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ENHANCING CONSTRUCTION SITE UTILIZATION EFFICIENCY: AN EVALUATION OF IMPLEMENTATION IN ADDIS ABABA BUILDING PROJECTS

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DECLARATION

I hereby confirm that this master thesis entitled ***Enhancing Construction Site Utilization Efficiency: An Evaluation of Implementation in Addis Ababa Building Projects*** is my own work. That is, it has not been submitted for any degree, diploma, or certificate at any other university. All material sources used for this thesis have been duly acknowledged by citation.

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ADVISOR'S RECOMMENDATION

I hereby certify that I have read the revised version of the thesis entitled "**Enhancing Construction Site Utilization Efficiency: An Evaluation of Implementation in Addis Ababa Building Projects**" prepared under my guidance by Genet Shewangizaw submitted in partial fulfillment of the requirements for the degree of Master of Science in Construction Management. Therefore, I recommend the submission of a revised version of the thesis to the department following the applicable procedures.

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ABSTRACT

Construction site utilization planning (SUP) is a critical factor influencing project efficiency, safety, and cost-effectiveness in building construction. However, in Ethiopia, particularly within the rapidly urbanizing environment of Addis Ababa, the effective implementation of SUP remains inconsistent and underexplored. This study evaluates current practices, constraints, and key performance indicators (KPIs) affecting SUP implementation in building projects in Addis Ababa. To achieve this, the study employs a mixed-method research design that combines descriptive and exploratory approaches, supported by both primary and secondary data. Following a pilot assessment, 36 relevant variables were identified, including 22 constraint indicators grouped into five categories: organizational challenges, technical indicators, resource constraints, temporary facility characteristics, and knowledge and understanding constraints. Additionally, 14 KPIs were categorized under safety and risk mitigation, material management, and site utilization facility indicators. Data were collected using standardized AHP-based expert questionnaires and Likert scale surveys administered to professionals from client organizations, consultants, and contractors. The Analytic Hierarchy Process (AHP) and descriptive statistics (SPSS) were employed for data analysis. Findings reveal that resource constraints are the most significant barrier to SUP implementation, followed by technical operational issues, organizational challenges, and temporary facility characteristics. Among KPIs, safety and risk mitigation emerged as the most influential success factor, ahead of indicators for site utilization facility and material management indicators. The study concludes with evidence-based recommendations for stakeholders to enhance SUP adoption, optimize spatial logistics, and improve project outcomes within Addis Ababa's constrained urban construction context.

Keywords*: Constrain, Key performance indicator, Planning, Site Utilization*

Table of Contents

LIST OF TABLE

LIST OF FIGUR

ABBREVIATIONS & ACRONYMS

2D	Two Dimensions
3D	Three Dimensions
AHP	Analytic Hierarchy Process
BIM	Building Information Modelling
CI	Consistency Index (AHP)
CPM	Critical Path Method
CR	Consistency Ratio (AHP)
CSUP	Construction Site Utilization Plan
GDP	Gross Domestic Product
GIS	Geographic Information System
KPIs	Key Performance Indicators
MCDM	Multi-Criteria Decision Making
NBCR	Non-Building Coverage Ratio
PPE	Personal Protective Equipment

RI	Random Index
SPSS	Statistical Package for the Social Sciences
SUP	Site Utilization Plan
TF	Temporary Facility
TFs	Temporary Facilities
UAV	Unmanned Aerial Vehicle
VR	Virtual Reality

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The construction industry plays a central role in national development, serving as a key driver of economic growth, job creation, and technological advancement. As highlighted by Pheng and Hou (2019), construction activity stimulates the broader economy through its extensive linkages with manufacturing, services, and finance, making it one of the most influential sectors in both developing and developed countries. The construction industry plays a significant role in Ethiopia's economic, political, and social development. It contributes 5.6% of the national GDP, a figure close to the sub-Saharan African average of 6% (Zewdu, 2015).

The construction industry operates within a highly complex and dynamic environment shaped by constantly changing technologies, stakeholder demands, regulatory conditions, and project uncertainties. As Son (2022) emphasizes, construction project organizations function as complex adaptive systems where interactions among teams, resources, and external conditions create unpredictable challenges throughout a project's lifecycle.

Site utilization, often realized in a formal construction site utilization planning (CSUP), is increasingly recognized as a fundamental concept to construction industry performance globally because properly designing the placement of temporary facilities, material storage, access paths, and work zones helps reduce waste, improve safety, lower costs, and boost productivity. As Whitman et al. (2021) notes CSUP influences safety, scheduling, budget, and overall project efficiency. Best practices include early stakeholder involvement, space flexibility, and clear mapping of temporary facilities.

In Addis Ababa Ethiopia's capital and largest city, the challenges of high population density, limited land availability, and the need to integrate new developments into an already constrained urban infrastructure create complex spatial and managerial difficulties (Koroso, et al., 2021). Despite legal ambiguity, Addis Ababa's real estate market is becoming a major engine of the economic growth of the city and the building sector is essential to this growth (Goodfellow, 2017).

Space optimization in inner-city urban areas entails the planned, orderly allocation and adaptive use of the available construction space at the construction site. The practice is supposed to facilitate all construction processes, such as material staging, equipment access, worker amenities, and the effective flow of workflow, while ensuring safety and reducing delays (Zouein, 2001).

It involves a change from traditional uniform site planning strategies to flexible, technologically enabled approaches including phased material delivery systems, lean construction concepts, and Building Information Modeling (BIM).Work areas, facility locations, and material flow are a couple of project-specific elements that should be considered when developing site utilization. These components differ based on the project (Zolfagharian, 2014).

The persistent demand for urban infrastructure and housing underscores the necessity for efficient space management in the city's construction projects. These factors position Addis Ababa as a relevant case study for exploring the broader implications of site utilization planning in rapidly urbanizing environments(Tanku, 2024).

Inefficient site arrangements result in increased travel distance, material handling delays, and interference between work areas. Lack of planning leads to underutilization of resources, cost escalation, and reduced productivity; thus, early planning involves all stakeholders to resolve these issues. Proper site planning and logistics are required to reduce waste, enhance safety, and improve efficiency(Dixit, 2022).

Even if growing awareness of the importance of space utilization the consistent implementation of site layout planning remains limited in Ethiopia. The adoption of new technologies or systems always requires the identification of potential barriers and key effective implementation strategies in order to ensure successful diffusion and implementation of the technologies(BELLETE, 2020).Ad hoc and unstandardized practices prevail due to weak institutional frameworks and low industry capacity

This study examines the implementation(Patel, 2011) of site utilization practices in selected building projects within Addis Ababa, identifying critical factors affecting space efficiency, assessing the level of optimization efforts, and suggesting strategies for optimizing spatial performance on construction sites depending on circumstances to inform solutions that can improve project outcomes under dense urban conditions in Addis Ababa.

1.2 Problem statement

The construction industry is among the most resource-intensive and complex sectors, with productivity delays, poor material flow, and occupational health and safety risks. One of the key drivers of construction project failure is site utilization planning, the strategic location of materials, plants, and temporary facilities on-site (Dixit, 2022).

As Patel (2011) Site Utilization Plan (SUP) is presented as a critical, dynamic management tool for the optimal organization and allocation of all physical resources and facilities within the construction site boundary. It is the cornerstone of effective materials management, directly impacting project efficiency, cost, safety, and timely completion.

Effective construction site layout planning is essential for improving safety, minimizing material handling, and ensuring smooth workflow across different project stages (Ganiyu, 2021). However, inadequate construction site layout planning causes extra cost and project delays, while proper planning results in enhanced productivity. Shorter travel distances, and better on-site working conditions(Hansen, 2021).However, this has not been the case across many African countries, where the practice remains underutilized and insufficiently studied (Tsegay, 2023).

Most construction projects in Addis Ababa, Ethiopia, are in areas of high density with smaller, more constrained site areas. These take place under logistical and spatial limitations that affect the way projects are carried out(Sokido, 2016).Despite the rapid growth of the construction sector in the city, site layout planning has remained inconsistent and underdeveloped.

Inefficient use of site space results in delays, material wastage, and operational inefficiencies that reduce overall productivity and compromise safety standards. To achieve more effective project performance, space management techniques must be advanced in Addis Ababa due to the city's growing urbanization, lack of available land, and complicated construction.

Therefore, this study aims to assess current site utilization practices, identify significant constraints and key performance indicators influencing site layout planning in Addis Ababa building projects, and evaluate stakeholder perceptions of how site utilization planning impacts project efficiency and cost outcomes. The study intends to contribute to the creation of a better, regulation-based site utilization system that encourages productivity, safety, and efficiency on Ethiopian urban construction projects.

1.3 Objective of the research

1.3.1 General Objective

To evaluate the implementation of construction site utilization by assessing current practices, identified key performance indicators, and constraints to enhancing efficiency in Addis Ababa building projects.

1.3.2 Specific Objective

The specific objectives of the research include:

1. Assess the current site utilization practices in Addis Ababa building construction projects
2. Identified and prioritized the key performance indicators and constraints to the effective implementation of construction site utilization planning practice in the case of Addis Ababa City building projects
3. stakeholder perceptions of how site utilization planning impacts project efficiency and cost outcomes in Addis Ababa building projects

1.4 Research Questions

1. What are the current site utilization practices applied in Addis Ababa?
2. What are the key performance indicators (KPIs) and constraints for effective implementation of construction site utilization planning practices in Addis Ababa City building projects?
3. How do stakeholders perceive the impact of site utilization planning on efficiency and cost projects?

1.5 Significance of the Study

The study investigates current site utilization practices, identifies key factors, and prioritizes the most critical constraints and Key Performance Indicators (KPIs) affecting site utilization planning (SUP) in construction projects in Addis Ababa city. This research is significant for stakeholders in the construction industry, as it offers practical, data-driven suggestions to enhance efficiency, reduce costs, improve on-site safety, and optimize the use of limited urban space. Contractors can evaluate the performance of their construction operations. Consultants can apply the findings to supervise and evaluate construction activities.

Additionally, authorities utilize these recommendations to authorize permits, monitor, and track building projects in relation to the execution of construction site utilization planning. This study contributes knowledge to existing literature by advancing the perspective of construction site utilization planning and serves as a reference for future research.

1.6 Scope and Limitation of the Study

Due to complex spatial constraints and the increasing demand for efficient urban development, as well as the high volume of materials, labor, and equipment required, this study focuses on mid-rise, high-rise building, commercial, and residential projects.

The research is geographically limited to selected construction project sites representing urban growth in Addis Ababa. The study examines the strategies, planning, and practices employed for site utilization design, material storage, equipment placement, and labor movement. Mixed-methods case study approach was used, incorporating site observations, expert interviews, and project documentation analysis.

1.7 Organization of the Research

The research work is organized into five chapters, the contents of which are briefly described below: Chapter 1 serves as an introduction, providing background information and outlining the research problem, the significance of the study, as well as its objectives and limitations.

Chapter 2 presents a literature review drawn from professional journals, books, internet sources, publications, previous research studies, and contract documents. This chapter offers a comprehensive background on construction site utilization planning in Addis Ababa, Ethiopia.

Chapter 3 discusses the research methodology followed to achieve the objectives of the study.

Chapter 4 presents the findings from case studies of projects selected for this research, accompanied by relevant discussions referencing the literature reviewed in Chapter 2.

Chapter 5 concludes by summarizing the findings of the case studies and offers recommendations along with suggestions for further research areas.

CHAPTER TWO

LITERATURE REVIEW

2.1 Nature of Construction Industry

The construction industry is considered complex because of its unique characteristics and project consisting of numerous connected tasks and activities. The size of the project, the number of stakeholders and approaches involved, and the methods utilized are the main project aspects that influence construction (Alghamdi, 2022).The degree of complexity of a construction project determines the overall approach to intended for continuous work, are large enough for an employee to enter, and have restricted means of entry or leave. These places can have environmental and physical risks, which can be avoided if addressed before using the area for work (Chochoms, 2016).

The construction industry is characterized by cycles of growth and depression, and the outcome of companies that make construction materials is closely tied to the amount of new construction taking place (Walker, 2015). The industry includes many stakeholders with different interests such as clients, designers, contractors, subcontractors, suppliers, and regulators. According to Ofori (2015), the construction industry produces various products, including houses, apartments, factories, offices, schools, roads, and bridges. Its activities involve new constructions and additions, alterations, and repairs of existing structures.

General contractors, specializing in either residential or commercial buildings, take full responsibility for a construction job, except for specified portions that may be excluded. Acceptable levels of risk and return are crucial for contractors to maintain the long-term health of the industry (Zavadskas, 2010).

2.2 Ethiopia construction Industry

The Ethiopian construction industry has experienced significant growth in recent decades, driven by extensive public investment and rapid urbanization, yet it continues to grapple with systemic challenges that constrain its performance and development (Ayalew T. D., 2016).Numerous obstacles hinder the expansion and development of the Ethiopian construction industry. Among these challenges, inadequate data management is frequently identified as a primary issue in studies by(Said, 2013).

Insufficient management practices, project managers' inexperience and absence of expertise, a low degree of adoption of appropriate construction management techniques, a lack of teamwork, and inadequate sharing of information are the causes of poor information management in Ethiopia's construction industry(Belay, 2021).

For the industry to enhance its information management and general performance, these factors must be addressed. Effective process coordination and awareness-raising, supporting technology and innovation in the procurement process, and taking these factors into account when registering

Building projects are a few recommended improvements (Mengistu, 2020).

2.3 Effective Site Layout Planning Practice

Besides ensuring that the job is carried out safely and effectively, a properly designed site layout can cut down on waiting, traffic, and travel time and boost worker morale and workplace efficiency (Sanad, 2008).

Planning for site usage is one of the main responsibilities of site management. Large projects involving a high number of personnel, subcontractors, and equipment could experience significant time loss and cost overruns if site planning is not done effectively and methodically (Andayesh, 2013). Better use of resources and space can be achieved by using optimization techniques for construction site utilization planning. These algorithms can help with the methodical arrangement of facilities to reduce waiting times, traffic, and travel times, increasing overall efficiency.

As Ismail (2025) mentioned, site-layout planning should explicitly consider all required amenities, from storage yards, welfare and sanitation facilities, washing areas, offices, and fabrication zones to emergency and access routes, and treat “site space” as a vital resource, akin to labor or materials. Moreover, by organizing facilities to allow logical flows of personnel, materials, and operations, a well-planned layout supports a safer work environment reducing hazards associated with congested or poorly organized sites which enhances worker safety, morale, and motivation, positively affecting worker performance and retention.

2.3.1 Elements and Term of Site Utilization Planning

The definitions that follow and a discussion of the concept from several perspectives are used to help understand the term as it relates to site utilization planning.

Construction Project Management: According to Walker (2015) defined arranging, coordinating, and controlling of a project from start to completion (including installation) on behalf of a client is known as construction project management. This involves determining the client's goals regarding utility function, quality, time, and cost; establishing relationships between resources; integrating, monitoring, and controlling the project's contributors and their output; conducting evaluations and choosing alternatives in order to ensure the client is satisfied with the project's outcome.

Construction Site Utilization Plans (CSUP): is defined as a dynamic, graphical, and strategic management document that details the optimized spatial arrangement and temporal scheduling of all temporary facilities, resources, materials, equipment, personnel pathways, and utilities within the boundaries of a construction site throughout the project lifecycle. Its primary purpose is to maximize operational efficiency, safety, and productivity while minimizing costs, travel distances, material handling, and spatial conflicts(Whitman, et al., 2021).

Temporary Facilities (TFs): refer to non-permanent, movable structures, equipment, and designated areas installed on a construction site to support the execution of the project. They are essential for operational, logistical, and human resource needs during construction but are removed once the project is completed (Kim, 2021).

Material management :can be defined as a procedure that coordinates planning, requirement assessment, purchasing, sourcing, transportation, storage, and material management, reducing waste and optimizing profitability by lowering material costs (Patel, 2011).In the context of construction projects, this process encompassing the organization, acquisition, storage, and overall management of materials ensures that the right materials are available at the right time, in the right quantity, and at the right cost.

2.3.2 Construction Site Management

According to Elbeltagi (2004), among the most significant sectors of the majority of countries' economies, the building industry, has had difficulties primarily due to managerial issues rather than innovations in technology. In the construction process, site-based management can significantly reduce costs and save time without requiring a lot of extra work.. Instead of focusing just on cost and distance, safety and accessibility should be given more thought when building a location along with a path for transportation(Andayesh, 2013).

Construction firms face all sorts of problems, to actually finish on time and meet the cost requirements. From lack of manpower, or qualified manpower, from low productivity to poor subcontractor's performance, from poor machinery utilization to equipment breakdown, from site organization issues to delays caused by transportation and logistics(Oseghale, 2021).

The construction project involves many stakeholders that related to the rapid development of the country's economic. There are many issues that need to be dealt with in the management of the construction site, such as the environment and management personnel, affecting the safe operation of the entire project (Wei, 2018).The site based management can make significant improvements in the cost and time savings during the construction process without involving a mass of additional work. The role of site managers is to control and maintain work performance and then taking actions to rectify situations where performance is unsatisfactory.

Among the important tasks of site management is the site utilization planning. Extensive time loss and cost overruns could result in large projects, where the number of manpower, subcontractors, and equipment involved are high, if there is no effective and systematic approach to site planning, A detailed planning of the site utilization and location of temporary facilities can enable the management to make considerable improvement by minimizing travel time, waiting time, and increasing workers morale by showing better and safer work environment(Jin, 2018).

The assessment on the extent of deviation from plan or predetermined requirements on these issues also reinforce this result. The amount of schedule slippage ranges between 61-80% and that of planed costs and other variables such as risk, quality, resources utilization and safety deviates in the range of 21-40% from predetermined requirements, planned or anticipated at the beginning (Ayalew, 2016).Site Management is the art of managing and arranging both material and personnel resources during the course of a project in order to fulfil project objectives within established constraints. The culture of Project management in the construction industry is different than in the other sectors(Yimam, 2011).

The process of identifying the required types of temporary facilities which used supports the construction works, determining their size and design, and also arranging them with in the available space on the construction site is known as site utilization planning. Thus, site utilization deals with the relative placements of the facility to be built, office space, plant, storage facilities, and other amenities.

Site organization refers to the organizational structure that guides site management and also referred as the processes of planning and controlling construction operations. The construction manager is usually responsible for the layout and management with in the site(Buniya, 2021).

The number, type, and size of temporary facilities depend upon the project type, scale, design philosophy, and construction execution strategy. Basically, CSUP is a trade-off problem in which decisions must be made based on project attributes without sacrificing site plan quality (Ning, 2011).

Typically, a project manager is responsible for developing a site utilization plan based on past experience, knowledge, intuition, and imagination (Osman, 2003).In the absence of a well-developed site utilization plan, many problems can occur resulting in delays and cost overruns. Site utilization planning is impacted by various project management tasks such as scheduling, selection of construction methods, procurement, material management, manpower, and equipment planning (Elbeltagi, 2004).

Despite the importance of site utilization planning, it is often done in a speedy manner or sometimes overlooked completely (Mawdesley, 2002). The results of such acts reflect in the day-to-day operations of a project, making it difficult to manage site operations.

Construction site utilization planning has been recognized as a critical step in construction planning, the basic function of the process is to find the most suitable arrangement for the positioning of the temporary facilities. Temporary facilities have to be placed right from the beginning of the project construction to the completion (Kim, 2021).

Construction project site utilization involves the identification, sizing, and placing of the temporary facilities (TFs) at the required positions within the boundaries of the construction project site. These temporary facilities may range from simple lay-down areas to warehouses, fabrication shops, maintenance shops, batch plant, and residence facilities. Required temporary facilities and their areas are depending in many factors including project type, scale, design, location, and organization of construction work (Song, 2017).

2.3.3 Considerations for Site Utilization Planning

To achieve an effective and efficient site layout, certain success factors has to be considered in the planning and implementation of a site utilization plan. From the literature review some of the factors that should be considered are preparation of site utilization designs before the start of site work, provision of on-site offices for clients, contractors, and consultants, building a fence around the construction site, ensuring a good positioning system for temporary facilities, first aid centers for workers emergency responses, safety and safety equipment; information signs and signals, public convenience for on-site workers, fabrication and maintenance shop, fire prevention and suppression, security checkpoints (Abdelalim, 2024). Preconstruction construction stage site utilization layouts should be prepared and reviewed to ensure that handling zones, access routes, and material storage areas are appropriately accommodated, minimizing rework and delays. For work to proceed smoothly, the site must have adequate roads and parking spaces. If sufficient space is not available on-site, parking facilities should be designed and located in a practical nearby area. This will also save time when traveling to and from the construction site (Elbeltagi, 2004).

Site offices and welfare facilities on-site offices for the client, contractors, and consultants improve coordination, while fencing and security checkpoints protect stored materials from theft and vandalism. According to Sutt (2013), construction site fencing it can also be done to keep people safe while construction is going on. And classified in protective & guard fences, safety fencing and, signal fencing.

Optimized temporary facility placement: positioning batch plants, fabrication shops, and first-aid tents effectively minimizes travel distance and improves emergency response and operational efficiency these temporary facilities could take up a lot of workspace and interfere with on-going major building projects if they are not positioned correctly utilizing an efficient site utilization design (Hammad, 2016).

Safety infrastructure: installing first-aid centers, fire-prevention equipment, safety signs and signals, and ensuring personal protective equipment (PPE) oversight are essential measures that safeguard workers and materials(Choudhry, 2007).

Public convenience and compliance: providing clean sanitation, hydration stations, and controlled pedestrian access not only meets labor welfare standards but also contributes to better material flow and less site disruption. Cleaning program for the construction site that requires all waste materials, scraps, and rubbish to be routinely removed during the building or repair process. Regular cleaning is required of the road, stairs, corridors, and work space (Selki, 2019).

In Addis Ababa through the city's regulatory framework, most notably the Addis Ababa City Administration's Guidelines on the Distance of Buildings from Roads (Setback) and Related Building Permits (2017). These guidelines serve as the foundational legal instrument for spatial organization within a project's plot. By mandating specific distances from roads (setbacks), the regulations inherently define the available and restricted areas on a site, forcing a structured site classification into functional zones. The setback areas themselves often become designated zones for access roads, utility corridors, and pedestrian pathways, ensuring public safety and unimpeded movement **(Appendix: VI).**

2.3.4 Factors Affecting the Decision Making Process of Site Utilization

The decision-making process for site utilization is influenced by several factors, including space management, construction layout design, pathway arrangement, and overall space organization. Site utilization planning may also be affected by input from the owner and subcontractors, as well as clauses specified in the contract terms. Effective housekeeping rules should consistently be implemented to maintain roads and laydown areas(Zhong, 2022).Planning site utilization is a crucial aspect of any construction project, and it requires careful consideration of several factors to ensure success. Some of the key success factors to consider when planning a site layout (LaGro Jr, 2011).

Site conditions: Before planning a site layout, it is essential to conduct a thorough assessment of the site conditions. This includes identifying the site boundaries, topography, soil, drainage, utilities, access roads, and existing structures(Birewar, 2021).

Objectives and requirements: The first step in planning site utilization is to define the objectives and requirements of the project. This includes identifying the scope, schedule, budget, quality standards, and stakeholder expectations of the project(Mok, 2015).

Topography and terrain features: Topography plays an important role in the layout of a site and determining necessary site work, such as storm water collection plans, grading requirement, and retaining walls (Elbeltagi, 2004).

Landscaping: The type and size of landscape features should be included in a site plan to address how they accompany and supplement other development features(Nassauer, 2012).

Dimensions and orientation of all proposed improvements: This shows where the actual physical vertical construction will take place on a site and its orientation relative to the parcel (Jaafar, 2021).

Easements: A site plan should include all easements to ensure that the project adheres to all applicable ordinances and development standards.

Location and accessibility: The location of the site should be able to serve the purpose of its existence, and it should be accessible to the intended users (Handy, 2002).

Size and shape: The size of the site should be able to give room for future extension, and the shape should be even and devoid of any sharp corners (Elbeltagi, 2004).

Environmental and social impacts: A good site utilization should minimize the environmental and social impacts of the project and should comply with the relevant codes, standards, and best practices (Vanclay, 2002).

Safety and visibility: Site utilization should be designed to minimize hazards and risks. This includes ensuring good visibility and adequate safety measures to prevent accidents, injuries, delays, and costs.

2.3.5 Optimized Practices for Effective Construction Site Utilization Planning

Effective construction site utilization planning is a holistic, iterative, and technological process that employs analytical and digital tools to design and manage a construction site. This planning must proactively consider all temporary facilities by strategically determining their optimal location and installation timing relative to the construction phasing. This following sections outline industry best practices and the site utilization planning procedures in various studies by(Whitman, et al., 2021).

Table 1 Optimized Practices for Effective Construction Site Utilization Planning

1	Recognize physical, regulatory, and logistical constraints affecting site layout.
2	Determine the Necessity of a Site Utilization Plan
3	Collect all relevant site information, including topography, access points, utility locations, and existing structures.
4	Involve project managers, superintendents, subcontractors, and other stakeholders early in the planning process.
5	Create a detailed plan showing locations of temporary facilities, material storage, equipment, and access routes.
6	Clearly communicate the site utilization plan to all project participants.
7	Put the site utilization plan into action, ensuring all elements are positioned as designed.
8	Monitor compliance and enforce adherence to the established site layout.
9	Continuously observe site conditions and evaluate the effectiveness of the layout.
10	Update the site utilization plan in response to changes in project scope, schedule, or site conditions.
11	Maintain thorough records of planning decisions, changes, and as-built layouts.
12	Leverage tools such as Building Information Modelling (BIM) and other digital technologies to enhance planning and visualization.
13	Ensure all personnel are trained on the site utilization plan, its rationale, and any updates or changes

2.4 Key performance indicators and Constraints in Site Utilization Planning

Site Utilization planning is an essential part of construction management that illustrates the proposed locations and relationship of facilities with its surroundings in terms of communication, accesses, and existing facilities. Well-organized site plan can significantly impact the project's timeline, budget, and overall success by optimizing space utilization, enhancing safety, and streamlining project workflow (Sadeghpour, 2015).

2.4.1 Importance of Site utilization Planning

Site identification and utilization are crucial management tasks that affect all aspect of construction site operations, from development plans and setup to efficiency, security, and well-being. Site design plans are often self-assertive without a thorough evaluation of all the crucial elements. The lack of adequate offices and mechanisms for monitoring well-being is another shortcoming of the hierarchical system that many tasks are carried out inside. The majority of the time, site and task directors will focus on reflections(bin Mamat, 2014).

Despite the fact that many incidents may be avoided or lessened with careful layout planning and organization from the outset, site and project managers typically prioritize productivity optimization over the health and safety consequences(Sanad, 2008)emphasize that a safe working environment and increased productivity depend on careful site layout design, which includes determining the best locations for temporary and permanent facilities.

2.4.2 Key Factor for Site Utilization

The achievements of building projects are significantly affected by the Key Drivers factor, which is an essential part of Site Utilization Planning. Safety, productivity, and other key drivers of construction projects are significantly impacted by the design of both temporary and permanent buildings on a construction site cost. According to (Kannimuthu, 2025) well-organized site utilization can minimize safety risks and accidents, contributing to the overall success of the project

Initial Site Assessment, Zoning, and Optimal Space Utilization: Prior to starting construction, the site must be thoroughly evaluated. This entails assessing elements including terrain, soil quality, accessibility points, and environmental issues. The foundation of an effective Construction Site Layout Planning (CSLP) process is a comprehensive site analysis that informs the creation of functional zones(Elbeltagi, 2004).

Access, Circulation, and Material Management: A well-designed circulation plan ensures the smooth movement of workers, equipment, and materials. Properly placed access points, roads, and pathways facilitate efficient traffic flow. Efficiency in construction logistics is governed by the circulation plan for men, materials, personnel, machinery. A layout that strategically positions material storage areas adjacent to points-of-use and ensures unimpeded access points of use cut non-value-added handling time by up reduce 30%, directly impacting the project schedule and cost benefiting cost (Sacks, 2010).

Safety, Compliance, and Temporary Facilities: Efficient site utilization takes into account safety considerations, including emergency exits, evacuation routes, and the placement of safety equipment. Compliance with local regulations and industry standards is crucial for maintaining a secure work environment (Hughes, 2012).To ensure employees remain comfortable and productive, local facilities such as offices, break rooms, and restrooms are essential.

Collaboration, Communication, and Environmental Considerations: Effective site planning encourages improved stakeholder participation and communication. Establishing central points and employing digital communication platforms improve information sharing and accelerate prompt decision-making (Elbeltagi, 2004). It is important to include sustainable construction methods into the site plan. Increasing natural light, cutting down on water runoff, and maintaining green areas all contribute to building a more aesthetically beautiful and environmentally friendly assets (Kibert, 2016).

2.4.3 Critical Constraints factor

Site utilization planning is a complex process that involves the coordination and movement of large quantities of materials, high-value products, plant, and people. Constraints to effective site utilization planning may arise from inadequate initial site assessment and analysis, poor communication, regulatory compliance issues, resource constraints, and resistance to change.

According to Al Hawarneh (2021), the effective implementation of Site Utilization Planning (SUP) is often hindered by a range of interrelated constraints that compromise project efficiency and safety. A primary and prevalent challenge is space limitation, particularly in dense urban environments like Addis Ababa, which severely restricts the optimal allocation of temporary facilities, material storage, and equipment, leading to congestion from the project's outset(Hammad, 2016).

This spatial constraint exacerbates issues of material management and poor traffic flow, where inadequate planning for deliveries and internal circulation creates bottlenecks, increases non-value-added travel time for personnel and equipment, and drives up handling costs(Khodabandelu, 2021).

Furthermore, the dynamic nature of construction often leads to trade stacking the poor sequencing and overlap of multiple subcontractors in a confined area which is a direct result of insufficient coordination and a lack of communication among stakeholders, fostering conflict and inefficiency(El Asmar, 2013).

These logistical failures often lead to safety hazards, as congested and poorly organized places increase the risk of accidents and make it difficult to maintain a clear escape route (Sanad, 2008).Compounding these operational constraints are foundational planning failures, including inadequate site access points for deliveries and inefficient use of resources, both of which directly inflate costs and reduce productivity(Zolfagharian, 2014).

Finally, modern projects must also contend with environmental considerations, where failure to integrate safeguards for natural resources and comply with regulations can result in significant legal and reputational repercussions(Darko, 2017).Collectively, these constraints underscore the complexity of SUP and highlight the critical need for proactive, integrated, and communicative planning processes to mitigate their impact.

2.4.4 Problems Caused By Inadequate Site Utilization

Poor site utilization planning constitutes a significant risk factor in construction project management, directly precipitating a cascade of operational, financial, and safety failures. Inadequate or haphazard spatial organization of resources leads to pronounced inefficiencies, including the double-handling of materials and excessive travel distances for workers and equipment, which in turn inflate labor costs and project duration (Sadeghpour, 2015).

These logistical failures are often manifested in specific on-ground issues such as insufficient workspace, the misplacement of material stacks, and the incorrect location of key plant and equipment, disrupting the planned workflow. Furthermore, locating essential temporary facilities such as site offices, welfare units, or fabrication yards too far from the active workface exacerbates delays and reduces effective supervision(Aziz, 2013).Ultimately, these compounded inefficiencies create an environment where project quality is inevitably compromised, as logistical chaos and time pressure force trade-offs in workmanship.

As noted by Mote (2019), such conflicts and inefficiencies within the site structure collectively undermine productivity, inflate budgets, and delay timely completion, underscoring that effective spatial planning is not a peripheral activity but a core determinant of project success

2.5 Improving Effective Site Utilization Planning

Improving site utilization planning offers several benefits, including enhanced team collaboration, better space management, and improved safety. Research has identified best practices for site utilization planning, such as early involvement of stakeholders, consideration of inclement weather and safety regulations, and regular plan updates (Whitman, et al., 2021).

A well-designed site utilization plan can help overcome resistance to change and communicate the benefits of space optimization. It also provides a roadmap for development projects, incorporating landscaping, construction, utilities, and terrain features, and ensures compliance with local building and zoning codes. Overall, effective site utilization planning is crucial for maximizing the use of space, resources, and personnel, ultimately leading to more efficient and successful construction projects (Bascoul, 2020).

2.5.1 Assess Site utilization planning Constraints in Ethiopia construction

Site utilization constraints can significantly affect construction project performance in Ethiopia. Factors such as inadequate contractor experience, ineffective project planning and scheduling, poor site management and supervision, design issues, lack of incentives system, and poor health conditions of workers can lead to decreased productivity and efficiency(Abera, 2021).

The Ethiopian construction industry faces challenges that impede its development, including limited access to finance, inadequate infrastructure, and a shortage of skilled labor. Site constraints in Ethiopia construction may include limited access to utilities, poor road infrastructure, and a lack of available land for development (Mengistu, 2020).

To overcome these constraints, it is important to involve stakeholders early in the planning process, consider safety regulations and inclement weather, and regularly update site utilization plans. Best practices for site utilization planning include identifying project constraints, acquiring necessary data, developing a plan, communicating the plan to stakeholders, implementing and enforcing the plan, and monitoring and evaluating progress. A study conducted in Addis Ababa, the capital city of Ethiopia, found that the utilization of personal protective equipment among construction site workers was 38% available(Alemu, 2020).

The factors related to site utilization planning in the Ethiopian construction industry include project management maturity, technology and innovation development, construction schedule risk assessment, and the practice of construction planning. Effective project delivery in terms of schedule, budget, and quality remains an issue, according to a study(Hailemarkos, 2020)on the development of project management skill affected the Ethiopian construction industry which show the site utilization planning the responsibility.

Furthermore, the practice of construction planning in the Ethiopian building construction industry has been studied, emphasizing the need to improve construction planning strategies(Prajapati, 2016).Additionally, research has been conducted on construction schedule risk assessment and management strategy for foreign general contractors working in Ethiopia(Cheng, 2021).

The challenges and improvement mechanisms for technology and innovation development in the Ethiopian construction industry have been studied. Some of the major challenges identified include the nature of the industry and lack of awareness, weak capacity of companies and regulatory instruments, corrupt practices in the procurement process, economic and financial difficulties, and lack of coordination among stakeholders (Mengistu, 2024).

2.5.2 Potential site utilization planning improvement methods

Software can be used to improve site utilization planning in the construction industry. These software tools can help improve productivity and efficiency in site utilization planning. Furthermore, the use of technology can help to identify and mitigate potential issues before they occur, reducing the risk of delays and cost.

Building Information Modelling (BIM): BIM technology can be used to create data-rich environments for site utilization plans, and graphical relationship information can be beneficial during collaborative meeting. BIM technology can be used to automate Site Utilization Planning, taking into account factors such as geometry data of buildings and obstacles, available equipment, number of staff, construction methods, and necessary safety measures (Hammad, 2021).

Design Authoring Software: Software tools for creating and manipulating 3D models can be used to develop site utilization plans and visualize the placement of facilities and equipment on the construction site(Vimonsatit, 2014).

Scheduling Software: Scheduling software can be used to integrate construction activity schedules with site utilization plans, allowing for the efficient allocation of resources and the optimization of construction sequences(Vimonsatit, 2014).

Unmanned Aerial Vehicles (UAVs): UAVs, commonly known as drones, can be used for dynamic Site Utilization Planning in large-scale construction projects. They can provide real-time aerial imagery for site analysis and planning(Hammad, 2021).

3D Laser Scanning Technology: technology can be used for survey layout, allowing for the accurate capture of physical data in a virtual environment. It can streamline workflows and improve the precision of Site Utilization Planning(Lindskog, 2016).

2.5.3 Optimal Space Allocation

Spatial requirements in construction refer to the amount of space needed for a building or construction project to function effectively. Spatial requirements can include the size and layout of rooms, open spaces, and outdoor area. Spatial requirements are essential to the design process, as they can have a significant impact on both the function and form of a building (Bhatt, 2010).

Site utilization objects are those that take space on the construction site for a long period of time. Temporary facilities, access roads, machineries, and materials are some examples of site utilization objects. Some characteristics of these objects are, such as typology (the object's nature and function), object boundary (the object's shape and size), and mobility (The capability of a site object to move). The most typically addressed property in the case of site utilization is the object border(Sadeghpour, 2015).

Object Typology

The object typology during the site utilization is critical because it has a direct influence on the required space for operation, handling, safety, or a combination of these A well-planned construction site utilization causes an increase in safety and productivity, a decline in areas required for temporary construction, and maximum utilization(Sadeghpour, 2015).

Contractors should submit their requirements for space for temporary structures and storage of materials to the Construction Officer before starting the work, and for the allocated space, the Contractor shall submit his proposed plan and layout for all temporary offices, sanitary facilities, temporary construction roads, storage buildings, storage yards, temporary water service and distribution, and temporary power service and distribution (Kim, 2021).

Effective site utilization design is crucial for the success of construction projects, and it can help to minimize the impact of temporary facilities on the regular project of some major construction activities that are taking place(Kim, 2021).

Object boundary modelling

Although dimensionless representation makes positioning easier, it ignores real-world geometries and considers every object as a point, ignoring size and shape constraints. In order to estimate the amount of space needed, approximate geometry models items using simple 2D or 3D shapes, like envelopes, cylinders, or rectangles. This approach allows planners to better account for overlaps and adjacencies by striking a balance between simplicity and reality (Borges, 2024).

Object mobility

This involves differentiating between stationary objects, such as tower cranes, which require fixed, foundational installations to facilitate vertical and horizontal material movement across a defined area for the project's duration, and mobile equipment, such as trucks and earthmovers, which must be routed efficiently to perform dynamic tasks like transporting, digging, and grading(Sadeghpour, 2015).

Construction site zones: are areas designated for specific activities on a construction site. Site utilization planning involves the identification and allocation of these zones to ensure that construction activities are carried out efficiently and inside a construction project's boundaries, there are functionally .These areas are allocated to support specific project activities, such as the storage of materials, the placement of equipment, the provision of worker facilities, administrative functions, or access for vehicles(Borges, 2024).

According to(Cho, 2013) **Construction site zones are areas:**

Central Zone: This refers to the area surrounding and including the building under construction. Tower cranes and other lifting or digging equipment primarily operate within this zone. The operational range and reach of the central tower crane can be used to define these zones.

Inner Zone: Located near the central zone, which includes loading and unloading areas, active (short-term) storage, and the main temporary access roads.

Outer Zone: In the outer zone, but within reach of the main tower crane, the auxiliary plant, workshops, yards, and general stores are located.

Neutral zones: located inside the boundary fence but typically out of reach of the main crane, accommodate auxiliary temporary structures such as site offices, parking areas, on-site production plants (e.g., batching areas), workshops, laboratories, equipment stores, earth/topsoil deposits, contaminated wastewater tanks, temporary waste material deposits, hazardous material stores, and more.

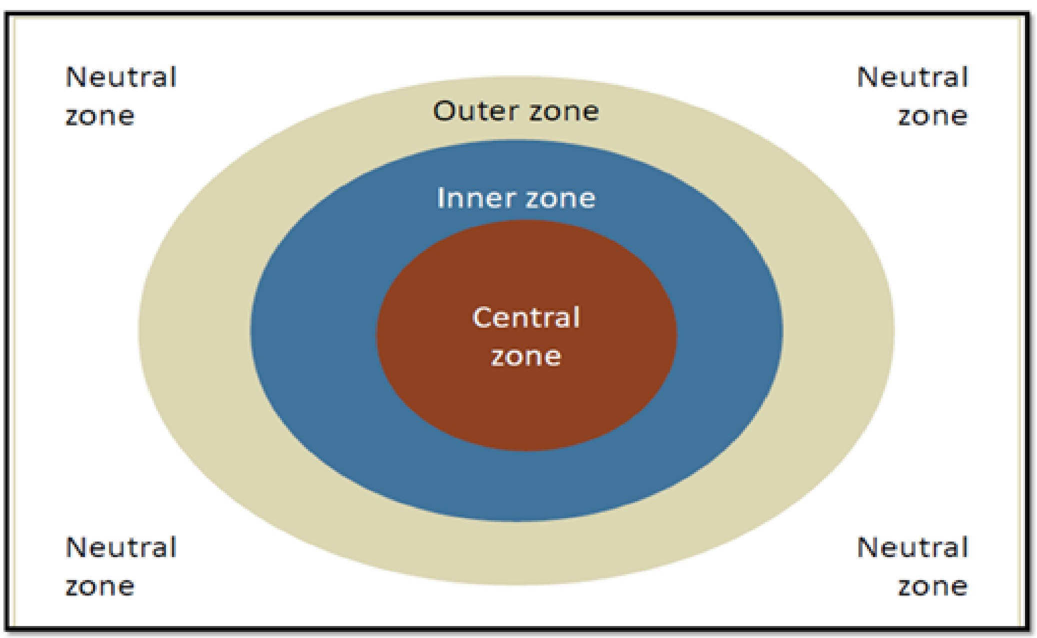

Figure 1 Four construction site zones

2.5.5 Procedures for Implementation in Site Utilization Planning

It is crucial to remember that the CSUP process is on-going and needs to be revised frequently to account for adjustments to the project timeline and site constraints. A site utilization plan is essential to establishing the layout of a project site as it progresses through the building phase since it records the project's designed status at a specific moment in time. A 4D, or visual model of a project's construction sequence, can be created by integrating a site application plan with a Critical Path Method (CPM) timetable(Chau, 2004).

Now a day technology is used in implementation Site Utilization Planning can help improve accuracy, efficiency, and safety, and can save time and money. By using these technologies, construction professionals can modernize their site utilization and surveying processes and improve their overall project outcomes.

According to studies (Whitman, et al., 2021)&(Messner, 2023) the procedure for effective implantation Construction Site Utilization Planning (CSUP) summarized the implantation process:

Site Assessment and Planning

- Initial assessment of the construction site, its available space, and logistical challenges
- Survey site conditions
- Identify key constraints (space, access, etc.)

Define Space Allocation Needs

- Determine the needs for space based on project requirements, safety standards, and workflow needs.
- Define storage areas
- Allocate space for material handling
- Assess worker movement needs

Develop Site Layout Plan

- Design a detailed site layout plan that optimizes space utilization and aligns with construction goals

Resource and Equipment Allocation

- Ensure that the required resources and equipment are available and placed efficiently on-site

Stakeholder Coordination

- Engage all stakeholders to ensure alignment with the layout and operational needs.

Implement Safety Protocols

- Ensure that the CSUP plan includes adequate safety measures to protect workers and site integrity

Continuous Monitoring and Adjustment

- Ongoing tracking of site utilization and adjustments based on real-time observations and feedback.

Performance Evaluation

- Evaluate the effectiveness of the CSUP plan after completion and identify areas for future improvement

Figure 2 Summarized the implantation process and develops CSUP implementation

2.6 Summery Literature

Construction site utilization design is regarded as an essential managerial approach that improves worker efficiency, solves safety and health issues, and organizes site materials. It also helps the construction site operate more efficiently. However, insufficient planning for the layout of the construction site also affects worker productivity, worker safety, and the performance of the construction project.

Therefore, the study focuses on assessing construction site utilization planning by grouping these variable indicators allows for a clearer understanding of the various aspects impacting construction site planning and execution, from leadership and organizational challenges to technical and site-specific issues. More efficient site utilization and improved project outcomes can result from systematic summarizing the indicators found in the literature review.

Table 2 Constraints indicators effective implantation of CSUP

Constraints Indicator		
Main Criteria	**Sub Criteria**	**Symbolized**
Organizational Challenges	Poor Leadership and Decision-Making	OC1
	Ineffective Organizational Structure	OC2
	Poor Communication and Workflow	OC3
	Lack of Stakeholder Involvement	OC4
Technical and Operational Issues	Lack of Technical Support	TOI1
	Limited On-Site Expertise	TOI2
	Contractual Limitations	TOI3
	Site-Specific Operational Challenges	TOI4
	Tight schedule and overlapping activity	TOI5

Constraints Indicator		
Main Criteria	**Sub Criteria**	**Symbolized**
Organizational Challenges	Poor Leadership and Decision-Making	OC1
	Ineffective Organizational Structure	OC2
	Poor Communication and Workflow	OC3
	Lack of Stakeholder Involvement	OC4
Technical and Operational Issues	Lack of Technical Support	TOI1
	Limited On-Site Expertise	TOI2
	Contractual Limitations	TOI3
	Site-Specific Operational Challenges	TOI4
	Tight schedule and overlapping activity	TOI5
Resource Constraints	Site and Space Limitations	RC1
	Lack of budget for CSUP	RC2
	Location of site (down town ,confined area urban)	RC3
	Lack of technological equipment for site layout planning	RC4
Temporary Facilities Characteristics	Improper Facility and Equipment Placement	TFC1
	Improper utilization available site space	TFC2
	Equipment Movement and Accessibility Issues	TFC3
	Inefficient Layout and Space Utilization	TFC4
	Out-dated Temporary Facilities	TFC5
Knowledge and Understanding	Limited Understanding of Site Layout Planning	KU1
	Poor technology for optimal use of resources	KU2
	Absence of common acceptable standard	KU3
	Resistance to adopt advanced technologies	KU4

Table 3KPIs in effective implantation of Construction Site Utilization Planning

Key Performance Indicators (KPIs)		
Main Criteria	**Sub Criteria**	**Symbolized**
Safety and Risk Mitigation	Emergency plan and procedures	SRM1
	Safety, Security, and Signage	SRM2
	Safety Zones	SRM3
	Hazard Mitigation	SRM4
	Provision PPE equipment	SRM5
Site Utilization Facility Indicators	Access and Circulation Infrastructure	SUFI1
	Site Offices and Administrative Facilities	SUFI2
	Utility and Essential Services Availability	SUFI3
	Welfare and Worker Support Facilities	SUFI4
Material Management Indicators	Material Utilization Efficiency	MMI1
	Timely and Accurate Delivery	MMI2
	Strategic Material Storage	MMI3
	Material Management Awareness	MMI4
	Waste and Excess Control	MMI5

2.7 Research Gap

There are few research studies addressing problems on Ethiopian construction sites, including site utilization planning, facility assignment strategies, and equipment management. Existing research does not adequately apply well-established methodologies to assess conditions in the Ethiopian construction industry. For example, frameworks for performance development, the implementation of technology and innovation in site utilization, and the use of digital tools to improve site utilization planning and facility allocation processes are low existence in Ethiopia.

This study fills the gap by analyzing deficit site utilization planning and the effectiveness of its optimization methods in the construction sector, enhancing safety, productivity, scheduling, cost management, budgeting, decision-making, and labor management.

CHAPTER THREE

RESEARCH METHODOLOGY

This research employs a systematic methodology to investigate the research problem. It outlines the techniques used, including research design, data collection, data analysis, and validation procedures, all applied within the context of Construction Site Utilization Planning (CSUP). Ethical considerations, foundational to the research framework, guided the development of the research questions and the entire methodological approach.

3.1 Research design

Research design exploratory, descriptive, and case study survey to holistically evaluate the implementation of construction site utilization efficiency in Addis Ababa building projects. The exploratory phase addresses the sector's scant prior investigation by identifying hidden problems, knowledge gaps, and foundational constraints, a prerequisite for defining relevant Key Performance Indicators (KPIs).Saka (2023) emphasizes, this approach is critical for effectively prioritizing KPIs and implementation barriers while assessing stakeholder perceptions of efficiency and cost impacts.

Subsequently, a convergent parallel mixed-methods design is applied within a case study survey framework. This integrates quantitative data on the prevalence of identified KPIs and constraints with qualitative insights from open ended surveys and interviews. This methodology enables an in depth, context-specific analysis of real-world space management practices, capturing their inherent diversity. It efficiently balances breadth and depth, allowing the research to comprehensively address its objectives regarding planning implementation, stakeholder evaluation, and practical outcomes.

3.2Research approach

3.2.1 Quantitative Research

This study objectively analyzes site utilization planning by adopting a quantitative, non-experimental descriptive design(Nwabuko, 2024). It employs structured questionnaires and multi-criteria decision-making models to statistically rank Key Performance Indicators (KPIs) and operational constraints. The quantitative component is required in order to subject site usage practices objectively to, analysis for patterns and statistically rank KPIs and Constraints with techniques such as structured questionnaires by multi criteria decision making models.

3.2.2 Qualitative Research approach

This study employs a qualitative approach, which prioritizes subjective meaning, behavior, and the researcher's interpretive analysis of phenomena in their real-world context(Lim, 2025). The design was selected to ensure alignment with the research questions, thereby effectively capturing the nuances of the studied phenomena.

3.2.4 Mixed methods research approach

This study employs a mixed-methods research design, integrating both quantitative and qualitative approaches(Clark, 2022), The quantitative component, utilizing numerical performance metrics, facilitates the broad identification and prioritization of Key Performance Indicators (KPIs) and constraints in site utilization planning. Concurrently, the qualitative component provides rich, contextual insight into stakeholder perceptions and the complex realities of on-site management(Dawadi, 2021).

This integrated design is particularly suited to the research objectives in the context of Addis Ababa's construction sector. It enables a comprehensive analysis where statistical data on site efficiency can be validated and deepened through qualitative findings from diverse stakeholders. The triangulation of data sources enhances the validity of the findings, yielding a more robust and nuanced understanding of how site planning impacts overall project performance(Östlund, 2011).

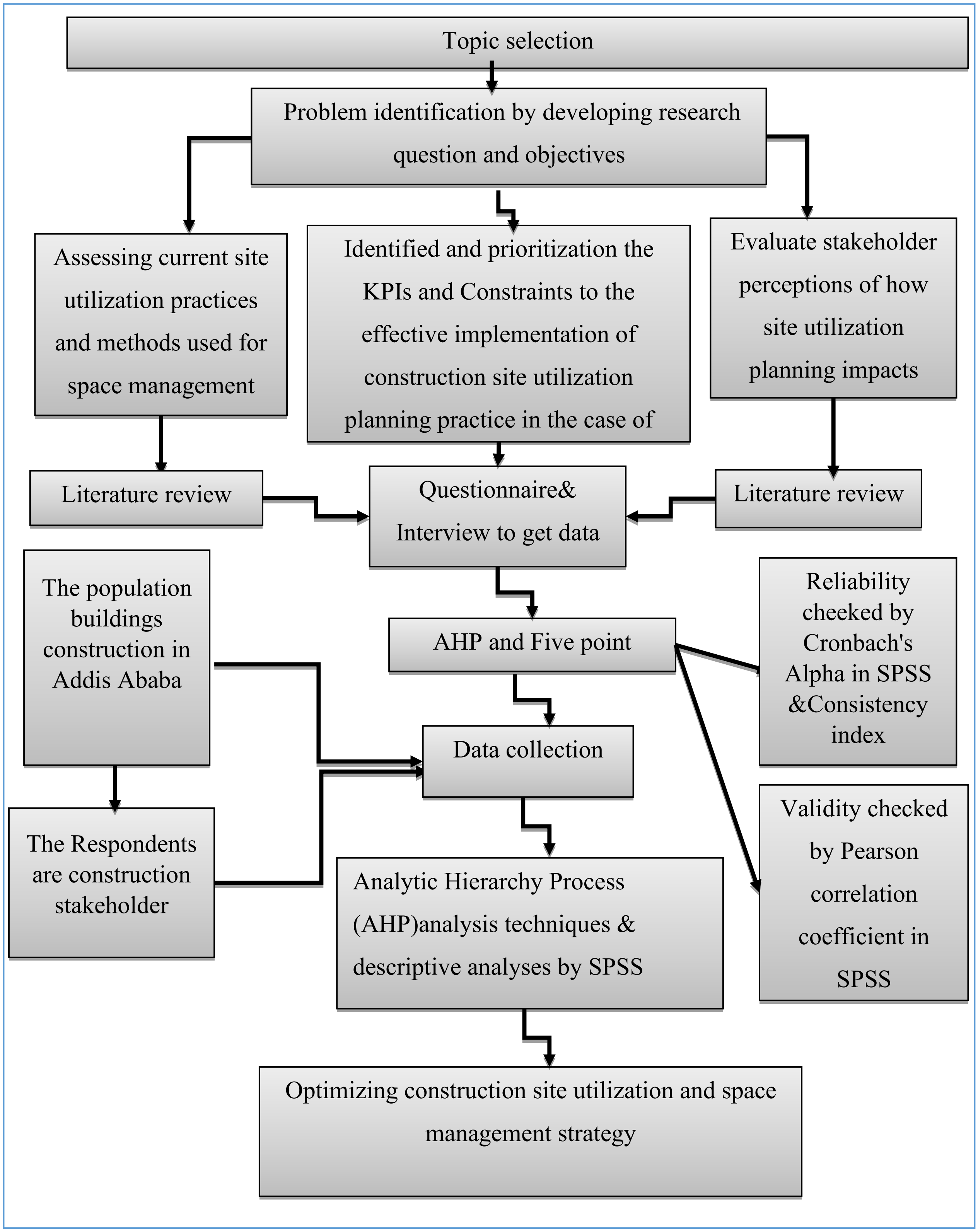

Figure 3 Research design flow

3.3 Study Area

Addis Ababa's rapid urban expansion is driving intense construction activity, making efficient site space utilization a critical factor for project success. However, studies indicate that the city's construction sector faces persistent challenges related to space utilization, including inadequate planning, poor material stacking, and poor coordination among teams, all of which compromise efficiency and increase costs.

This study directly addresses this problem by analyzing on-site practices in Addis Ababa. Its aim is to provide an accurate diagnosis of current constraints and key performance indicators, then evaluate the application of technology for improved space planning. The findings will identify key industry challenges and propose actionable solutions to enhance construction efficiency and project execution.

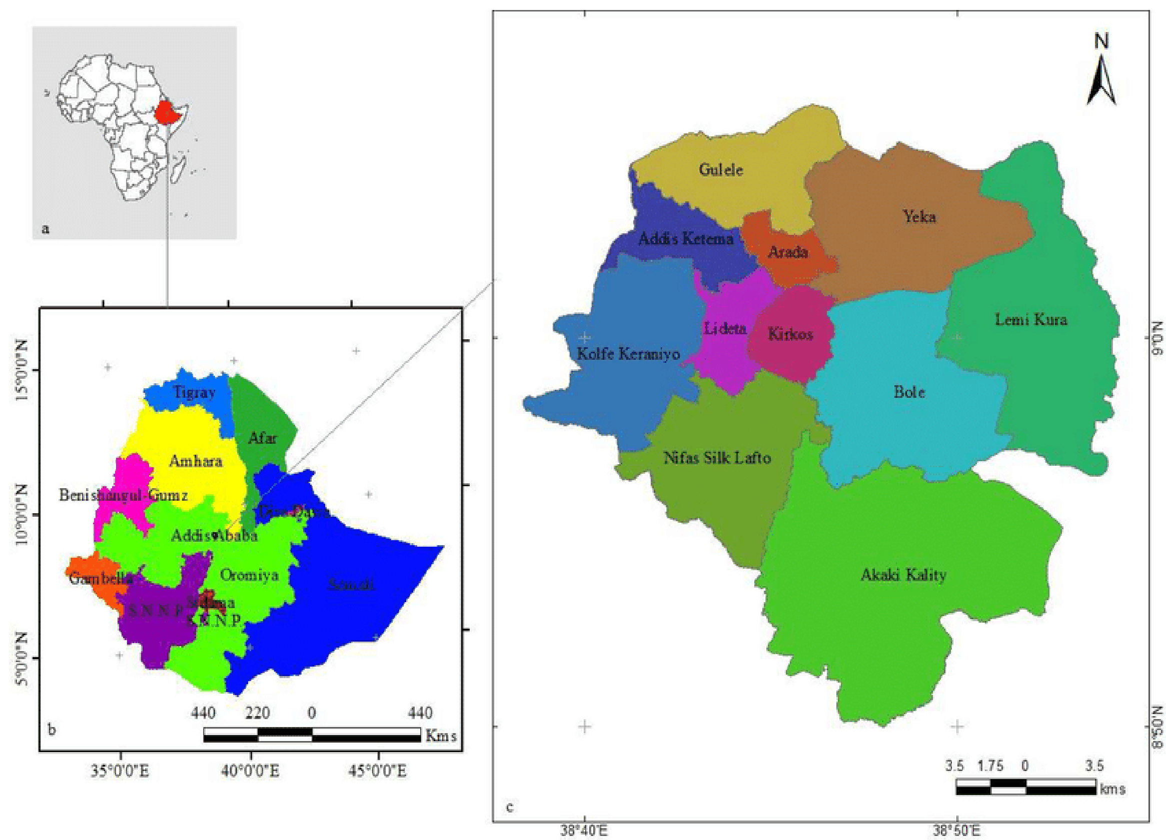

Figure 4 Study area map

3.4 Populations of the Study

Study requires a carefully determined sample size and the selection of appropriate expert participants. Such methodological rigor is essential for generating valid and generalizable results when applying the Analytic Hierarchy Process (AHP) and Likert scale methods. Engaging qualified respondents and ensuring a representative sample will strengthen the findings, which serve as the foundation for developing effective interventions to improve construction site utilization efficiency in Addis Ababa. Due to the unavailability of exact data on recent ongoing building construction projects from official sources (Addis Ababa City Construction Bureau), the population size is assumed to be unknown. Therefore, Cochran's formula for an infinite population (Cochran, 1977) was applied using p = 0.5, Z = 1.96, and e = 0.05.

Step 1: Cochran's Sample Size Formula for an Unknown Population

Cochran's formula(Cochran, 1977) is widely used when the population size is large or unknown:

$$n_0 = \frac{z2*p*(1-p)}{d2}$$

Where:

n_0 = required sample size

Z = z-score (usually 1.96 for 95% confidence)

p= estimated proportion (use 0.5 if unknown, for maximum variance)

d= margin of error (0.05)

Substituting values:

n= 384.16

Thus, the minimum required sample size is approximately 385 respondents.

Step 2: Estimating the Population Size (N)

Based on site visits and formal estimates, an average of 40 workers was found per construction site, across 10 sites. Hence, the estimated total population (N) is:

N=10 sites×40 workers=400 workers

Step 3: Kalton's Finite Population Correction

Since the estimated population (N = 400) is not very large, Cochran's correction formula for finite populations was applied to adjust the sample size:

$$n_{adj}=\frac{n}{1+(\frac{n-1}{N})}=\frac{385}{1+(\frac{384}{400})}=\frac{385}{1.96}\approx 197$$

Therefore, the final adjusted sample size is 197 respondents

For large scale the initial sample size was calculated using Cochran's formula for infinite populations, resulting in a requirement of 385 respondents. Considering an estimated population of 400 workers, the final sample size was adjusted to 197 using the finite population correction method(Kalton, 1983) .

Based on Cochran's formula and the finite population correction, a minimum of 197 valid responses were targeted to ensure the statistical representativeness of the estimated population of 400 construction workers. The focus group for this study included construction managers, site engineers, architects, project managers, and clients. These professionals were selected because of their direct involvement in construction site utilization and management, ensuring a comprehensive range of perspectives.

To calculate an appropriate sample size for the Analytic Hierarchy Process (AHP) questionnaire, the approach suggested by(Mu, 2016)&(Belton, 2012) AHP emphasizes the quality and consistency of expert judgments rather than large sample sizes. Therefore, the required number of participants depends on the complexity of the decision-making problem.

Table 4 Sample size for an Analytic Hierarchy Process (AHP)

Application Context	**Recommended Expert Sample Size**
Simple decision problem	3–7 experts
Medium complexity with multiple criteria	7–15 experts
High complexity (many criteria & alternatives)	15–25 experts

Very large public decision-making studies	25–50+ (rarely needed in AHP)

According to(Belton, 2012)the Analytic Hierarchy Process (AHP) relies on the consistency and quality of judgments rather than large sample sizes. For highly complex decision problems, a sample of 15–25 carefully selected experts is considered sufficient to ensure reliable pairwise comparisons and consistency in judgment.

This focus group was selected based on experience, involvement in construction site utilization planning, and the ability to provide informed, consistent decisions. As (Belton, 2012)suggest that analytical hierarchal analysis (AHP) places greater emphasis on the quality and consistency of experts such as site engineers, supervisors, contractors, consultants, architects, and clients rather than on large sample sizes.

3.5 Sampling Techniques

An expert sampling technique, a non-probability method, was employed to select participants possessing specific, relevant knowledge regarding site utilization planning (Rahman, 2022).The target population comprised construction industry professionals in Addis Ababa. The target population comprised construction industry professionals in Addis Ababa.

To address the first two objectives assessing current practices and prioritizing KPIs and constraints an Analytic Hierarchy Process (AHP) questionnaire was developed. In a pilot study, between 15 and 25 questionnaires were purposively distributed to selected stakeholders in the Addis Ababa building construction industry. The study combined 5-point Likert scale as input for the performance evaluation process.

3.6 Data collection method

Data for this research was gathered from primary and secondary sources using a mixed-methods design. Secondary data defined as information previously produced by other researchers(Ajayi, 2017)was obtained from academic literature (e.g., journals, books, theses). Primary data was generated through structured questionnaires featuring both open and closed-ended questions.

3.6.1 Survey and Questioner

Study employed surveys and structured questionnaires, well-established methods in construction management research for collecting quantitative data from large populations (Groves, 2011).

The primary data source was a semi-structured questionnaire distributed to construction professionals in Addis Ababa. Its purpose was to assess the perceived impact of site utilization planning and to rank key performance indicators and constraints.

The questionnaire incorporated two methodological tools. First, the Analytic Hierarchy Process (AHP) was employed to achieve the study's primary objectives. This mathematical decision-making technique(Saaty, 2010) facilitates pairwise comparisons to determine the relative weights and priorities of indicators and constraints based on expert judgment (Vaidya, 2006)&(Belton, 2012). Second, a 5-point Likert scale was used to assess stakeholder perceptions on a broader scale. This format converts subjective opinions into quantifiable data, reducing ambiguity and enabling statistical analysis(Rattray, 2007; Boone Jr, 2012).The combined approach allowed for the examination of both qualitative and quantitative dimensions, thereby supporting evidence-based decision-making(Naoum, 2012).

3.6.2 Semi-structural interview

This study employed semi-structured interviews as its primary qualitative method to explore participants' experiences, perceptions, and contextual meanings in depth (Gill, 2008). The format provided a flexible yet guided framework, enabling probes into critical themes while allowing for follow-up on unanticipated responses. This approach was particularly suited to investigating the specific site conditions, spatial constraints, and planning practices within Addis Ababa's construction sector.

Naoum (2012) supports that, method proved effective for eliciting detailed, experience-based insights from experts insights often missed by standardized surveys. It was instrumental in gathering rich, qualitative data on Key Performance Indicators (KPIs), implementation constraints, and stakeholder priorities from regulators, contractors, and consultants. Furthermore, it allowed respondents to evaluate the impact of site utilization practices on project efficiency (time, cost, safety, and workflow), providing concrete project examples.

Therefore, this methodology aims to engage decision-making project managers, engineers, and regulatory authorities to obtain rich, contextually informed data that align with the research objectives:

(1) to assess current site utilization practices and issues; (2) to explore specialist attitudes towards KPIs and constraints; and (3) to evaluate stakeholder perceptions of how site utilization planning impacts project efficiency and cost outcomes in building projects in Addis Ababa.

3.7 Data Analysis techniques

This study employs a Multi-Criteria Decision-Making (MCDM) methodology, specifically the Analytic Hierarchy Process (AHP), integrated with descriptive analysis. This approach rigorously analyzes and ranks the complex factors influencing construction site utilization planning in Addis Ababa, thereby enhancing the validity and reliability of the findings.

3.7.1 Quantitative Analysis of AHP Questionnaire Data

To address the study complex decision criteria, the Analytical Hierarchy Process (AHP) is employed. This well-established multi-criteria decision-making (MCDM) tool facilitates the evaluation of competing qualitative and quantitative factors through a structured hierarchical model and pairwise comparisons (Saaty, 2008).

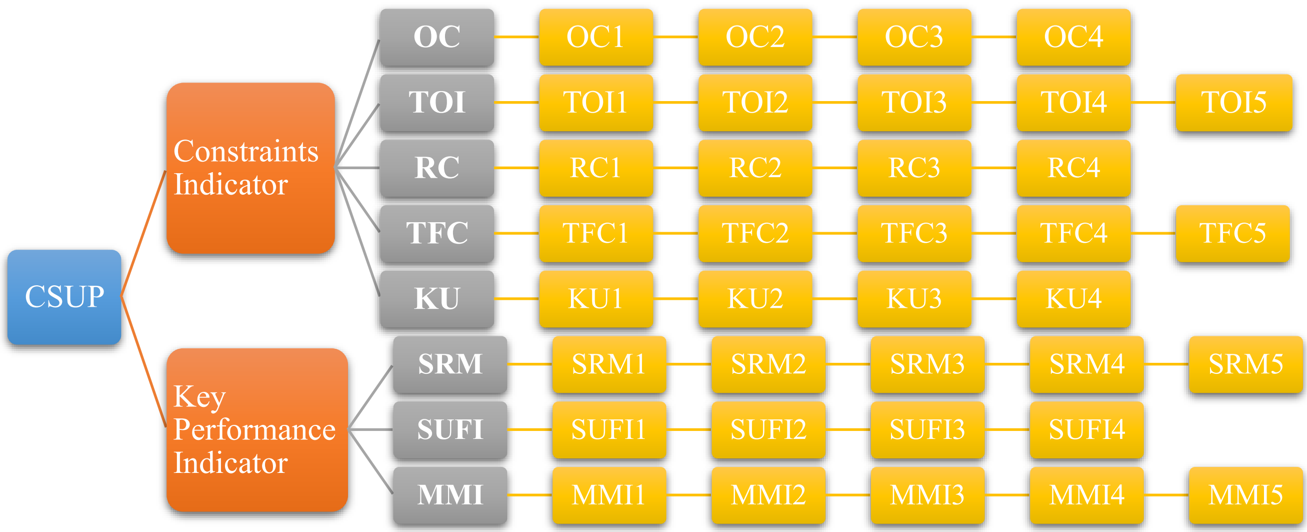

Figure 5 Hierarchy Structure for Proposed Construction Site utilization Planning

The AHP process in this study follows the methodological steps outlined by(Dalalah, 2010) as summarized below:

Step 1: Define the Problem and Objective

The main objective is to prioritize key performance indicators and obstacles to Addis Ababa's successful implementation of CSUP. The hierarchical structures of AHP aid in the analysis of this complex decision problem by breaking it down into phases

Step 2: Structure the Hierarchy

The AHP hierarchy consists of three levels:

Level 1: Goal – Prioritization of CSUP success and barrier indicators.

Level 2: Criteria Five key performance indicator categories (Organizational Challenges, Technical and Operational Issues, Resource Constraints, Temporary Facilities Characteristics, and Knowledge and Understanding) and three barrier categories (Safety and Risk Mitigation, Site Utilization Facility Indicators, and Material Management Indicators)

Level 3: Sub-criteria – 14 sub-indicators for success and 22 sub-indicators for Constraints

All elements in the hierarchy are made comparable by ensuring they operate at the same scale and contribute directly to the decision objective(Wasti, 2022).

Step 3: Construct Pairwise Comparison Matrices

Each criterion and sub-criterion is compared using Saaty's fundamental 1–9 scale to determine relative importance.

Table 5Saaty's fundamental 1–9 scale

Intensity of importance	**Definition**	**Explanation**
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgement moderately favour one activity over another
5	Essential or Strong importance	Experience and judgement strongly favour one activity over another
7	Very Strong importance	An activity is strongly favoured and its dominance
9	Extreme importance	An activity is extremely favoured and its dominance demonstrated in practice
2,4,6,8	Intermediate values between the two adjacent judgments	
Reciprocals if activity i has one of the above numbers assigned to it when compared with activity then j has the reciprocal value when compared with i.		

Step 4: Normalize the Matrix and Calculate Weights

Sum all values in each column.

Divide each element by its respective column total to normalize the matrix.

Compute the Criteria weight (CW) by averaging the normalized values in each row:

$$CW_i=\frac{\sum_{j}^{n}=1 \text{ aijnorm}}{n}$$

The percentage weight of each criterion is calculated by:

%CWi=CWi*100

Step 5: Check for Consistency

Consistency in the judgment matrix is tested using (Saaty, 2008)Consistency Ratio (CR). First, the weighted sum vector (WSV) is calculated by multiplying the original matrix by the criteria weights.

Consistency is related to the internal coherence of the decision-maker when the judgment is considered in the pairwise comparison matrix. It is the most important measurement for the results which generated from the pairwise comparison.

Lambda Max (λmax) is the maximum eigenvalue of the matrix and it is needed to calculate the consistency index. Λmax was calculated as the average values of the ratios which generated by dividing weighted sum values of variable in each row to the respective criteria weighted of each variable.

$$\Lambda max=\frac{1}{n}\sum\left(\frac{\text{WSVi}}{\text{CWi}}\right)$$

The Consistency Index (CI) is computed by:

$$CI=\frac{\lambda max-n}{n-1}$$

The Consistency Ratio (CR) is calculated as:

$$CR=\frac{CI}{RT}$$

The consistency ratio (CR) determines that the compassion matrix is consistence and reliable to use the criteria weight for rating. Further, Saaty's rule of thumb can be used to accept only judgment matrices with the consistency ratio must be less than 0.1 or CR < 0.1 (Deng, 2014). This consistency ratio value is generated by using a Randomized Index (RI) and the average consistency index (CI) for randomly filled matrices(Goepel, 2013).

Where RI is the Random Index, depending on matrix size (Saaty, 2008).

Table 6 Random Index depending on matrix size

Matrix Size (n)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Random Index	0	0	0.58	0.89	1.11	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

3.7.2 Descriptive Analysis techniques

To analyze stakeholder opinions on construction site utilization efficiency, quantitative data from structured surveys were processed using SPSS. Descriptive statistics including means, standard deviations, frequencies, and percentages were calculated to identify central tendencies, dispersion, and trends in the data related to practices in Addis Ababa. The reliability of the Likert-scale instrument was assessed using Cronbach's alpha to ensure internal consistency. Furthermore, Pearson's correlation coefficient was applied to examine associations between key variables, following established methodological guidelines for survey analysis (Creswell, 2014).

As emphasized by (Foster, 1998), Cronbach's alpha is a widely accepted method for evaluating the reliability of instruments that produce composite scores.

In the statistical analysis of survey data, mean score ranking is a widely used method for interpreting responses measured on ordinal scales, such as the 5-point Likert scale.

Lim (2025) notes thatthe mean (M) is calculated by averaging all responses for each individual item, providing a measure of central tendency that facilitates the ranking and comparison of items based on respondent agreement. The scale is typically anchored from 1 ("Strongly Disagree") to 5 ("Strongly Agree"). To interpret the calculated means, research often use descriptive ranges that classify the average scores: a mean between 1.00 and 1.49 corresponds to "Strongly Disagree," 1.50–2.49 to "Disagree," 2.50–3.49 to a neutral or "Neither Agree nor Disagree" position, 3.50–4.49 to "Agree," and a score of 5.00 specifically indicates "Strongly Agree."

3.7.3 Reliability and validity

To ensure the credibility of the findings, the research instruments underwent rigorous testing for validity and reliability. Validity was established through pre-testing and expert judgment to confirm that the items accurately measured the intended constructs of construction site planning and utilization.

Reliability, defined as the internal consistency of a measurement instrument, was assessed using Cronbach’s alpha coefficient (α). This is the most common and effective measure for Likert-scale instruments (Taherdoost, 2016), serving as an indicator of the average inter-correlation among a set of items(Singh, 2015). In this study, a Cronbach’s alpha value greater than the widely accepted threshold of 0.7 was used to confirm the scale's reliability and the integrity of the collected data(Gliem, 2003).

3.8 Ethical Considerations

The researcher adhered to a commitment to honesty and transparency to preserve the integrity of the research findings. Predetermined findings were supported by factual data that was collected and presented without distortion or modification. Furthermore, precautions were taken to protect the confidentiality and privacy of participant data. Every effort was made to ensure that participants did not experience any physical or psychological harm during the study. Regarding respondents' privacy, their answers were kept strictly confidential and used solely for scholarly research. All relevant materials and sources were appropriately cited.

CHAPTER FOUR

RESULT AND DISCUSSION

This chapter analysis of data and discussions of the data gathered through case studies and questionnaires. Based on the specific objectives, the study's main findings have been described and discussed below.

4.1 Demographic Characteristics Analysis

During the survey, various individuals participated to fulfill the study's objectives. For the study, a sample size of 10 construction sites and 197 questionnaires were distributed. From these, 172 were returned, resulting in a valid response rate of 87.30%, which is considered sufficient for analysis.

During the survey for AHP, 24 questionnaires were distributed to experts, and 21 complete and valid responses in the AHP format were collected for the study. Additionally, two returned questionnaires were deemed incomplete and excluded from the analysis. The respondent profiles represent the backgrounds of the 19 individuals who provided thorough answers during the AHP data collection.

4.2 Results and Discussion of Descriptive Analysis

Reliability Test: is essential for measuring the internal consistency of a scale, indicating the extent to which respondents rate the items in a similar pattern. Cronbach's alpha coefficient is an important measure of reliability. In this study, the reported Cronbach's alpha was 0.713, which indicates acceptable reliability.

Section 1: General assessment Site Utilization Facility Indicators

Table 7General assessment Site Utilization Facility Indicators result summery

Item	Mean	Std. Deviation
Access roads (for vehicles and trucks)	1.17	0.381
Site offices (for all stakeholders)	1.65	0.478
Material storage areas	1.17	0.381
Parking lots	1.17	0.381
Utility availability (water, power, telecom)	1	0.23
Welfare facilities (toilets, sanitation, drinking water)	1.65	0.478
Information signs and site maps	1.17	0.381
Security features (fencing, guard houses, lighting)	1.17	0.381
Cranes and lifting equipment	1	0.23
Worker accommodations	1.3	0.461

Utility Availability (Water, Power, and Telecom) and Cranes/Lifting Equipment both have a perfect mean of 1.00 and the lowest standard deviations (0.23). This indicates these are consistently present on almost all sites. Foundational requirements. Studies show (Whitman, et al., 2021) and regulations such as(Summerhayes, 2016)emphasize the necessity of utilities and proper equipment for basic operability and safety. The high availability suggests these are recognized as non-negotiable, baseline resources.

Site Offices and Welfare Facilities (Toilets, Sanitation) have a mean of 1.65, indicating they are frequently absent or inadequate. The higher standard deviation (0.478) suggests inconsistency on some projects. Numerous studies(Adewuyi, 2015)&(Wolday, 2025) highlight that welfare facilities (offices, toilets, drinking water) are critical for worker productivity, morale, safety, and compliance.

Their inconsistent availability points to a major gap between recognized best practices and on-the-ground implementation, likely due to cost-cutting, space constraints, or lack of enforcement. Worker Accommodations shows a slightly better but still problematic mean of 1.30.

Access Roads, Material Storage, Parking, Information Signs, and Security Features all have a mean of 1.17 with a very low standard deviation (0.381), which strongly suggests these facilities are consistently underdeveloped and poorly planned. Access, Storage, and Parking: Delays, double-handling, and increased costs directly correlate with inefficient material flow and storage (Andy, 2010). The lack of proper access and parking disrupts deliveries and internal traffic.

Information Signage and Site Maps: The absence of clear signage and maps contradicts principles of effective site communication and orientation, increasing confusion and safety risks(Elbeltagi, 2004)&(Jaafar, 2021).

Security Features (Fencing, Lighting): Inadequate security compromises site safetyand fails to meet basic regulatory and best practice standards (Sutt, 2013)&(Selki, 2019).

Section 2: Objective 1 - Assessing Current Site Utilization Practices

Table 8Assessment current site utilization practices result summery

Item	Mean	Std. Deviation
Functional zones (e.g., work areas, storage, and welfare) are clearly defined and consistently applied.	3.6	0.915
Construction operations are carried out smoothly and without disruption.	2.72	0.669
Material flow across the site is not obstructed by poor layout or disorganized paths.	2.07	0.667
Material storage areas are well-organized and do not cause delays.	2.67	0.845
Access routes for workers, vehicles, and materials are clearly planned and efficiently used.	2.49	0.902
Temporary facilities (offices, toilets, storage) are conveniently located and easily accessible.	2.78	0.964
Stakeholder communication effectively supports space coordination on the site.	3.03	0.7
Regular site meetings are contribute to the efficient use and management of site space.	2.83	0.773

Functional zoning is relatively well-implemented (Mean: 3.6) the role of structured zoning in improving site organization and safety.Bogale (2020), notes that zoning is a commonly adopted practice in Ethiopian construction for basic site management.

Stakeholder communication is somewhat effective (Mean: 3.03): stress that effective communication supports spatial coordination and conflict reduction.Abdelalim (2024), Highlight communication as a key enabler of coordination in constrained sites.

Material flow and storage are major pain points (Means: 2.07–2.67) identify poor material handling and storage as primary causes of delays, congestion, and cost overruns (Bogale, 2020)notes that material mismanagement is a recurrent issue in Ethiopian construction due to limited space and planning.

Access routes and temporary facility placement need improvement (Mean: 2.49–2.78) Temporary facility placement is often overlooked, leading to operational inefficiencies.Elbeltagi (2004) argues that poorly planned access routes increase travel time and reduce efficiency.

Section 3: Objective 2: Identifying Key Performance Indicators (KPIs) and consternate

A. How of Key Performance Indicators (KPIs)

Table 9 Impact of Key Performance Indicators (KPIs)

Item	Mean	Std. Deviation
Initial site assessment and analysis significantly improve the effectiveness of site utilization	3.59	0.904
Clearly defined zoning and functional areas (e.g., work, storage, and welfare) are essential for efficient site utilization	3.82	0.877
Planning of access and circulation routes significantly does not improves site efficiency	2.01	0.732
Regulatory compliance is prioritized in site planning	3.53	0.704
Stakeholder collaboration supports the success of site utilization planning	3.58	0.666

Zoning is a recognized strength, but execution is inconsistent. Mean: 3.6, Std Dev: 0.915 that functional zoning (work, storage, welfare) is generally well-defined. Zoning is a recognized best practice for reducing congestion, improving workflow, and enhancing safety(bin Mamat, 2014)&(Whitman, et al., 2021).

Material flow and storage remain critical congestion points:

Material flow obstruction- Mean: 2.07, Std Dev: 0.667 disagree that material flow is unobstructed. Poor layout planning disrupts material flow, leading to double-handling, delays, and increased costs (Andy, 2010)and inefficient material paths are a common symptom of inadequate site utilization planning(Elbeltagi, 2004).

Material storage organization Mean: 2.67, Std Dev: 0.845 neutral to slightly disagree. Disorganized storage areas contribute to delays, material damage, and safety hazards(Selki, 2019).Well-organized storage is critical for just-in-time delivery and reducing non-value-added movements (Abdelalim, 2024)&(Adeagbo, 2019).

Access, temporary facility placement, and communication show moderate performance with room for improvement:

Access routes Mean:-2.49, Std Dev: 0.902 disagree about clear and efficient access planning. Poorly planned access routes increase travel time, congestion, and safety risks (Jaafar, 2021)&(Sutt, 2013)(. Effective circulation planning is essential for smooth movement of labor, materials, and equipment (CDM Regulations 2015) &(Kim, 2021).

Temporary facilities Mean: 2.78, Std Dev: 0.964 It is convenience and accessibility that still have problems. Optimal placement of temporary facilities (offices, toilets, storage) is key to operational efficiency and worker welfare (Kim, 2021)&(Small, 2016).Poor placement leads to reduced productivity and increased idle time(Jusoh, 2017)&(Oseghale, 2021).

Stakeholder communication Mean: 3.03, Std Dev: 0.7 agree that communication supports coordination on site utilization. Effective communication is linked to better spatial coordination and conflict resolution(Tafesse, 2021)&(Zewdu, 2015).However, breakdowns in communication remain a common barrier to effective site management (Adeagbo, 2019)&(Buniya, 2021).

B. Impact of Barriers

Table 10Impact Constraints result summery

Item	Mean	Std. Deviation
Site utilization is designed to overcome space limitations and support effective utilization.	3.25	0.968
Well-coordinated trade schedules contribute to efficient site utilization.	3.64	1.189
Inadequate material handling and poor storage lead to inefficient use of site space.	3.27	0.949
lack of collaboration among stakeholders often creates Constraints to effective site utilization	3.66	0.945
Digital tools (e.g., BIM) are actively used to improve site utilization and utilization.	2.07	0.667

Site utilization is designed to overcome space limitations and support effective utilization:

Mean = 3.25 (Agree), Std. Dev = 0.968 agree that planning helps, but high standard deviation reflects inconsistent implementation across projects. Site planning strategies are developed to mitigate spatial constraints in urban construction. (Zewdu, 2015)&(Oseghale, 2021) note that site layout planning is essential in confined urban areas to optimize limited space.

Well-coordinated trade schedules contribute to efficient site utilization:

Mean = 3.64 (Agree), Std. Dev = 1.189 Strong agreement, but high variability indicates that not all projects successfully implement coordinated scheduling. Poor scheduling to congestion and workflow disruption (Andy, 2010)emphasize that synchronized scheduling reduces conflicts and improves spatial efficiency.

Inadequate material handling and poor storage lead to inefficient use of site space:

Mean = 3.27 (Agree), Std. Dev = 0.949 Consensus that material mismanagement is a key inefficiency driver. Identify poor material storage as a major cause of site congestion and wasted space(Adeagbo, 2019)note that disorganized storage increases handling time and reduces usable space.

Lack of collaboration among stakeholders often creates constraints to effective site utilization:

Mean = 3.66 (Agree), Std. Dev = 0.945 collaboration is seen as a major barrier to efficient site use. That poor communication between clients, contractors, and consultant's leads to spatial conflicts (Wang, 2016) identify stakeholder misalignment as a critical barrier to effective site layout planning.

Digital tools (e.g., BIM) are actively used to improve site utilization:

Mean = 2.07 (Disagree), Std. Dev = 0.667 that digital tools are not actively used, reflecting a significant technology gap. (Jaafar, 2021)&(Elbeltagi, 2004) point out that limited technical capacity and resistance to technology hinder digital tool integration.

Section 4: Objective 3: Evaluating Stakeholder Perceptions on Efficiency and Cost Outcomes

Table 11 Stakeholder Perceptions on Efficiency and Cost Outcomes result summary

Item	Mean	Std. Deviation
Site utilization planning has an impact on the efficiency of construction projects	3.74	0.712
Inadequate space management often results in increased project costs.	3.22	0.891
Well-executed site utilization planning supports adherence to project timelines.	3.74	0.835
Insufficient site planning increases the risk of safety incidents.	3.22	0.891
Poor site planning increases the likelihood of safety incidents on-site.	3.48	0.82
Stakeholder involvement in site planning positively affects cost control and risk reduction.	3.99	0.787
Collaborative planning among stakeholders improves space utilization and site efficiency.	3.74	0.835
Poor site utilization planning has led to increased costs on this project (e.g., material damage, delays).	3.18	0.887

Proper allocation of storage zones has helped reduce material handling and associated costs	3.67	0.837
Inadequate access routes have shown to time loss and cost increases in this projects.	3.66	0.783
Inefficient site space planning frequently leads to delays on our project sites	3.29	0.887

Stakeholder Communication is Moderately Effective:

Mean: 3.03, Std Dev: 0.7 communication happens but lacks the structure needed to fully support site utilization.Abdelalim (2024) and Adeagbo (2019) argue that communication as critical for spatial coordination, but often undermined by fragmented teams.

Safety is Strongly Linked to Planning Quality:

Means: 3.22–3.48 confirm that professionals recognize the planning safety link, even if execution is weak. Kim (2021) aguryrequire systematic planning to mitigate safety risks something often lacking in practice.

Cost and Schedule Impacts are acknowledged but Less Prominent:

Means: 3.18–3.22 Cost impacts are recognized but may be less immediately visible and measured. (Zewdu, 2015)&(Tafesse, 2021) note that in Ethiopian projects, cost overruns are often attributed to poor material and site management.

The Ethiopian, Addis Ababa context amplifies these challenges due to urban density, regulatory gaps, and technological adoption barriers.

4.3 Results and Discussion of AHP-Based Data Analysis

AHP-Data Analysis of Constraints for Construction Site Utilization Planning

AHP: Data analysis for implementation constraint that prevent construction site utilization planning from successfully completing the following stage involved calculating a vector of priorities or weighting of matrix members after acquiring the average pairwise assessments of participants regarding the significance of the variable under the major category.

Step-1 Sum up the column of Pair-wise comparisons matrix

In the Pairwise Comparisons matrix, enter the average score values that respondents provided. Using the first and second columns of the Pair-wise comparisons matrix as an example, this is demonstrated.

Column- 1: (1.00+1.14+4.55+1.00+0.81=8.49)

Column- 2: (0.88+1.00+3.23+0.32+0.30=5.73)

Likewise, all the columns were calculated and added to arrive at the total sum.

Table 12Pair-Wise Comparisons Matrix – main criteria

Constraints to effective implementation construction site utilization planning					
Main Criteria	OC	TOI	RC	TFC	KU
OC	1	0.88	0.22	1	1.23
TOI	1.14	1	0.31	3.1	3.35
RC	4.55	3.23	1	4.16	6.11
TFC	1	0.32	0.24	1	1
KU	0.81	0.3	0.16	1	1
SUM	8.49	5.73	1.93	10.26	12.69

Step 2 Normalize the comparison: to normalize each columns of Pair-wise comparisons matrix to total sum of 1.0 or 100%, each elements of the column was divided by the total sum of respective column

As an example, the normalizing procedure was shown below for the first entity of the first column and the first entity of the second column by dividing to their respective column total sum.

Column-1 first entity: (1/8.49 = 0.12) Column-2 first entity: (0.88/5.73 = 0.15) Likewise, all columns were normalized. Also the horizontal total sum of normalized entities in each rows were divided to the number of variables (n) to generate a criteria weighted matrix. For instance, criteria = 0.12.

Table 13 Normalized Pairwise Matrix and Weighted Matrix

Normalized pair -wise comparison Matrix								
Main Criteria	OC	TOI	RC	TFC	KU	sum	criteria weights	criteria weight%
OC	0.12	0.15	0.11	0.1	0.1	0.58	0.12	11.59
TOI	0.13	0.17	0.16	0.3	0.26	1.03	0.21	20.7
RC	0.54	0.56	0.52	0.41	0.48	2.5	0.5	50.05
TFC	0.12	0.06	0.12	0.1	0.08	0.47	0.09	9.49
KU	0.1	0.05	0.08	0.1	0.08	0.41	0.08	8.17
	1	1	1	1	1	5	1	100

Every normalized column added vertically must result in a value of 1. The first column below serves as an illustration of this: 0.12+0.13+0.54+0.12+0.1 = 1

Step 3 Consistency calculation

Following normalization, the data's consistency must be examined.

Step 1: Multiply each pairwise comparison matrix entity by the weight assigned to it. This is further explained by taking the first two entities from column one and column two as follows: components in the first column of the pairwise comparison matrix were multiplied by the first criteria weight in order to determine the consistency of column one. Take the first two entities described below, for example. Regarding column one's first entity: (1 * 0.12 = 0.12),

The consistency of column two for the second entity of column one was calculated by multiplying the items in the second column of the pairwise comparison matrix by the second criteria weight: (0.88 * 0.21 = 0.18). The variables in the second column of the pairwise comparison matrix were multiplied by the second criteria weight in order to determine the consistency of column two for the second entity of column one: (0.88 * 0.21 = 0.18). Take the first two entities described below

Step 2: The weighted sum value (WSV) is generated by applying the total horizontal sum of all entities in each row once the consistency matrix has been fully computed and filled. The initial rows of the consistency matrix are used to further explain this.

Weighted sum value of first row (WSV1) = 0.6+1.06+2.59+0.48+0.14 = 5.15,

The total sum of the weighted sum values with criteria weighted (CW) from normalization was divided to get the ratio (WSV/CW). Using the consistency matrix's first row, this is further explained. WSV/CW ratio of the first row = 0.6 / 0.12 = 5.2

Table 14Consistency Calculation

Calculating consistency								
Cw	0.12	0.21	0.5	0.09	0.08			
Main Criteria	OC	TOI	RC	TFC	KU	weighted sum value	criteria weight	WSV/CW
OC	0.12	0.18	0.11	0.09	0.1	0.6	0.12	5.21
TOI	0.13	0.21	0.16	0.29	0.27	1.06	0.21	5.13
RC	0.53	0.67	0.5	0.39	0.5	2.59	0.5	5.17
TFC	0.12	0.07	0.12	0.09	0.08	0.48	0.09	5.05

KU	0.09	0.06	0.08	0.09	0.08	0.41	0.08	5.07
								5.13

Step 4: λ max Following the calculation of the consistency index, the consistency ratio was determined as 0.028. Using the RI value of 1.11, the resulting consistency ratio of 0.03 obtained from the AHP data analysis is acceptable because it is less than the threshold value of 0.10

Likewise, the same all steps and procedures were followed to Analyze other remaining categories

Table 15 Main Criteria Weight

Main Criteria Weight	**Symbolized**	**Criteria Weighted (Cw)**	**Rank**
Resource Constraints	RC	50.05	1
Technical and Operational Issues	TOI	20.7	2
Organizational Challenges	OC	11.59	3
Temporary Facilities Characteristics	TFC	9.49	4
Knowledge and Understanding	KU	8.17	5

Resource constraints on the site were identified as the most dominant barrier to the implementation of CSUP, accounting for 50.05% of the priority rate. Technical and operational issues ranked second with a priority rate of 20.70%. Organizational challenges followed in third place, receiving 11.59% of the computed priority.

Temporary facilities characteristics were identified as the fourth barrier, with a priority rate of 9.49%, while knowledge and understanding ranked fifth, accounting for 8.17% of the priority rate.

AHP-Data Analysis for sub-criteria Organizational challenge

Based on the comprehensive research procedure detailed in the preceding AHP, the final summary of results was systematically derived. Each finding is directly linked to its source data and foundational calculations, all of which are presented for verification in Organizational challenge **Appendix IV.**

Table 16 Organizational challenge Criteria Weight

Organizational challenge	Symbol	criteria weighted	Rank
Poor Leadership and Decision-Making	OC1	60.73	1
Poor Communication and Workflow	OC3	18.53	2
Ineffective Organizational Structure	OC2	14.55	3
Lack of Stakeholder Involvement	OC4	6.9	4

Major organizational challenges affecting the implementation of construction site utilization planning are poor leadership and decision-making, poor communication and workflow, ineffective organizational structure, and lack of stakeholder involvement. Among these, poor leadership and decision-making emerged as the most dominant barrier, with a priority rate of 60.73%. Such weaknesses undermine planning efforts and hinder effective site utilization (Andy, 2010)&(Elbeltagi, 2004).

Poor communication and workflow ranked as the second major barrier at 18.53%, as ineffective communication and coordination often lead to spatial conflicts on construction sites (Jaafar, 2021). Ineffective organizational structure was the third challenge, with a priority rate of 14.55%, reflecting structural limitations that impede efficient planning and execution. Lastly, lack of stakeholder involvement was identified as the fourth barrier, accounting for 6.9% of the priority rate. Limited engagement from stakeholders reduces buy-in and weakens the effectiveness of CSUP implementation (Sutt, 2013).

AHP-DataAnalysis of Technical and Operational Issues

Based on the comprehensive research procedure detailed in the preceding AHP, the final summary of results was systematically derived. Each finding is directly linked to its source data and foundational calculations, all of which are presented for verification in technical and operational issues in **Appendix IV**.

Table 17 Criteria Weight - Technical and Operational Issues

Technical and Operational Issues	Symbolized	criteria weighted	Rank
Tight schedule and overlapping activity	TOI5	32.22	1
Limited On-Site Expertise	TOI2	30.65	2
Lack of Technical Support	TOI1	19.92	3
Site-Specific Operational Challenges	TOI4	10.07	4
Contractual Limitations	TOI3	7.14	5

Tight schedules and overlapping activities are the most critical challenge, with the highest relative weight (32.22%). This finding strongly aligns with prior studies, which emphasize that compressed project timelines and concurrent activities significantly disrupt site layout efficiency, material flow, and equipment allocation. Bin Mamat and bin Mohamad Zin (2014), Andy and Price (2010), and Elbeltagi (2008) argue that overlapping tasks increase spatial conflicts and reduce operational flexibility, thereby undermining effective site utilization

The second-ranked constraint, **limited on-site expertise** with a weight of 30.65%, underscores the importance of skilled technical personnel in managing complex site operations. This result corroborates the findings of Bogale.B (2020) and AbdulAzeez et al. (2016), noted that insufficient technical competence among site staff leads to poor decision-making, ineffective layout planning, and improper coordination of site resources.

Lack of technical support ranked third (19.92%), indicating that insufficient access to planning tools, technical guidance, and institutional support negatively affects construction site utilization. This outcome is consistent with the arguments of Whitman (2014) and Elbeltagi (2008), highlighted that weak technical backing limits the ability of project teams to respond to dynamic site conditions.

The fourth-ranked factor, **site-specific operational challenges** (10.07%), reflects issues such as restricted access, terrain limitations, and environmental conditions. This finding is supported by

Jaafar et al. (2021), Sutt et al. (2013), and Salih et al. (2019), who observed that physical and contextual site characteristics significantly influence layout feasibility and logistics planning.,

Final contractual **limitations** received the lowest weight (7.14%), suggesting a comparatively lower but still relevant impact on site utilization planning. Studies by Buniya et al. (2021), and Wang et al. (2016) further explain that rigid contract provisions may restrict adaptive site planning,while contractual frameworks influence operational flexibility but typically become critical only when combined with other dominant constraints

AHP-Data Analysis of Resource Constraints

Based on the comprehensive research procedure detailed in the preceding AHP, the final summary of results was systematically derived. Each finding is directly linked to its source data and foundational calculations, all of which are presented for verification in Resource Constraints**Appendix IV**.

Table 18 Criteria Weight - Resource Constraints

Resource Constraints	Symbolized	Criteria Weighted	Rank
Site and Space Limitations	RC1	49.34	1
Location of site (down town ,confined area urban)	RC3	30.20	2
Lack of technological equipment for Site Utilization Planning	RC4	12.95	3
Lack of budget for CSUP	RC2	7.51	4

Site and space limitations were identified as the most dominant barrier to the implementation of CSUP, receiving a priority rate of 49.34%. This finding aligns with previous studies indicating that restricted site conditions are common obstacles in urban construction projects(bin Mamat, 2014). The location of the site particularly when situated in downtown or other confined urban areas was ranked as the second major barrier, with a priority rate of 30.20%.

Lack of technological equipment for site utilization planning emerged as the third barrier, accounting for 12.95%, consistent with literature noting that insufficient technological support limits modern planning practices (Andy, 2010). Finally, lack of budget for CSUP was ranked fourth, with a priority rate of 7.51%, indicating that financial constraints significantly affect the ability to plan and implement effective site layouts (Bogale, 2020).

AHP Temporary Facilities Characteristics

Based on the comprehensive research procedure detailed in the preceding AHP, the final summary of results was systematically derived. Each finding is directly linked to its source data and foundational calculations, all of which are presented for verification in Temporary Facilities Characteristics **Appendix IV.**

Table 19 Temporary Facilities Characteristics

Temporary Facilities Characteristics	Symbolized	criteria weighted	Rank
Improper utilization available site space	TFC2	46.57	1
Improper Facility and Equipment Placement	TFC1	18.05	2
Equipment Movement and Accessibility Issues	TFC3	13.97	3
Inefficient Layout and Space Utilization	TFC4	11.14	4
Out-dated Temporary Facilities	TFC5	10.26	5

Improper utilization of available site space was identified as the most dominant barrier to the implementation of CSUP, receiving the highest priority rate at 46.57%. The second major barrier was improper facility and equipment placement, which accounted for 18.05% and reflects how poorly positioned temporary facilities such as offices and storage areas can disrupt workflow(bin Mamat, 2014).

Equipment movement and accessibility issues ranked third, with a priority rate of 13.97%, followed by inefficient layout and overall space utilization, which accounted for 11.14%. The fifth significant barrier was the use of outdated temporary facilities, contributing 10.26% and highlighting the challenges posed when facilities fail to meet modern operational and safety standards (Abdelalim, 2024).

AHP Knowledge and understanding

Based on the comprehensive research procedure detailed in the preceding AHP, the final summary of results was systematically derived. Each finding is directly linked to its source data and foundational calculations, all of which are presented for verification in Knowledge and understanding**Appendix IV.**

Table 20 Criteria Weight - Knowledge and understanding

Knowledge and understanding	Symbolized	criteria weighted	Rank
Limited Understanding of Site Layout Planning	KU1	53.35	1
Resistance to adopt advanced technologies	KU4	21.25	2
Poor technology for optimal use of resources	KU2	17.27	3
Absence of common acceptable standard	KU3	8.13	4

Limited understanding of site layout planning was identified as the most dominant barrier to the implementation of CSUP, with a priority rate of 53.35%. This lack of understanding often leads to suboptimal design decisions(Whitman, et al., 2021). Resistance to adopting advanced technologies was ranked as the second major barrier, receiving a priority rate of 21.25%, as reluctance to use tools such as BIM and drones reduces planning accuracy and efficiency(Kim, 2021).

Poor technology for optimal resource utilization followed as the third barrier with a priority rate of 17.27%. The absence of a commonly acceptable standard was ranked fourth, with a priority rate of 8.13%, as the lack of standardized guidelines results in inconsistent practices(Elbeltagi, 2004). Contractual limitations were also identified as a significant barrier, ranked fifth with a priority rate of 7.14%.

AHP-DataAnalysisofKPIs Supporting Site Utilization Effectiveness

AHP- DataAnalysis fortheMain ThreeCategories

The next step was to compute a vector of priorities or weighting of components in the matrix after getting the average pairwise evaluations of participants regarding the significance of the three primary categories of site layout KPIs.

Step 1: Add up the pairwise comparisons matrix's column. The entire sum of each column of the Pair-wise Comparisons matrix can be found by inserting the average score values of the respondents' responses. Using the first and second columns of the Pairwise Comparisons matrix as an example, this is demonstrated.

Column 1: (1 + 0.29 + 0.34 = 1.64); similarly, the sum of all the columns was computed and added.

Table 21 Pair-Wise Comparisons Prioritization of KPIs Site Utilization Effectiveness

Prioritization of KPIs Supporting Site Utilization Effectiveness			
Main Criteria Comparison	SRM	MMI	SUFI
SRM	1	3.42	2.9
MMI	0.29	1	0.33
SUFI	0.34	3.03	1
sum	1.64	7.45	4.23

Step 2. Normalize the comparison

To normalize each columns of Pair-wise comparisons matrix to a total sum of 1.0 or 100%, each elements of the column was divided by the total sum of respective column.

Table 22Normalized Pairwise Matrix Three Main Indicator Categories

Normalized pair -wise comparison Matrix						
Main Criteria Comparison	SRM	MMI	SUFI	sum	criteria weights	criteria weight%
SRM	0.61	0.46	0.69	1.76	0.59	58.51
MMI	0.18	0.13	0.08	0.39	0.13	13.03
SUFI	0.21	0.41	0.24	0.85	0.28	28.46
	1	1	1	3	1	100

Step2 aftertheentireconsistencymatrix

Table 23Consistency Calculation of Three Main Indicator Categories

Calculating consistency						
CW	0.59	0.13	0.28			
Main Criteria Comparison	SRM	MMI	SUFI	weighted sum value	criteria weight	WSV/CW
SRM	0.59	0.45	0.83	1.86	0.59	3.17
MMI	0.17	0.13	0.09	0.4	0.13	3.03
SUFI	0.2	0.39	0.28	0.88	0.28	3.1
						3.1

Step 4: λ max is calculated of the consistency index, the consistency ratio was determined as 0.09 using the RI value of 0.52. The consistency ratio of 0.09 obtained from the AHP data analysis is acceptable because it is less than the threshold value of 0.10.

Table 24 Criteria Weight of Three Main Indicator Categories

Main Indicator	Symbolized	Criteriaweight (CW)	Rank
Safety and Risk Mitigation Indicators	SRM	58.51	1
Site Utilization Facility Indicators	SUFI	28.46	2
MaterialManagement Indicators	MMI	13.03	3

Safety is consistently identified as the most critical factor in site utilization planning. This aligns with regulatory requirements, ethical responsibility, and the direct impact of safety on project continuity, cost, and reputation bin Mamat (2014), emphasizes safety as a top priority in construction site planning.

Site Utilization Facility put in second Facility planning directly affects workflow efficiency, worker productivity, and spatial optimization. While material management is essential, but it's lower ranking.

AHP-Data Analysis for Safety Considerations and risk mitigation

Criteria Weight – Safety Considerations and risk mitigation

Safety Considerations & risk mitigation	**Symbolized**	**criteria weighted(CW)**	**Rank**
Provision PPE equipment	SRM5	35.56	1
Safety Zones	SRM3	28.17	2
Safety, Security, and Signage	SRM2	15.25	3
Hazard Mitigation	SRM4	12.08	4

Emergency plan and procedures	SRM1	8.95	5

PPE Equipment is the top-ranked KPI in your AHP results, emphasizing its role as a foundational safety measure (Belyu Bogale, 2020; Mohammadi et al., 2018). Safety Zones rank second, supported by studies on spatial zoning and effective safety planning (Andy & Price, 2010; Jaafar et al., 2021). Safety, Security, and Signage follow in third place, clear signage and proper security systems help prevent accidents on construction sites (Sutt et al., 2013; Dhanjode, 2010). Although Hazard Mitigation and Emergency Plans rank lower in the AHP results, they remain essential components of regulatory requirements and best-practice safety frameworks (Whitman, 2008).

AHP-DataAnalysisforMaterialManagementCategory

Based on the comprehensive research procedure detailed in the preceding AHP, the final summary of results was systematically derived. Each finding is directly linked to its source data and foundational calculations, all of which are presented for verification in MaterialManagementCategory**Appendix V.**

Table 25 Criteria Weight – Material Management

MaterialManagementIndicators	Symbolized	(CW)	Rank
Material Management Awareness	MMI4	33.85	1
Material Utilization Efficiency	MMI1	24.42	2
Strategic Material Storage	MMI3	15.15	3
Waste and Excess Control	MMI5	14.68	4
Timely and Accurate Delivery	MMI2	11.89	5

Material management awareness highest the importance of stakeholders being well-informed about material requirements, handling procedures, and inventory tracking. Improving this awareness helps reduce issues such as material misplacement, over ordering, and theft, as noted by (Bogale, 2020)&(Abdelalim, 2024).

In addition second, material utilization efficiency has a direct impact on cost control and waste reduction, since inefficient use of materials can lead to increased project expenses and delays, a concern emphasized by(Whitman, et al., 2021).Strategic material storage put on third is also essential, requiring proper planning with respect to proximity to work areas, security measures, and environmental protection to maintain material quality and ensure workflow continuity.

AHP-DataAnalysis forSite Utilization Facility Indicators

Based on the comprehensive research procedure detailed in the preceding AHP, the final summary of results was systematically derived. Each finding is directly linked to its source data and foundational calculations, all of which are presented for verification in Site Utilization Facility Indicators **Appendix V**.

Table 26 Criteria Weight - Site Utilization Facility Indicators

Site Utilization Facility Indicators	Symbolized	Criteriaweighted (CW)	Rank
Site Offices and Administrative Facilities	SUFI2	44.36	1
Utility and Essential Services Availability	SUFI3	30.0	2
Access and Circulation Infrastructure	SUFI1	17.60	3
Welfare and Worker Support Facilities	SUFI4	8.04	4

Site Offices and Administrative Facilities emerged as the top priority, underscoring the critical role of well-located and functional administrative spaces in enhancing coordination, supervision, and communication among project stakeholders(bin Mamat, 2014)&(Bogale, 2020), who emphasize that effective site offices improve decision-making and project oversight.

Utility and Essential Services Availability ranked second, highlighting the importance of uninterrupted access to water, electricity, and telecommunications for seamless construction operations. Studies by(Whitman, et al., 2021)&(Abdelalim, 2024) confirm that utility reliability directly impacts productivity and reduces downtime.

Access and Circulation Infrastructure was identified as the third most important KPI. Efficient movement of personnel, materials, and equipment is vital for minimizing delays and congestion, as supported by (Michael, 2021) & (Andy & Price, 2010).

Welfare and Worker Support Facilities, while ranked fourth, remains essential for worker well-being, safety, and morale(Selki, 2019)indicates that adequate welfare facilities contribute to higher productivity and compliance with health and safety regulations.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Functional zoning structures and moderate stakeholder communication represent notable strengths in planning and coordination. However, significant deficiencies persist in logistical and spatial execution, particularly concerning material flow, access routes, and storage elements that received the lowest performance scores. While essential facilities are generally present on-site, they are often poorly planned and underutilized, revealing a critical gap between availability and effective application. Among the enabling factors for improvement, collaborative planning and clearly defined zoning are perceived as top success drivers. Conversely, the adoption of digital tools such as BIM remains markedly low, representing a significant technological gap in the local industry. Importantly, active stakeholder involvement is strongly correlated with enhanced cost control and improved on-site safety outcomes.

During the study, several factors were identified as obstacles to the effective implementation of a construction site utilization plan. Among these obstacles, the most significant category was Resource Constraints, which included site and space limitations, the location of the site (downtown, confined urban areas), lack of technological equipment for site utilization planning, and lack of budget for CSUP. Next in line were Technical and Operational Issues, such as tight schedules and overlapping activities, limited on-site expertise, lack of technical support, site-specific operational challenges, and contractual limitations. The third major obstacle was Organizational Challenges, including poor leadership and decision-Making, poor communication and workflow, an ineffective organizational structure, and lack of stakeholder involvement. Additional barriers included Temporary Facilities Characteristics, such as improper utilization of available site space, improper facility and equipment placement, equipment movement and accessibility issues, inefficient layout and space utilization, and outdated temporary facilities. Finally, Knowledge and Understanding constraint were identified, including limited understanding of site utilization planning, resistance to adopting advanced technologies, poor technology for optimal resource use, and the absence of commonly accepted standards.

Conversely, the study also identified several critical KIP factors that contribute to the successful implementation of a construction site utilization plan. The most influential enabler was Safety and Risk Mitigation Indicators, which include the provision and availability provision PPE equipment, safety zones, security measures, signage, hazard mitigation, and emergency plans and procedures. The second category, Site Utilization Facility Indicators, is supported by the provision of site offices and administrative facilities, availability of utilities and essential services, access and circulation infrastructure, and welfare and worker support facilities. The third category, Material Management, encompasses awareness, material utilization efficiency, strategic material storage, waste and excess control, and timely and accurate delivery, which falls under the Site Utilization Facility Indicators category.

5.2 Recommendation

Based on the conclusions presented, the following recommendations are suggested.

5.2.1 Recommendation for Construction Stakeholders

Contractor

- Enhance the logistics of material flow and access by using BIM or similar tools to model and optimize these elements early in the design process. Studies indicate that BIM improves site logistics by addressing scheduling and space constraints.

- Enhance safety and welfare infrastructure by prioritizing disaster recovery measures, establishing PPE stations, and ensuring clear access corridors as essential structural components of the site.
- Enhance logistics planning by conducting comprehensive evaluations of load management, routing, and storage. To reduce inefficiencies, implement warehouse zoning near work zones and improve inventory tracking.
- Ensure regular site meetings and implement necessary modifications to the layout. Establish weekly site mobilization evaluations focusing on active workflows, access, and routing, and standardize the development of temporary facilities.
- Utilize performance-based KPIs linked to evaluations and rewards, such as flow efficiency and access incidents.

Consultant

- Design plans that incorporate safe pathways, equipment routes, and designated material zones.
- Offer standards and upgrades in digital processes. Provide best-practice checklists, templates, and shared data environments for safety planning, modelling, and BIM-based layout.

Client

- Provide incentives for stakeholder cooperation: to avoid delays and safety issues, link contract gains to early stakeholder involvement, planning quality, and communication. Encourage the adoption of new technologies.
- To encourage the application of technologies that enable real-time tracking and decision optimization, allocate reserve funding for digital tools such as BIM systems, logistics apps, and drones.

5.2.2 Recommendations for Future Work

- A guideline that enhances construction site utilization strategy planning in Ethiopia is one instance of the additional work needed to improve these planning practices.

- To effectively assess site utilization issues across diverse spatial and regulatory contexts, future research should include infrastructure and rural construction projects.

BIBLIOGRAPHY

Abdelalim, A. A. a. A. K., 2024. Construction site layout planning.. *Journal of Engineering, Management and Competitiveness,* 14(1), pp. 3-20.

Abera, Y., 2021. Challenges on successful completion and delivery of public building construction projects: the case of west Shoa zone, Oromia, Ethiopia.. *Indian Journal of Science and Technology, ,* Volume 14, pp. 1534-1544.

Adeagbo, D. D. A. (. I. h. c. ". D. A. i. t. s. f. ". A. a. I. Y., 2019. Safety practices on building construction sites for sustainable development in Nigeria.. *Journal of Sustainable Development in Africa,* 21(4).

Adeagbo, D. D. A. a. I. Y., 2019. Safety practices on building construction sites for sustainable development in Nigeria.. *Journal of Sustainable Development in Africa,* 21(4), pp. 45-60.

Adewuyi, T., 2015. Factors affecting material waste on construction sites in Nigeria.. *Journal of Engineering and Technology.*

Ajayi, V., 2017. Primary sources of data and secondary sources of data.. *Benue State University,* 1(1-6), p. 1.

Al Hawarneh, A. B. S. a. G. F., 2021. Construction site layout planning problem: Past, present and future.. *Expert Systems with Applications,,* 168(114247).

Alemu, A. Y. M. A. A. a. K. S., 2020. Utilization of personal protective equipment and associated factors among building construction workers in Addis Ababa, Ethiopia, 2019. *BMC Public Health,* 20(1), p. 794.

Alghamdi, M. B. T. a. R. Y., 2022. Reviewing the effects of deploying building information modelling (BIM) on the adoption of sustainable design in Gulf countries: A case study in Saudi Arabia.. *City, Territory and Architecture,* 9(1), p. 18.

Andayesh, M. a. S. F., 2013. Dynamic site layout planning through minimization of total potential energy.. *Automation in Construction,* pp. 92-102.

Andy, K. a. P. D., 2010. Causes Leading to poor site coordination in building projects.. *Organization, Technology & Management in Construction: An International Journal,* 2(2), pp. 167-172.

Ayalew, T. D., 2016. Assessment on performance and challenges of Ethiopian construction industry.. *Journal of Architecture and Civil Engineering,* 2(11).

Aziz, R. a. H. S., 2013. Applying lean thinking in construction and performance improvement.. *Alexandria Engineering Journal (Italicized),* 52(4), pp. 679-695.

Bascoul, A. T. I. a. D. D., 2020. Visual management of daily construction site space use.. *Frontiers in Built Environment,* Volume 6, p. 139.

Belay, S. G. J. W. A. a. R. S., 2021. Enhancing BIM implementation in the Ethiopian public construction sector: an empirical study.. *Cogent Engineering,* 8(1), p. 1886476.

BELLETE, H., 2020. A Phenomenological Study of the Perceptions Towards BIM Adoption Barriers and Strategies in Addis Ababa Construction Industry. *Doctoral dissertation,ADDIS ABABA SCIENCE AND TECHNOLOGY UNIVERSITY.*

Belton, V. a. S. T., 2012. *Multiple criteria decision analysis: an integrated approach.* New York: Springer Science & Business Media.

Bhatt, M. H. J. K. O. a. D. F., 2010. *Modelling functional requirements in spatial design..* Berlin, Heidelberg, Springer Berlin Heidelberg.

bin Mamat, M. a. b. M. Z. R., 2014. Site Layout Design That Ensures the Efficiency at Construction Site..

bin Mamat, M. a. b. M. Z. R., 2014. Site Layout Design That Ensures the Efficiency at Construction Site.. *Jurnal Teknologi,* 70(7), pp. 79-83.

Birewar, R., 2021. *Generative design for construction site layout planning..* West Lafayette, IN.: Purdue University.

Bogale, B., 2020. Investigation on the Current Practice of Local Contractor on Site Layout Planning In Bahir Dar City Public Buildings.. *Doctoral dissertation.[Bahir Dar University]..*

Boone Jr, H. a. B. D., 2012. Analyzing likert data. *The Journal of extension,* 50(2), p. p.48.

Borges, M. G. A. a. M. A., 2024. A Hybrid Framework for Multi-Objective Construction Site Layout Optimization.. *Buildings,* 14(12).

Borges, M. G. A. a. M. A., 2024. A Hybrid Framework for Multi-Objective Construction Site Layout Optimization.. *Buildings,* 14(12).

Buniya, M. O. I. S. R. K. A. M. E. a. A. H., 2021. Barriers to safety program implementation in the construction industry.. *Ain Shams Engineering Journal,* 12(1), pp. 65-72.

Buniya, M. O. I. S. R. K. G. D. S. I. S. A.-A. M. a. L. H., 2021. Critical success factors of safety program implementation in construction projects in Iraq.. *nternational Journal of Environmental Research and Public Health,* 18(16), p. 8469.

Chau, K. A. M. a. Z. J., 2004. Four-dimensional visualization of construction scheduling and site utilization. *Journal of construction engineering and management,* 130(4), pp. 598-606.

Cheng, M. a. D. M., 2021. Construction schedule risk assessment and management strategy for foreign general contractors working in the Ethiopian construction industry.. *Sustainability,* 13(14), p. 7830.

Chochoms, M., 2016. *Confined Space Evaluation Student Manual, # 19613,* Los Alamos, NM: Los Alamos National Laboratory (LANL).

Cho, K. H. T. a. H. C., 2013. Space zoning concept-based scheduling model for repetitive construction process.. *Journal of Civil Engineering and Management,* 19(3), pp. 409-421.

Choudhry, R. F. D. a. M. S., 2007. The nature of safety culture: A survey of the state-of-the-art.. *Safety Science,* 45(10), pp. 993-1012.

Clark, R. a. C. V., 2022. The use of mixed methods to advance positive psychology: a methodological review.. *International Journal of Wellbeing,* 12(3).

Cochran, W., 1977. *Sampling techniques.* New York: John Wiley & Sons Inc..

Creswell, J. a. C. J., 2014. *Research design: qualitative, quantitative and mixed methods approaches.* United State of America : Sage Publications.

Dalalah, D. A.-O. F. a. H. M., 2010. Application of the Analytic Hierarchy Process (AHP) in multi-criteria analysis of the selection of cranes.. *Jordan Journal of Mechanical & Industrial Engineering,* 4(5).

Darko, A. Z. C. a. C. A., 2017. Drivers for green building: A review of empirical studies. *Habitat International ,* Volume 60, pp. 34-49.

Dawadi, S. S. S. a. G. R., 2021. Mixed-methods research: A discussion on its types, challenges, and criticisms.. *Journal of Practical Studies in Education,* 2(2), pp. 25-36.

Dixit, M. V. V. P. F. B. J., 2022. Site logistics factors impacting resource use on construction sites: A Delphi study.. *Frontiers in Built Environment,* Volume 8, p. 858135..

El Asmar, M. H. A. a. L. W., 2013. Quantifying performance for the integrated project delivery system as compared to established delivery systems. *ournal of Construction Engineering and Management,* 139(11), p. 04013012 .

Elbeltagi, E. H. T. a. E. A., 2004. Dynamic layout of construction temporary facilities considering safety.. *Journal of Construction Engineering and Management,* 130(4), pp. 534-541.

Foster, J., 1998. *Data Analysis Using SPSS for Windows-Version 6: A Beginner's Guide..* London: Sage.

Ganiyu, S. a. O. G., 2021. *Construction site layout planning methods: an analytical review.Proceedings of the IDoBE International Conference on Uncertainty in the Built Environment: How can we build a resilient future in the new normal?.* London, s.n.

Gliem, J. a. G. R., 2003. *Calculating, interpreting, and reporting Cronbach's alpha reliability coefficient for Likert-type scales..* s.l., Midwest Research-to-Practice Conference in Adult, Continuing, and Community Education.

Goepel, K., 2013. *Implementing the analytic hierarchy process as a standard method for multi-criteria decision making in corporate enterprises–a new AHP excel template with multiple inputs..* Kuala Lumpur, Creative Decisions Foundation.

Goodfellow, T., 2017. Urban fortunes and skeleton cityscapes: real estate and late urbanization in Kigali and Addis Ababa.. *International Journal of Urban and Regional Research,* 41(5), pp. 786-803.

Groves, R. F. J. F. C. M. L. J. S. E. a. T. R., 2011. *Survey methodology.* Hoboken, NJ: John Wiley & Sons..

Hailemarkos, H., 2020. *Ethiopian construction project management maturity model determination and correlational prediction of project success..* s.l.:s.n.

Hammad, A. A. A. a. R. D., 2016. A multi-objective mixed integer nonlinear programming model for construction site layout planning to minimise noise pollution and transport costs.. *Automation in Construction,* Volume 61, pp. 73-85.

Hammad, A. d. C. B. S. C. a. H. A., 2021. The use of unmanned aerial vehicles for dynamic site layout planning in large-scale construction projects. *Buildings,* 11(12), p. 602.

Hammad, A. d. C. B. S. C. a. H. A., 2021. The use of unmanned aerial vehicles for dynamic site layout planning in large-scale construction projects. *Buildings,* 11(12), p. 602.

Handy, S. B. M. E. R. K. R., 2002. How the built environment affects physical activity: views from urban planning.. *American Journal of Preventive Medicine,* 23(2), pp. 64-73.

Hansen, S., 2021. Lessons learned from construction site layout planning practices.. *Ingeniería e Investigación,* 44(4), p. 9.

Hughes, P. a. F. E., 2012. *Introduction to health and safety in construction.* Abingdon, UK: Routledge.

Ismail, O. N. A. S. H. a. E. H., 2025. 4D-BIM based dynamic construction site layout planning.. *Journal of Umm Al-Qura University for Engineering and Architecture,* 16(4), pp. 1499-1518.

Jaafar, K. E. R. &. K. J., 2021. Construction site layout optimization model considering cost and safety in a dynamic environment. *Asian Journal of Civil Engineering,* 22(2), p. 297–312.

Jin, H. Z. M. a. Y. Y., 2018. Analytic network process-based multi-criteria decision approach and sensitivity analysis for temporary facility layout planning in construction projects.. *Applied Sciences,* 8(12), p. 2434.

Jusoh, Z. a. K. N., 2017. Influential factors affecting materials management in construction projects.. *Management and Production Engineering Review,* 8(3).

Kalton, G., 1983. Models in the practice of survey sampling. International Statistical Review / Revue Internationale de Statistique,. 51(2), pp. 175-188.

Kannimuthu, M., 2025. Effective Site Logistics and Spatial Layout Planning for Construction Efficiency. . In: *In: Handbook of Construction Project Management. Singapore.* Singapore: Springer Nature Singapore, pp. 491-525.

Khodabandelu, A. a. P. J., 2021. Agent-based modeling and simulation in construction.. *Automation in Construction,* Volume 131, p. 103882.

Kibert, C., 2016. *Sustainable construction: green building design and delivery.* Hoboken, NJ for Wiley: John Wiley & Sons.

Kim, M. R. H. a. K. T., 2021. A typology model of temporary facility constraints for automated construction site layout planning.. *Applied Sciences,* 11(3), p. 1027.

Koroso, N., Lengoiboni, M. & Zevenbergen, J., 2021. Urbanization and urban land use efficiency: Evidence from regional and Addis Ababa satellite cities, Ethiopia. *Habitat International,* Volume 117, p. 102437.

LaGro Jr, J., 2011. *Site analysis: A contextual approach to sustainable land planning and site design..* Hoboken, New Jersey: John Wiley & Sons.

Lim, W. M., 2025. 'What Is Qualitative Research? An Overview and Guidelines'. *Australasian Marketing Journal.*

Lindskog, E. B. J. V. J. a. J. B., 2016. Layout planning and geometry analysis using 3D laser scanning in production system redesign. *Procedia CIRP,* Volume 44, p. 126–131.

Mawdesley, M. A.-J. S. a. Y. H., 2002. Genetic algorithms for construction site layout in project planning.. *Journal of Construction Engineering and Management,* 128(5), pp. 418-426.

Mengistu, D. A. D. a. H. H., 2024. Technology and innovation development in Ethiopian construction industry: The challenges and improvement mechanisms.. *Journal of Engineering, Design and Technology,* 22(6), pp. 1936-1957.

Mengistu, D. a. M. G., 2020. Challenges in developing the Ethiopian construction industry.. *African Journal of Science, Technology, Innovation and Development,* 12(4), pp. 373-384.

Messner, J., 2023. BIM project execution planning guide. *Computer Integrated Construction Research Program.*

Mok, K. S. G. a. Y. J., 2015. Stakeholder management studies in mega construction projects: A review and future directions.. *International journal of project management,* 33(2), pp. 446-457.

Mu, E. a. P.-R. M., 2016. Practical Decision Making: An Introduction to the Analytic Hierarchy Process (AHP) Using Super Decisions V2.. *Cham: Springer..*

Naoum, S., 2012. *Dissertation research and writing for construction students.* Abingdon : Routledge..

Nassauer, J., 2012. Landscape as medium and method for synthesis in urban ecological design.. *Landscape and Urban Planning,* 106(3), pp. 221-229.

Ning, X. L. K. a. L. M., 2011. A decision-making system for construction site layout planning.. *Automation in Construction,* 20(4), pp. 459-473.

Nwabuko, O., 2024. An overview of research study designs in quantitative research methodology. *American Journal of Medical and Clinical Research & Reviews,* 3(5), pp. 1-6.

Ofori, G., 2015. Nature of the construction industry, its needs and its development: A review of four decades of research.. *Journal of Construction in Developing Countries,* 20(2), p. 115.

Oseghale, G. A. J. a. O. B., 2021. Evaluation of material management methods in selected building construction sites in Abuja and Lagos state, Nigeria.. *American Journal of Mechanical and Materials Engineering,* 5(1), pp. 11-17.

Oseghale, G. E. A. J. D. &. O. B., 2021. Evaluation of Material Management Methods in Selected Building Construction Sites in Abuja and Lagos State, Nigeria.. *American Journal of Mechanical and Materials Engineering,,* 5(1), pp. 11-17..

Osman, H. G. M. a. I. M., 2003. A hybrid CAD-based construction site layout planning system using genetic algorithms.. *Automation in construction,* 12(6), pp. 749-764.

Östlund, U. K. L. W. Y. a. R.-D. N., 2011. Combining qualitative and quantitative research within mixed method research designs: a methodological review. *International Journal of Nursing Studies (in italics),* Volume 48(3), pp. 369-383.

Patel, K. a. V. C., 2011. *Construction materials management on project sites.National Conference on Recent Trends in Engineering & Technology.* Bhavnagar, India, s.n.

Pheng, L. a. H. L., (2019). *The economy and the construction industry.Construction quality and the economy: A study at the firm level.* Singapore: Springer Singapore.

Prajapati, S. G. R. a. P. M., 2016. Causes and effects of cost overrun on construction projects in Madhya Pradesh. *International Journal of Engineering Development and Research,* Volume 2, p. 4.

Rahman, M. T. M. S. A. A. S. a. R. M., 2022. Sampling techniques (probability) for quantitative social science researchers: a conceptual guidelines with examples. *Seeu Review,* 17(1), pp. 42-51.

Rattray, J. a. J. M., 2007. Essential elements of questionnaire design and development.. *Journal of Clinical Nursing,* 16(2), pp. 234-243.

Saaty, T., 2008. Decision making with the analytic hierarchy process.. *International journal of services sciences,* 1(1), pp. 83-98.

Saaty, T. a. S. M., 2010. The Analytic Hierarchy and Analytic Network Measurement Processes: The measurement of intangibles: Decision making under benefits, opportunities, costs and risks.. In: *Handbook of multicriteria analysis.* Berlin, Heidelberg: Springer Berlin Heidelberg, p. 91–166.

Sacks, R. K. L. D. B. O. R., 2010. Interaction of lean and building information modeling in construction.. *Journal of Construction Engineering and Management,* 136(9), pp. 968-980.

Sadeghpour, F. a. A. M., 2015. The constructs of site layout modeling: an overview. *Canadian Journal of Civil Engineering,* 42(3), p. 199–212.

Sadeghpour, F. a. A. M., 2015. The constructs of site layout modeling: an overview.. *Canadian Journal of Civil Engineering,* 42(3), pp. 199-212.

Sadeghpour, F. a. A. M., 2015. The constructs of site layout modeling: an overview.. *Canadian Journal of Civil Engineering,* 42(3), pp. 199-212.

Said, H. a. E.-R. K., 2013. Performance of global optimization models for dynamic site layout planning of construction projects.. *Automation in Construction,* Volume 36, pp. 71-78.

Saka, E., 2023. An analysis of the questions on mathematical literacy designed by mathematics teachers with a postgraduate degree.. *Journal of Theoretical Educational Science,* Volume 16, pp. 617-640.

Sanad, H. A. M. a. I. M., 2008. Optimal construction site layout considering safety and environmental aspects.. *Journal of Construction Engineering and Management,* 134(7), pp. 536-544.

Sanad, H. A. M. a. I. M., 2008. Optimal construction site layout considering safety and environmental aspects.. *Journal of Construction Engineering and Management,* 134(7), pp. 536-544.

Selki, H. O. A. D. O. a. A. A., 2019. Performance evaluation of construction project in Erbil city by adopting site layout planning. *Performance Evaluation.*

Selki, H. O. A. D. O. a. A. A., 2019. Performance evaluation of construction project in erbil city by adopting site layout planning.. *Performance Evaluation,* p. 595.

Singh, A., 2015. *Tests, measurements and research methods in behavioural sciences..* Patna : Bharati Bhawan..

Small, E. a. B. M., 2016. Examination of job-site layout approaches and their impact on construction job-site productivity.. *Procedia Engineering,* Volume 164, pp. 383-388.

Sokido, D., 2016. Density in Relation to Patterns of Built-forms (Case Study: Addis Ababa, Ethiopia)..

Song, X. X. J. S. C. P.-M. F. a. Z. Z., 2017. A decision making system for construction temporary facilities layout planning in large-scale construction projects.. *International Journal of Civil Engineering,* 15(2), pp. 333-353.

Son, J., 2022. Complexity and dynamics in construction project organizations. *Sustainability,* 14(20), p. 13599..

Summerhayes, S., 2016. *CDM Regulations 2015 Procedures Manual.* Chichester : John Wiley & Sons.

Sutt, J. L. I. a. M. O., 2013. *The Engineer's Manual of Construction Site Planning.* s.l.:John Wiley & Sons.

Tafesse, S., 2021. Material waste minimization techniques in building construction projects.. *Ethiopian Journal of Science and Technology,* 14(1), pp. 1-19.

Taherdoost, H., 2016. Validity and reliability of the research instrument; how to test the validation of a questionnaire/survey in a research. *International Journal of Academic Research in Management (IJARM),* 5(3), p. 28–36.

Tanku, M., 2024. Rethinking urban spatial planning and industrial development approaches in Ethiopia: bridging gaps for better outcomes.. *Frontiers of Urban and Rural Planning,* 2(1), p. 17.

Tsegay, F. E. B., 2023. Construction site layout planning practices in inner-city building projects: space requirement variables, classification and relationship.. *Urban, Planning and Transport Research,* 11(1), p. 2190793 .

Vaidya, O. a. K. S., 2006. Analytic hierarchy process: An overview of applications.. *European Journal of Operational Research,* 169(1), pp. 1-29..

Vanclay, F., 2002. Conceptualising social impacts. *Environmental impact assessment review,* 22(3), pp. 183-211.

Vimonsatit, V. a. L. M., 2014. *Use of BIM tools for site layout planning..* s.l., [Proceedings of the 4th International Conference on Structural Engineering and Construction Management (ICSECM.

Walker, A., 2015. *Project Management in Construction.* New Jersey, USA : John Wiley & Sons.

Wang, J. Z. P. a. L. P., 2016. Critical factors and paths influencing construction workers' safety risk tolerances.. *Accident Analysis & Prevention (Italicized),* Volume 93, pp. 267-279.

Wasti, S. S. P. v. T. E. S. B. a. B. I., 2022. The growing importance of mixed-methods research in health. *Nepal Journal of Epidemiology,* 12(1), p. 1175.

Wei, W. a. G. C., 2018. Effective Strategy and Practice of Construction Site Management in Construction Engineering.. *In IOP Conference Series: Earth and Environmental Science,* 189(2), p. 022039.

Whitman, J., Deshpande, A., Zech, W. & Perez, M., 2021. Construction site utilization planning: A process based upon industry best practices. *CivilEng,* 2(2), p. 309–324.

Wolday, S., 2025. *Factors affecting project management success: the case of selected building construction in Addis Ababa.,* , Addis Ababa.: St. Mary's University.

Yimam, A., 2011. *Project management maturity in the construction industry of developing countries (the case of Ethiopian contractors).,* College Park, MD: University of Maryland.

Zavadskas, E. T. Z. a. T. J., 2010. Risk assessment of construction projects.. *Journal of Civil Engineering and Management,* 16(1), pp. 33-46.

Zewdu, Z., 2015. Causes of contractor cost overrun in construction projects: The case of Ethiopian construction sector. *International Journal of Business and Economics Research,* Volume 4(4), pp. pp. 180-191.

Zhong, S. E. H. a. E. H., 2022. Key factors affecting the decision-making process for buildings projects in Egypt.. *Ain Shams Engineering Journal,* 13(3), p. 101597.

Zolfagharian, S. a. I. J., 2014. Current trends in construction site layout planning.Construction Research Congress 2014: Construction in a Global Network. *American Society of Civil Engineers (ASCE),* pp. 1723-1732.

Zouein, P. a. T. I., 2001. Improvement algorithm for limited space scheduling.. *Journal of construction engineering and management,* 127(2), pp. 116-124.

Appendix: I Questionnaire Structure

Title Optimizing Space Utilization on Construction Sites in Addis Ababa

Introduction:

Dear Participant,

I am Genet Shewangizaw, a graduate student pursuing an MSc in Construction Management at Addis Ababa University, EiABC. I am conducting a research study aimed at evaluating current practices, identifying challenges, and exploring strategies to improve the efficient use of space on construction sites within Addis Ababa.

Your insights as a construction professional are invaluable in understanding the realities of site management and in formulating practical recommendations to enhance project performance.

Please be assured that all responses will remain strictly confidential and will be used solely for academic purposes. The survey is expected to take approximately 20–25 minutes to complete.

Thank you for your time and valuable contribution to this research.

Sincerely,

Genet Shewangizaw

Graduate Student – MSc in Construction Management

Addis Ababa University, EiABC

Department of Construction Management

Section 1: Respondent Information

This section collects demographic and background information to support the analysis of responses.

1. Role in the Construction Project:

☐ Project Manager ☐ Site Supervisor ☐ Subcontractor ☐ Architect ☐ Engineer ☐ Client

☐other (please specify): __________

2. Years of Experience in Construction:

☐ 1–3 years ☐ 3–5 years ☐ 5–10 years ☐ More than 10 years

3. Sex:

☐ Male ☐ Female

4. Highest Degree Qualification:

☐ Diploma ☐ Bachelor's Degree ☐ Master's/Professional Degree ☐ Doctorate

5. Field of Highest Degree:

☐ Architecture ☐ Civil Engineering ☐ Construction Management ☐ other (please specify): __________

6. Types of Construction Projects Involved In:

☐ Residential ☐ Commercial ☐ Industrial ☐ Infrastructure ☐ other (please specify): __________

Section 2: General assessment Site Utilization Facility Indicators

no	Site Utilization Facility Indicators	Exist	Not exist
1	Access roads (for vehicles and trucks)		
2	Site offices (for all stakeholders)		
3	Material storage areas		
4	Parking lots		
5	Utility availability (water, power, telecom)		
6	Welfare facilities (toilets, sanitation, drinking water)		
7	Information signs and site maps		
8	Security features (fencing, guard houses, lighting)		
9	Cranes and lifting equipment		
10	Worker accommodations		

Section 3: Objective 1 - Assessing Current Site Utilization Practices

Please indicate your level of agreement with the following statements using a 5-point Likert scale:

no	Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
		1	2	3	4	5
1	Functional zones (e.g., work areas, storage, and welfare) are clearly defined and consistently applied.					
2	Construction operations are carried out smoothly and without disruption.					

3	Material flow across the site is not obstructed by poor layout or disorganized paths.					
4	Material storage areas are well-organized and do not cause delays.					
5	Temporary facilities (offices, toilets, storage) are conveniently located and easily accessible.					
6	Stakeholder communication effectively supports space coordination on the site.					
7	Regular site meetings are contribute to the efficient use and management of site space.					

Section 4: Objective 2: Identifying Key Performance Indicators (KPIs) and Constraints

A. How of Key Performance Indicators (KPIs)

no	Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
		1	2	3	4	5
1	Initial site assessment and analysis significantly improve the effectiveness of site utilization					

2	Clearly defined zoning and functional areas (e.g., work, storage, and welfare) are essential for efficient site utilization					
3	Planning of access and circulation routes significantly does not improves site efficiency					
4	well organized material storage and handling processes reduce site congestion					
5	Regulatory compliance is prioritized in site planning					
6	Stakeholder collaboration supports the success of site layout planning					

B. Impact of Constraints

no	Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
		1	2	3	4	5
1)	Site layout is designed to overcome space limitations and support					
2)	Well-coordinated trade schedules contribute to efficient site utilization.					

3)	Inadequate material handling and poor storage lead to inefficient use of site space.					
4)	lack of collaboration among stakeholders often creates Constraints to effective site utilization					
5)	Digital tools (e.g., BIM) are actively used to improve site layout and utilization.					

Section 5: Objective 3: Evaluating Stakeholder Perceptions on Efficiency and Cost Outcomes

Please indicate your level of agreement with the following statements:

No	Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
		1	2	3	4	5
1	Site utilization planning has an impact on the efficiency of construction projects					
2	Inadequate space management often results in increased project costs					

3	Well-executed site utilization planning supports adherence to project timelines					
4	Insufficient site planning increases the risk of safety incidents					
5	Poor site planning increases the likelihood of safety incidents on-site					
6	Stakeholder involvement in site planning positively affects cost control and risk reduction.					
7	Collaborative planning among stakeholders improves space utilization and site efficiency					
8	Poor site utilization planning has led to increased costs on these projects (e.g., material damage, delays)					
9	Proper allocation of storage zones has helped reduce material handling and associated costs					
10	Inadequate access routes have shown to time loss and cost increases in this projects					

Appendix – II AHP -Based Questionnaire Format

Objective 2: Identifying and Prioritizing Key Performance Indicators (KPIs) and Constraints

This questionnaire is developed as part of a research study titled Enhancing Construction Site Utilization Efficiency: An Evaluation of Implementation in Addis Ababa Building Projects. The primary objective of this section is to identify and prioritize the Key Performance Indicators (KPIs) and Constraints that influence the effective implementation of construction site utilization planning using the Analytic Hierarchy Process (AHP) methodology.

You have been selected to participate in this study due to your expertise and professional experience in the construction industry. Your insights will provide valuable input for developing an objective decision-making framework that can guide improvements in space management practices on building sites across Addis Ababa.

Section 1: Constraints to Effective Implementationthat contribute to the successful for construction site utilization planning.

Main Criteria Comparison

- Organizational Challenges
- Technical and Operational Issues
- Resource Constraints
- Temporary Facilities Characteristics
- Knowledge and Understanding

Constraints to Effective Implementation That Obstruct the Success of Construction Site Utilization Planning					
Main Criteria Comparison	Organizational Challenges	Technical and Operational Issues	Resource Constraints	Temporary Facilities Characteristics	Knowledge and Understanding
Organizational Challenges	1.00				

Technical and Operational Issues		1.00			
Resource Constraints			1.00		
Temporary Facilities Characteristics				1.00	
Knowledge and Understanding					1.00

Sub-criteria Comparisons

- **Organizational challenge**

Sub-criteria	Poor Leadership and Decision-Making	Ineffective Organizational Structure	Poor communication and workflow	Lack of stakeholder involvement
Poor Leadership and Decision-	1.00			

Making				
Ineffective Organizational Structure		1.00		
Poor Communication and Workflow			1.00	
Lack of Stakeholder Involvement				1.00

- **Technical and Operational Issues**

Sub-criteria	Lack of Technical Support	Limited On-Site Expertise	Contractual Limitations	Site-Specific Operational Challenges	Tight schedule and overlapping activity

Lack of Technical Support	1				
Limited On-Site Expertise		1			
Contractual Limitations			1		
Site-Specific Operational Challenges				1	
Tight schedule and overlapping activity					1

- **Resource Constraints**

Sub-criteria	Site and Space Limitations	Location of site (down town ,confined area	Lack of technological equipment for site layout	Lack of budget for CSUP

		urban)	planning	
Site and Space Limitations	1			
Location of site (down town ,confined area urban)		1		
Lack of technological equipment for site layout planning			1	
Lack of budget for CSUP				1.00

- **Temporary Facilities Characteristics**

Sub-criteria	Improper Facility and Equipment Placement	Improper utilization available site space	Equipment Movement and Accessibility	Inefficient Layout and Space Utilization	Out dated Temporary Facilities

			Issues		
Improper Facility and Equipment Placement	1				
Improper utilization available site space		1			
Equipment Movement and Accessibility Issues			1		
Inefficient Layout and Space Utilization				1	
Out-dated Temporary Facilities					1

- **Knowledge and understanding**

Sub-criteria	Limited Understanding of Site Layout	Poor technology for optimal use	Resistance to adopt advanced

	Planning	of resources	technologies
Limited Understanding of Site Layout Planning	1		
Poor technology for optimal use of resources		1	
Resistance to adopt advanced technologies			1

Section 2: Prioritization Key Performance Indicators (KPIs) for effective implementation of such planning practices.

Main Criteria Comparison

- Safety and Risk Mitigation
- Site Utilization Facility Indicators
- Material Management Indicators

Prioritization of KPIs Supporting Site Utilization Effectiveness

Main Criteria Comparison	Site Utilization Facility Indicators	Material Management Indicators	Safety and Risk Mitigation
Site Utilization Facility Indicators	1.00		
Material Management Indicators		1.00	
Safety and Risk Mitigation			1.00

- **Safety and Risk Mitigation**

Sub-criteria	Emergency plan and procedures	site Safety Zones	Hazard Mitigation	Provision PPE equipment	Safety, Security, and Signage
Emergency plan and procedures	1.00				
Safety Zones		1.00			
Hazard Mitigation			1.00		
Provision PPE equipment				1.00	
Safety, Security, and Signage					1.00

- **Sub Safety and Risk Mitigation**

Sub-criteria	Access and Circulation Infrastructure	Site Offices and Administrative Facilities	Utility and Essential Services Availability	Welfare and Worker Support Facilities
Access and Circulation Infrastructure	1.00			
Site Offices and Administrative Facilities		1.00		
Utility and Essential Services Availability			1.00	
Welfare and Worker Support Facilities				1.00

- **Material Management Indicators**

Sub-Criteria	Material Utilization Efficiency	Timely and Accurate Delivery	Strategic Material Storage	Waste and Excess Control	Material Handling and Storage Facilities
Material Utilization Efficiency	1.00				
Timely and Accurate Delivery		1.00			
Strategic Material Storage			1.00		
Waste and Excess Control				1.00	
Material Handling and Storage Facilities					1.00

Appendix: III Semi-Structured Interview

Thank you for agreeing to participate in this interview. The purpose of this discussion is to gain insights into current practices, challenges, and recommendations related to construction site utilization and space management in Addis Ababa. Your responses will be used strictly for academic research purposes and will remain confidential.

Interview Questions

- What site utilization and space management practices are commonly implemented in your project?
- How are materials, equipment, and temporary facilities (such as offices and restrooms) typically allocated and arranged on construction sites?
- What tools or technologies (e.g., Building Information Modelling - BIM) are used to plan and manage site layouts, and how effective are they in practice?
- How frequently are site layouts reviewed and adjusted throughout the project lifecycle?
- What are the major challenges or Constraints to implementing effective site utilization and space management in Addis Ababa building specially in your site?
- How do space constraints, material handling, and trade stacking affect the overall efficiency of your construction projects?
- What key performance indicators (KPIs) do you use to evaluate the success of site utilization and space management efforts?
- How do you balance factors like safety, cost efficiency, and workflow optimization in your site planning process?
- Can you share specific examples where site utilization practices positively or negatively impacted project timelines or costs?
- What recommendations or best practices would you suggest to improve site utilization and space management efficiency in Addis Ababa's construction industry?

Appendix: IVConstraint Sub-Criteria Detail Calculation

AHP-Data Analysis for sub-criteria Organizational challenge

Step-1.Sum up the column of Pair-wise comparisons matrix

Sub-criteria Comparisons				
Organizational challenge				
Sub-criteria	OC1	OC2	OC3	OC4
OC1	1	5.74	4.12	6.32
OC2	0.17	1	0.85	3.1
OC3	0.24	1.18	1	4.12
OC4	0.16	0.32	0.24	1
SUM	1.58	8.24	6.21	14.54

Step2Normalizethecomparison

Normalized pair -wise comparison Matrix							
Sub-criteria	OC1	OC2	OC3	OC4	sum	criteria weights	criteria weight%
OC1	0.63	0.7	0.66	0.43	2.43	0.61	60.73
OC2	0.11	0.12	0.14	0.21	0.58	0.15	14.55
OC3	0.15	0.14	0.16	0.28	0.74	0.19	18.53
OC4	0.1	0.04	0.04	0.07	0.25	0.06	6.19
	1	1	1	1	4	1	100

Step3 Consistencycalculation asit waspresented

Calculating consistency							
Cw	0.61	0.15	0.19	0.06			
Sub-criteria	OC1	OC2	OC3	OC4	weighted sum value	criteria weight	WSV/CW
OC1	0.61	0.84	0.76	0.39	2.6	0.61	4.28
OC2	0.11	0.15	0.16	0.19	0.6	0.15	4.13
OC3	0.15	0.17	0.19	0.25	0.76	0.19	4.09
OC4	0.1	0.05	0.04	0.06	0.25	0.06	4.04
							4.13

Step 4: λ maxis calculated using the equation presented. Following the calculation of the consistency index, the consistency ratio was determined as 0.05 using the RI value of 0.89. The consistency ratio of 0.05 obtained from the AHP data analysis is acceptable because it is less than the threshold value of 0.10.

Organizational challenge	Symbol	criteria weighted	Rank
Poor Leadership and Decision-Making	OC1	60.73	1
Poor Communication and Workflow	OC3	18.53	2
Ineffective Organizational Structure	OC2	14.55	3
Lack of Stakeholder Involvement	OC4	6.9	4

AHP-DataAnalysis of Technical and Operational Issues

Step-1 Sum up the column of Pair-wise comparisons matrix.

Technical and Operational Issues					
Sub-criteria	TOI1	TOI2	TOI3	TOI4	TOI5
TOI1	1	0.89	2.22	1.89	0.64
TOI2	1.12	1	4.1	5.51	0.73
TOI3	0.45	0.24	1	0.59	0.21
TOI4	0.53	0.18	1.69	1	0.39
TOI5	1.56	1.37	4.76	2.56	1
sum	4.67	3.69	13.78	11.55	2.97

Step2.Normalizethecomparison

Normalized pair -wise comparison Matrix								
Sub-criteria	TOI1	TOI2	TOI3	TOI4	TOI5	sum	criteria weights	criteria weight%
TOI1	0.21	0.24	0.16	0.16	0.22	1	0.2	19.92
TOI2	0.24	0.27	0.3	0.48	0.25	1.53	0.31	30.65
TOI3	0.1	0.07	0.07	0.05	0.07	0.36	0.07	7.14
TOI4	0.11	0.05	0.12	0.09	0.13	0.5	0.1	10.07
TOI5	0.33	0.37	0.35	0.22	0.34	1.61	0.32	32.22
sum	1	1	1	1	1	5	1	100

Step3 Consistencycalculation

Calculating consistency								
CW	0.2	0.31	0.07	0.1	0.32			
Sub-criteria	TOI1	TOI2	TOI3	TOI4	TOI5	weighted sum value	criteria weight	WSV/CW
TOI1	0.2	0.27	0.16	0.19	0.21	1.03	0.2	5.16
TOI2	0.22	0.31	0.29	0.55	0.24	1.61	0.31	5.26
TOI3	0.09	0.07	0.07	0.06	0.07	0.36	0.07	5.08
TOI4	0.11	0.06	0.12	0.1	0.13	0.51	0.1	5.05
TOI5	0.31	0.42	0.34	0.26	0.32	1.65	0.32	5.13
								5.14

Step 4: λ max is calculated using the equation presented. Following the calculation of the consistency index, the consistency ratio was determined as 0.028 using the RI value of 1.11. The consistency ratio of 0.03 obtained from the AHP data analysis is

Technical and Operational Issues	Symbolized	criteria weighted	Rank
Tight schedule and overlapping activity	TOI5	32.22	1
Limited On-Site Expertise	TOI2	30.65	2
Lack of Technical Support	TOI1	19.92	3
Site-Specific Operational Challenges	TOI4	10.07	4
Contractual Limitations	TOI3	7.14	5

AHP-Data Analysis of Resource Constraints

Step-1 Sum up the column of Pair-wise comparisons matrix.

Resource Constraints				
Sub-criteria	RC1	RC2	RC3	RC4
RC1	1	2.11	3.9	5.2
RC2	0.47	1	3.04	4.1
RC3	0.26	0.33	1	2.2
RC4	0.19	0.24	0.45	1
sum	1.92	3.68	8.39	12.5

Step2Normalizethecomparison

Normalized pair -wise comparison Matrix							
Sub-criteria	RC1	RC2	RC3	RC4	sum	criteria weights	criteria weight%
RC1	0.52	0.57	0.46	0.42	1.97	0.49	49.34
RC2	0.25	0.27	0.36	0.33	1.21	0.3	30.2
RC3	0.13	0.09	0.12	0.18	0.52	0.13	12.95
RC4	0.1	0.07	0.05	0.08	0.3	0.08	7.51
Sum	1	1	1	1	4	1	100

Step3.Consistencycalculation

Calculating consistency							
CW	0.49	0.3	0.13	0.08			
Sub-criteria	RC1	RC2	RC3	RC4	weighted sum value	criteria weight	WSV/CW
RC1	0.49	0.64	0.5	0.39	2.03	0.49	4.11
RC2	0.23	0.3	0.39	0.31	1.24	0.3	4.1
RC3	0.13	0.1	0.13	0.17	0.52	0.13	4.02
RC4	0.09	0.07	0.06	0.08	0.3	0.08	4.03
							4.06

Step 4: λ max is calculated using the equation presented after the consistency index has been computed. Following the calculation of the consistency index, the consistency ratio was determined as 0.02 using the RI value of 1.11. The consistency ratio of 0.02 obtained from the AHP data analysis is acceptable because it is less than the threshold value of 0.10.

Resource Constraints	Symbolized	criteria weighted	Rank
Site and Space Limitations	RC1	49.34	1
Location of site (down town ,confined area urban)	RC3	30.20	2
Lack of technological equipment for Site Utilization Planning	RC4	12.95	3
Lack of budget for CSUP	RC2	7.51	4

AHP Temporary Facilities Characteristics

Step-1Sum up the column of Pair-wise comparisons matrix

Temporary Facilities Characteristics					
Sub-criteria	TFC1	TFC2	TFC3	TFC4	TFC5
TFC1	1	0.25	2	1.3	2.5
TFC2	4	1	5.6	2.9	3.1
TFC3	0.5	0.18	1	2.6	1.23
TFC4	0.77	0.34	0.38	1	1.1
TFC5	0.4	0.32	0.81	0.91	1
sum	6.67	2.1	9.8	8.71	8.93

Step 2 Normalize the comparison

Normalized pair - wise comparison Matrix								
Sub-criteria	TFC1	TFC2	TFC3	TFC4	TFC5	sum	criteria weights	criteria weight%
TFC1	0.15	0.12	0.2	0.15	0.28	0.9	0.18	18.05
TFC2	0.6	0.48	0.57	0.33	0.35	2.33	0.47	46.57
TFC3	0.07	0.09	0.1	0.3	0.14	0.7	0.14	13.97
TFC4	0.12	0.16	0.04	0.11	0.12	0.56	0.11	11.14
TFC5	0.06	0.15	0.08	0.1	0.11	0.51	0.1	10.26
Sum	1	1	1	1	1	5	1	100

Step3 Consistencycalculation

Calculating consistency								
Cw	0.18	0.47	0.14	0.1	0.1			
Sub-criteria	TFC1	TFC2	TFC3	TFC4	TFC5	weighted sum value	criteria weight	WSV/CW
TFC1	0.18	0.12	0.28	0.1	0.26	0.98	0.18	5.42
TFC2	0.72	0.47	0.78	0.3	0.32	2.61	0.47	5.61
TFC3	0.14	0.16	0.05	0.1	0.11	0.58	0.14	4.13
TFC4	0.07	0.15	0.11	0.1	0.1	0.54	0.11	4.85
TFC5	0.07	0.15	0.11	0.1	0.1	0.54	0.1	5.26

Step 4: λ max is calculate the calculation of the consistency index, the consistency ratio was determined as 0.01 using the RI value of 1.11. The consistency ratio of 0.01 obtained from the AHP data analysis is acceptable because it is less than the threshold value of 0.10.

Temporary Facilities Characteristics	Symbolized	criteria weighted	Rank
Improper utilization available site space	TFC2	46.57	1
Improper Facility and Equipment Placement	TFC1	18.05	2
Equipment Movement and Accessibility Issues	TFC3	13.97	3
Inefficient Layout and Space Utilization	TFC4	11.14	4
Out-dated Temporary Facilities	TFC5	10.26	5

AHP Knowledge and understanding

Step-1 Sum up the column of Pair-wise comparisons matrix

Knowledge and understanding				
Sub-criteria	KU1	KU2	KU3	KU4
KU1	1	4.26	2.53	5.1
KU2	0.23	1	0.68	3.21
KU3	0.4	1.47	1	2.45
KU4	0.2	0.31	0.41	1
sum	1.83	7.04	4.62	11.76

Step2.Normalizethecomparison

Normalized pair -wise comparison Matrix							
Sub-criteria	KU1	KU2	KU3	KU4	sum	criteria weights	criteria weight%
KU1	0.55	0.6	0.55	0.43	2.13	0.53	53.35
KU2	0.13	0.14	0.15	0.27	0.69	0.17	17.27
KU3	0.22	0.21	0.22	0.21	0.85	0.21	21.25
KU4	0.11	0.04	0.09	0.09	0.33	0.08	8.13
Sum	1	1	1	1	4	1	100

Step3 Consistencycalculation

Calculating consistency							
cw	0.53	0.17	0.21	0.08			
Sub-criteria	KU1	KU2	KU3	KU4	weighted sum value	criteria weight	WSV/CW
KU1	0.53	0.74	0.54	0.41	2.22	0.53	4.16
KU2	0.13	0.17	0.14	0.26	0.7	0.17	4.07
KU3	0.21	0.25	0.21	0.2	0.88	0.21	4.12
KU4	0.1	0.05	0.09	0.08	0.33	0.08	4.02
							4.09

Step4: λmaxisthe calculation of the consistency index, the consistency ratio was determined as 0.05 using the RI value of 0.89. The consistency ratio of 0.05 obtained from the AHP data analysis is acceptable because it is less than the threshold value of 0.10.

Knowledge and understanding	Symbolized	criteria weighted	Rank
Limited Understanding of Site Layout Planning	KU1	53.35	1
Resistance to adopt advanced technologies	KU4	21.25	2
Poor technology for optimal use of resources	KU2	17.27	3
Absence of common acceptable standard	KU3	8.13	4

AHP-DataAnalysisforMaterialManagementCategory

Step-1.Sum up the column of Pair-wise comparisons matrix

Material Management Indicators					
Sub-Criteria	MMI1	MMI2	MMI3	MMI4	MMI5
MMI1	1	0.17	0.69	3.56	0.3
MMI2	5.88	1	0.16	0.39	0.23
MMI3	1.45	6.25	1	2.1	0.51
MMI4	0.28	2.56	0.48	1	0.43
MMI5	3.33	4.35	1.96	2.33	1
sum	11.95	14.33	4.29	9.38	2.47

Step2.Normalize the compariso

Normalized pair -wise comparison Matrix								
Sub-Criteria	MMI1	MMI2	MMI3	MMI4	MMI5	sum	criteria weights	criteria weight%
MMI1	0.08	0.01	0.16	0.38	0.12	0.76	0.15	15.15
MMI2	0.49	0.07	0.04	0.04	0.09	0.73	0.15	14.68
MMI3	0.12	0.44	0.23	0.22	0.21	1.22	0.24	24.42
MMI4	0.02	0.18	0.11	0.11	0.17	0.59	0.12	11.89
MMI5	0.28	0.3	0.46	0.25	0.4	1.69	0.34	33.85
sum	1	1	1	1	1	5	1	100

Step3.Consistencycalculation

Calculating consistency								
Cw	0.15	0.15	0.24	0.12	0.34			
Sub-Criteria	MMI1	MMI2	MMI3	MMI4	MMI5	weighted sum value	criteria weight	WSV/CW
MMI1	0.15	0.02	0.17	0.42	0.1	0.87	0.15	5.74
MMI2	0.89	0.15	0.04	0.05	0.08	1.2	0.15	8.18
MMI3	0.22	0.92	0.24	0.25	0.17	1.8	0.24	7.39
MMI4	0.04	0.38	0.12	0.12	0.15	0.8	0.12	6.73
MMI5	0.51	0.64	0.48	0.28	0.34	2.24	0.34	6.61
								6.93

Step 4: λ max is the calculation of the consistency index, the consistency ratio was determined as 0.08 using the RI value of 1.11. The consistency ratio of 0.08 obtained from the AHP data analysis is acceptable because it is less than the threshold value of 0.10.

MaterialManagementIndicators	Symbolized	criteria weighted(CW)	Rank
Material Management Awareness	MMI4	33.85	1
Material Utilization Efficiency	MMI1	24.42	2
Strategic Material Storage	MMI3	15.15	3
Waste and Excess Control	MMI5	14.68	4
Timely and Accurate Delivery	MMI2	11.89	5

Appendix VKPIs Sub-Criteria Detail Calculation

AHP-DataAnalysis forSafety Considerations and risk mitigation

Step-1Sumup thecolumnof Pair-wisecomparisonsmatrix

Safety Considerations and risk mitigation					
Sub-criteria	SRM1	SRM2	SRM3	SRM4	SRM5
SRM1	1	0.3	1.9	0.22	0.37
SRM2	3.33	1	4.11	0.5	3.36
SRM3	0.53	0.24	1	0.31	3.15
SRM4	4.55	2	3.23	1	2.6
SRM5	2.7	0.3	0.38	1	1
Sum	12.11	3.84	10.62	3.03	10.48

Step2.Normalizethe comparison

Normalized pair -wise comparison Matrix								
Sub-criteria	SRM1	SRM2	SRM3	SRM4	SRM5	sum	criteria weights	criteria weight%
SRM1	0.08	0.08	0.18	0.07	0.04	0.45	0.09	8.95
SRM2	0.28	0.26	0.39	0.17	0.32	1.41	0.28	28.17
SRM3	0.04	0.06	0.09	0.1	0.3	0.6	0.12	12.08
SRM4	0.38	0.52	0.3	0.33	0.25	1.78	0.36	35.56
SRM5	0.22	0.08	0.04	0.33	0.1	0.76	0.15	15.25
sum	1	1	1	1	1	5	1	100

Step3Consistencycalculation

Calculating consistency								
Cw	0.09	0.28	0.12	0.36	0.15			
Sub-criteria	SRM1	SRM2	SRM3	SRM4	SRM5	weighted sum value	criteria weight	WSV/CW
SRM1	0.09	0.08	0.23	0.08	0.06	0.48	0.09	5.38
SRM2	0.3	0.28	0.5	0.18	0.51	1.25	0.28	4.45
SRM3	0.05	0.07	0.12	0.02	0.18	0.26	0.12	2.16
SRM4	0.41	0.56	0.39	0.18	0.4	1.54	0.36	4.32
SRM5	0.24	0.08	0.05	0.36	0.15	0.73	0.15	4.77
								4.22

Step 4: λ max is calculated using the equation presented. Following the calculation of the consistency index, the consistency ratio was determined as 0.06 using the RI value of 1.11. The consistency ratio of 0.06 obtained from the AHP data analysis is acceptable because it is less than the threshold value of 0.10.

Safety Considerations & risk mitigation	Symbolized	criteria weighted(CW)	Rank
Provision PPE equipment	SRM5	35.56	1
Safety Zones	SRM3	28.17	2
Safety, Security, and Signage	SRM2	15.25	3
Hazard Mitigation	SRM4	12.08	4
Emergency plan and procedures	SRM1	8.95	5

AHP-DataAnalysis forSite Utilization Facility Indicators

Step-1.Sum up the column of Pair-wise comparisons matrix

Sub-criteria	SUFI1	SUFI2	SUFI3	SUFI4
SUFI1	1	3.1	1.9	3.9
SUFI2	0.32	1	3.1	4
SUFI3	0.53	0.32	1	2.63
SUFI4	0.26	0.25	0.38	1
sum	2.11	4.67	6.38	11.53

Step2.Normalizethe comparison.

Normalized pair - wise comparison Matrix							
Sub-criteria	SUFI1	SUFI2	SUFI3	SUFI4	sum	criteria weights	criteria weight%
SUFI1	0.47	0.66	0.3	0.34	1.77	0.44	44.36
SUFI2	0.15	0.21	0.49	0.35	1.2	0.3	30
SUFI3	0.25	0.07	0.16	0.23	0.7	0.18	17.6
SUFI4	0.12	0.05	0.06	0.09	0.32	0.08	8.04
Sum	1	1	1	1	4	1	100

Step 3 Consistency calculation

Calculating consistency							
Cw	0.44	0.3	0.18	0.08			
Sub-criteria	SUFI1	SUFI2	SUFI3	SUFI4	weighted sum value	criteria weight	WSV/CW
SUFI1	0.44	0.93	0.33	0.31	2.02	0.44	4.56
SUFI2	0.14	0.3	0.55	0.32	1.31	0.3	4.37
SUFI3	0.23	0.1	0.18	0.21	0.72	0.08	8.93
SUFI4	0.11	0.08	0.07	0.08	0.34	0.08	4.18
							5.51

Step 4: λ maxis calculated using the equation presented. Following the calculation of the consistency index, the consistency ratio was determined as 0.09 using the RI value of 0.89. The consistency ratio of 0.09 obtained from the AHP data analysis is acceptable because it is less than the threshold value of 0.10.

Site Utilization Facility Indicators	Symbolized	Criteriaweighted (CW)	Rank
Site Offices and Administrative Facilities	SUFI2	44.36	1
Utility and Essential Services Availability	SUFI3	30.0	2
Access and Circulation Infrastructure	SUFI1	17.60	3
Welfare and Worker Support Facilities	SUFI4	8.04	4

Appendix VI: Addis Ababa City Administration's guidelines on the distance of buildings from roads (setback) and related building permits, 2017

1) <u>የይዞታ ስፋት (Area) እና የይዞታን የፊት ገፅታን (Frontage) በተመለከተ የሚከተለው ውሳኔ ተወስኗል።</u>

1.1. በከተማዋ ውስጥ ያሉ የመንገድ አይነቶች (Type/Hierarchy) ፣ ስፋት (Street Width)፣ ግንባታ ከመንገድ የሚኖረው ርቀት (Setback) እንዲሁም በተሻሻለው የመሬት አጠቃቀም ፕላን መሰረት በግል ይዞታቸው ላይ በራሳቸው የማልማት ፍላጎት ያላቸው ባለይዞታዎች ወደግንባታ ለመግባት በእያንዳንዱ የመንገድ አይነት ላይ ሊያሟሉ የሚገባቸውን ከሴትባክ በኋላ ቀሪ ዝቅተኛ የቦታ ስፋት (Plot Area) እና የፊት ገፅታ (Plot Frontage) በተመለከተ የሚከተለው ተወስኗል፤

የመንገድ ዓይነት (Road Type)	የመንገድ ስፋት (በሜትር) (Road Width in M)	ግንባታው ከወሰን ጠርዝ መራቅ ያለበት (Setback)	ዝቅተኛ ስፋት እና የፊት ገፅ (Minimum Area (m²) & Plot Frontage (m))
1. ዋና መንገድ (PAS)	30ሜ እና ከዚያ በላይ (≥30)	10ሜትር	❖ 500ሜ.ካ እና 20ሜ የፊት ገፅ ❖ ±10% [illegible] (10% Tolerance Limit for both Area & Frontage)
2. ንዑስ ዋና መንገድ (SAS)	25ሜ እና ከዚያ በላይ - 30ሜ በታች (≥25 - <30)	5ሜትር	
3. ሰብሳቢ መንገድ (CS)	15ሜ እና ከዚያ በላይ - 25ሜ በታች (≥15 - <25)	3 ሜትር	❖ [illegible] ✓ [illegible] 12ሜ [illegible] ✓ 5% [illegible] (5% Tolerance Limit for both Area & Frontage) ❖ [illegible] (Area) [illegible] (Frontage) [illegible] ❖ [illegible] (Frontage) [illegible] ❖ [illegible] ≤100ሜ.ካ [illegible] ❖ [illegible] ✓ [illegible] 20ሜ [illegible] (Frontage) [illegible] ✓ [illegible] (Area) [illegible] (Frontage) [illegible] 10% [illegible] (10% Tolerance Limit for both Area & Frontage) [illegible] ✓ [illegible] • [illegible] • [illegible] ✓ [illegible] Maximum Land Utilization [illegible] (Regularization) [illegible]
4. የአካባቢ አገልግሎት መንገድ (LS)	ከ15ሜ በታች (<15)	2 ሜትር	❖ [illegible] ✓ [illegible]

1.2. የመንገድ ስፋት የሚባለው የመንገዱን ወሰን (Right of Way) ያለው የልኬት መጠን (Measurement) ማለት ነው። በዚህ መሰረት ለማንኛውም አገልግሎት ፕላን ላይ በተቀመጠው የመንገድ ስፋት ልኬት (Road Width Measurement) መሰረት በማድረግ አገልግሎት እንዲሰጥ።

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Page | 3

Enhancing Construction Site Utilization Efficiency: An Evaluation of Implementation in Addis Ababa Building Projects