K. (2022). Mechanization and automation in construction. *International Journal of Advances in Engineering and Management (IJAEM), 4*(5), 2395–5252. https://doi.org/10.35629/5252-04053856

Wachira, I. N. (1999). Labour productivity in the Kenyan construction industry. In P. Bowen & R. Hindle (Eds.), *CIB W55 & W65 Joint Triennial Symposium* (pp. 1–9). http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:LABOUR+PRODUCTIVITY+IN+THE+KENYAN+CONSTRUCTION+INDUSTRY#1

Walton, R. E. (1973). Quality of working life: What is it? *Sloan Management Review, 15*(1), 11–21.

Willis, R. (1875). *Principles of mechanism: Designed for the use of students in the universities and for engineering students generally*. Wiley.

Workplace Health and Safety Queensland. (2023). *Working at heights remains a leading cause of work fatalities*. WorkSafe. Available at: d-events/newsletters/esafe-newsletters/esafe-editions/esafe-construction/march

Yadav, R., Khanna, A., & Panday, P. (2019). Dimensions of quality of work life affecting commitment and performance: A theoretical framework. *Pacific Business Review International, 12*(1), 125–137.

Zhu, R., et al. (2024). Measuring safety performance of construction employees using data envelopment analysis: A case in Australia. *Journal of Safety Research, 88*, 293–302. https://doi.org/10.1016/j.jsr.2023.11.016

Zin, R. M. (2004). Perception of professional engineers toward quality of work life and organizational commitment. *Gadjah Mada International Journal of Business, 6*(3), 323–334. https://journal.ugm.ac.id/gamaijb/article/view/5553/4524