Enhancing Collaboration and Adaptability in Sustainable Construction: Integrating Lean Construction and Scrum Methodology

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# Chapter:1 Introduction

## Background of the study

Xing et al, (2021) concluds that adoption towards sustainable practices has become an essential requirement for construction businesses as accommodating environmental concerns have become prior responsibility to contribute towards. Integration of digital technological practices has provided accuracy and precision in terms of managing resources, directing workers, organizing tasks and attaining construction deliverables within the allocated time scale (Heigermoser and de Soto, 2022). The implication of lean principles provided convenience in terms of structuring project deliverables and constructing based on designed plans and procedures (Lalmi et al, 2021). Agile manufacturing practices provide construction managers, project engineers etc., to organize resources for the effective completion of a project within the associated timescale. The findings of (Vaz-Serra et al, 2021) conclude that managing stakeholders' expectations require continuous improvement techniques and innovative procedures based on which operational efficiencies are maintained and designed outcomes can be achieved.

The usage of green manufacturing procedures has become necessary for construction-based companies as the adoption of waste management practices and cost-effective approaches enable project managers to minimize operational wastes and overhead costs (Prabhakaran et al, 2022). Labour training has been determined to be one of the prime aspects to guide based on sustainable development goals and has become an important factor through which consistency in performance and effective accomplishment of outcomes can be obtained. Research findings of Leong et al, (2023) conclude that construction businesses are major contributor towards economic stability and GDP growth in a country. Digital development has become the need of time as people prefer to live within well-furnished and sustainable houses (Salama and Said, 2023). Sustainable construction has become a priority for construction companies. With large-scale investments, new techniques and approaches have been introduced within construction procedures to construct well-structured and highly sustainable models. The concept of agile manufacturing in construction businesses indicates the implication of continuous improvement mechanisms and just-in-time phenomena based on which wastes are minimized through operational practices used (Ozorhon et al,2022).

Research by Ng et al, (2023) shows that process of deconstruction includes disassembling constructed building structure to utilize its resources, i.e. materials etc., within the construction procedure of future construction projects. Effective utilization of resources has been determined to be essential based on deconstruction practices. Although the phenomenon of deconstruction is a traditional practice, however, its usage has been valued currently by construction companies. Strategic objectives associated with construction projects have a broader emphasis on eliminating waste and effective utilization of available resources based on which sustainable construction dimensions can be performed (Chathuranga et al, 2023). The findings of Ramos Steiner, 2020) show that scrum methodology has been introduced in digital construction procedures that indicate effective management of the labour force to organize their working patterns. Integration of quality improvement techniques is substantial to maximize productivity by minimizing waste and operational costs.

The role of effective leadership practices and sustainable management decisions were determined to be the adequate necessity to guide operational plans, working patterns, standards of procedures etc. (Martinez and Pfister, 2023). Operational guidance is the prime responsibility of project managers to direct workers' performance towards designed objectives. By conducting team meetings and orientation sessions, working dimensions can be directed. Research by DABASH (2022) shows that sustainable construction is a collective procedure that requires teamwork and collaboration from project handlers with front-line workers who are directly involved in construction procedures. Integration of participative leadership practices has been determined to be one of the key aspects of scrum methodology, as to timely guide and monitor the operational performance of construction workers is considerable responsibility of the project supervisor (Martinez and Pfister, 2023). Budget planning, project scheduling, risk management, supervising subordinates etc., are a few of the many responsibilities required of project managers to attain sustainable development goals (Alshammari, 2022). Operational strategies adopted by construction managers are significant in terms of minimizing operational waste and reducing production costs, as effective planning is necessary while adopting highly constructive business models.

## Research aim

The current study aims to identify how collaboration and adaptability can be enhanced within sustainable construction with the integration of lean construction and scrum methodology.

## Research objectives

* To investigate the role of collaboration and adaptability in sustainable construction projects.
* To evaluate implication of lean construction dimensions in sustainable construction businesses.
* To analyze the usage and effectiveness of scrum methodology within construction-based projects.

## Research questions

* What is the role of collaboration and adaptability in the sustainable construction proejcts?
* What is collaboration and adaptability in sustainable construction businesses?
* How is usage of scrum methodology within construction-based projects effective?

## The rationale of the study

This study highlights valuable insights related to sustainable development practices performed within construction-based projects to minimize waste and to effectively contribute towards environmental concerns. This study directs and strategically guides readers to understand the significance of lean construction dimensions and agile practices. The discussion is about how project managers have introduced new concepts and construction procedures to obtain highly sustainable business models. Further, the role of digital technology and its wider acceptance in managing construction-based projects is highlighted in the study further how digital transformation has been adopted within construction-based projects globally.

# Chapter:2 Literature review

## Sustainable construction

Usage of sustainable construction dimensions has become necessary to minimize operational waste and to improve efficiencies is essential to fulfilling sustainable development goals (Ogunmakinde et al, 2022). Environmental degradation has become most common as many construction companies are polluting surroundings based on huge-scale construction projects being designed and executed. Traditional construction practices failed in many aspects in terms of adopting sustainable practices, due to which construction-based projects are determined to be major contributors towards environmental pollution (Cui et al, 2021). Hoosain et al,(2020) shows that need for sustainable development principles has risen with an increase in environmental awareness among construction companies. Project managers nowadays have broader knowledge regarding what practices to adopt and implement while performing construction activities within densely populated regions.

Construction of commercial and residential-based projects requires proper scheduling and strategic planning, as the involvement of key stakeholders is necessary to obtain highly sustainable outcomes. Research findings of Hossain et al,(2020) conclude that sustainable construction projects require effective usage of resources. Recycling procedures and usage of renewable raw materials have been determined to be essential in construction of sustainable processes (Tiza et al,2021). Usage of green building materials is considerable for the construction of digitally designed models. Traditional methods in construction include the elimination of excessive waste while performing construction activities due to inadequate planning, lack of renewable resources, minimal expertise and knowledge among project handlers, lack of trained workers/labour force, inappropriate construction methods etc., that increase time for completion of the project and increase the number of resources (Zhang et al, 2021). However, existing digital construction models are well-organized and highly structured to avoid lead times and to maintain operational efficiencies.

Training of labours has become relevant for project managers as guiding construction workers at on-site locations is convenient with digital technological models. Usage of building information modelling technology (BIM), project handlers, construction engineers, architects, contractors etc., are able to construct digital formation of buildings etc., through which relative guidance can be delivered among front-line construction workers (Alaloul et al,2023). By displaying the operational features and internal infrastructure of a project required for construction, project handlers strategically guide workers to perform consistently and within accordance with designed procedures (Tanko et al, 2022). The usage of robotics technology, additive manufacturing features, virtual and augmented reality etc., has transformed construction models and planning procedures by providing real-time solutions for the construction of highly sustainable business models (Sawhney et al, 2020). Optimizing procedures have provided strategic direction among construction managers regarding how to gain assistance from architectural models that are constructed based on traditional practices to make improvements within existing business models through which operational errors are minimized and construction of digitally designed buildings is applicable (Jalaei et al, 2021).

Quality improvement methods have become essential within the construction sector as adaptability for inspection plans and procedures can be optimal to identify certain challenges that might encounter within operational principles and methods adopted (Moshood, 2020). Providing workers with essential construction resources is one of the core aspects associated with quality assurance practices. Defining standards of procedure within an operational setting can be adequate based on which performance evaluation of labours can be determined and predicted (Turner et al,2020). To identify individual skills and efficiencies within workers, key performance indicators are to be used to analyze productive capacities and relative capabilities. Well-recognized construction companies invest heavily in training manpower to enhance their expertise (Hwang, 2022). Field-based learning is substantial as project handlers are required to provide on-site training to make workers aware of certain standards of procedures and working conditions to improve their performance rate.

Inventory and raw material management is another essential component that is to maintain to fulfil tasks assigned by project managers sufficient amount of inventory is needed through which construction of a project can be performed. To strategic planning for unpredictable situations and uncertainty is necessary to overcome future hazards, adequate controlling and monitoring are needed (Rodríguez-Rivero et al, 2020). Sustainable construction projects demand effective communication and management skills based on which each deliverable of the project can be accomplished within the expected time scale. A study by Alsharef et al (2021) shows that by maintaining safety hazards, risks can be managed at construction sites with precautionary measures, operational efficiencies can be obtained, and challenges in operational delays can be overcome. Equipment handling, damage control initiatives, maintaining standards procedures on-site locations, guidance for the labour force etc., can be substantial based on which construction risks can be avoided (Majumder and Biswas, 2021).

Sustainable construction practices demand effective collaboration between project managers and front-line workers (Wu et al, 2019). With effective leadership practices and management guidance principles, operational wastes can be reduced, and quality improvement procedures can be performed. Usage of renewable resources can be optimal for sustainable initiatives, i.e. energy resources to be used can be wind, solar system etc., as avoiding usage of fuel consumption is essential for zero carbon footprint (Chenic et al, 2022). Construction businesses have major responsibilities towards environmental concerns and social development (Assaad and El-Adaway, 2020). Investment in corporate social responsibilities and sustainable dimensions assist in creating a global reputation. To predict the future scope of a project by defining the adequate budget required to meet the strategic objectives of the project to include within the planning procedure through which each deliverable of the project can be obtained within the expected time scale.

## Lean construction procedures

The findings of Hussain et al,(2023) conclude that sustainable construction business models have larger dependability on agile procedures to minimize operational wastes and to obtain outcomes in construction projects based on stakeholders' relative expectations. The usage of artificial intelligence techniques enables project managers to identify, plan, handle, manage etc., construction resources based on which expected construction procedures are adopted and performed (Reja and Varghese, 2019). Identifying rather renewable raw materials that have been attained from suppliers is possible based on digital technological applications (Sadeghi et al, 2023). The usage of agile software within construction projects enables in management of project resources, scheduling time scales for each activity, defining functions to perform within project milestones, operational policies and guidelines to adopt etc., through which labours are directed, and operational hazards are minimized.

The research study of Chin (2023) shows that inventory management, identification of defects, strategic planning, training of the labour force etc., is manageable based on automation practices used by construction managers within construction projects. Distributing a construction project into sequential milestones is significant functioning of the lean construction technique through which the extent of operational errors is minimized and productivity is increased (Swefie, 2021). By dividing a project into various production zones, project managers are able to handle and achieve the feasibility of completing a project based on a scheduled time scale (Zhao et al, 2020). Further capacities of the labour force are determined based on which tasks are assigned, and teams are constructed at on-site locations. Labour-force who lack to perform according to expected requirements are supervised on time and provided training by experienced construction workers and project managers (Manoharan et al, 2023). In case any delay within project tasks is determined, project managers can effectively communicate with subordinates who are assigned specific tasks to perform based on schedules assigned and responsibilities needed.

The findings of Deng et al (2022) show that by supervising and monitoring each milestone, construction tasks are managed and achieved within the expected time scale. With lean procedures, production tasks are adjusted and accomplished. With agile-based functioning, construction tasks are completed in a sequential manner, and overburdens on front-line workers and project engineers are minimized. Coordinating with construction teams who are allocated project tasks is an essential procedure that requires effective communication and timely collaboration based on which rescheduling, overproduction, inadequate usage of resources etc., can be managed and sustainable procedures can be performed (Jang et al, 2022). Capacity management, assigning tasks based on expertise, developing teams related to skills etc., can be performed based on optimization practices and agile functioning tools. Research by Çınar et al (2020) concludes that predictive maintenance procedures add value to construction principles through which sustainable development goals can be attained.

A study by Płoszaj-Mazurek et al (2020) shows that while designing an outlay of the building construction, it is necessary to evaluate the environmentally conscious pattern that has been formed as construction of the green building is required within a digital phase. With the integration of digital technological patterns, a quality amount of practices can be introduced while constructing building design through which environmental concerns can be maintained (Boje et al, 2020). Waste management procedures are needed within the construction process to ensure effective disposal. Recycling practices are determined to be alternatives for non-reusable materials. Resources that are of no use can be recycled for further construction projects. The findings of McCarthy and Glekas (2020) conclude that deconstruction can be appropriate rather than demolition practices. To avoid environmental waste, corporate social responsibilities are required to perform. To avoid the excretion of toxic waste usage of renewable materials is needed within construction-based projects.

Lean construction institute has identified various categories of wastes within construction procedures, including, i.e. excessive production, unnecessary transportation, defects etc., that can increase the lead time of construction and resources. Well-structured designing, strategic planning, controlling, monitoring, guiding labours based on defined procedures etc., are determined to be essential factors in minimizing environmental wastes and operational hazards (Asah-Kissiedu et al,2021). To maximize productivity within construction procedures, timely meetings between, i.e. project managers, architectures, construction engineers, front-line workers etc., are needed through which expected outcomes can be obtained. Aminzadeh et al, (2023) conclude that quality maintenance initiatives enable in reduction of production burdens and assist the labour force in distributing operational tasks based on their skills and capabilities. Team contribution assists in the integration of continuous improvement based on which defined milestones can be accomplished within the expected time scale (Zayat and Senvar, 2020).

Maximizing stakeholders' expectations is a prime principle needed within construction-based projects. Optimizing resources to be used within the project process is adequate based on which productivity ratio is increased (Lepage et al,2021). Labour safety is one of the major aspects to consider within construction-based projects, as workers' health and well-being need to be ensured. Research by Weber-Lewerenz,(2021) shows that smart decision-making can be a substantial phase within construction-based projects as by defining ethical codes of conduct, working procedures, workplace guidelines etc. front, line workers operating at construction sites are provided with strategic direction based on which extent of operational hazards can be reduced. Managing budget, operational costs, lead time etc., is an essential aspect of lean manufacturing procedure (De Silva and Seneviratne, 2022). With agile dimensions, sustainable construction practices can be performed through which environmental concerns are stabilized.

## Scrum methodology

Scrum methodology is a digital concept used within construction-based projects to organize, guide and schedule construction teams towards common strategic objectives obtained based on the construction of highly sustainable models (Costa et al,2023). A research study by Pirzadeh and Lingard (2021) shows that with effective leadership practices, labours are guided to perform consistently. Adoption of sustainable construction procedures demands accommodating stakeholders based on their expectations as it requires a personalized based approach to perform within construction-based projects to deliver highly sustainable business models among users (Kineber et al,2022). The usage of scrum methodology in construction projects requires testing procedures while implementing transformed business models, as minimizing errors while utilizing new construction procedures is an essential phase of the project development (Xing et al, 2021). Project managers who utilize scrum methodological principles are highly capable of performing consistently to overcome operational wastes and in increasing production deliverables.

A study by Turner (2020) shows that scrum methodological principles enable project handlers to manage each milestone of the construction project by assigning tasks to each team and estimating production to obtain based on planning procedures. Project managers are able to schedule activities, align resources, guide labour force etc., based on which project feasibility is increased. Project cost estimation is applicable to avoid over budget as the construction of sustainable projects can be performed by implementing scrum methodological techniques (Herath and Perera, 2022). Large and complex construction projects are aligned and divided based on sprints through which the feasibility of the projects can be obtained. With constructive feedback from labour-force operational hazards are identified and overlooked by project managers based on which applicable solutions are presented and executed to achieve project milestones (Renault et al, 2020). Scrum methodology is a continuous improvement technique through which track records of performance are maintained, and operational efficiencies can be maintained.

Complex phased projects can be organized based on scrum techniques as to handle its framework, professional and experienced individuals are needed, i.e. construction engineers, architectures, project contractors etc., as with effective communication and consistent support, tasks can be segmented into subdivisions to obtain optimal outcomes. With real-time information, operational hazards are minimized. Scheduling reviews are needed to ensure the implication of planning procedures to obtain the expected outcomes of the project (Abdul Nabi and El-Adaway, 2021). Scrum framework has transformed traditional construction dimensions into agile principles through which the construction of quality projects is performed (Jethva and Skibniewski, 2022). To create productive project teams, organizing and clearly defining project objectives to accomplish is associated with the scrum methodological procedure. The findings of McLellan et al (2021) conclude that scrum masters overlook the implementation of scrum principles as they ensure the effectiveness of project team members. Project managers have a strategic responsibility to manage and monitor logistic functioning, i.e. budget planning, risk management, resource allocation, time management etc. (Simonaitis et al, 2023). Including a scrum master within the project planning phase can be essential for the effective accomplishment of each deliverable of the project.

The implication of agile dimensions ensures the completion of each phase of the project within the allocated time scale as a new phase is initiated after the accomplishment of the prior project milestone. Specific construction projects that have fixed timescale and scope implication of scrum methodology are not applicable; however, traditional project management technique waterfall methodology is significant to accomplish goals of project (Leong et al,2023). Integration of just-in-time mechanism and lean principles are appropriate within construction-based projects to improve their feasibility and to reduce time scale (Moballeghi et al, 2022). Project management principles are essential to align personnel and resources for the completion of a project to determine operational complexities and avoid overhead costs is applicable to the implementation of project management guidelines (Butler et al, 2020). Risk management strategies and cost-effective procedures are the two most common phases of scrum methodology through which operational efficiencies are maintained.

With increased competition in the construction industry, project managers are determining new approaches and methods to facilitate stakeholders with sustainable construction dimensions. With collaborative construction planning, real-time scheduling optimal project outcomes can be obtained. Project feasibility depends on the approach implemented by project managers for the accomplishment of strategic goals (Ingle et al, 2021). The selection of the project management dimension can be the individual decision of the project manager, or combining collective overviews of project stakeholders can be essential (Bjørner, 2021). Maintaining quality dimensions is an adequate factor within an operational phase of the construction-based project through which risks are timely mitigated and costs are minimized.

# Chapter:3 Research Methodology

The methodology provides readers with the researcher’s approach used for evaluating research objectives. The selection of methodology describes a particular direction obtained to fulfill the rationale of the study. The selection of data collection procedure and research approach depends on the topic under consideration and the results obtained within a study.

## Research Philosophy

Research philosophy defines the nature of data to include in studies to determine the origin or source of information associated with philosophical patterns (Nickerson, 2022). Extraction of appropriate data sets relevant to the topic requires practical research and external analysis based on which logical information can be obtained to include in studies. Researchers' prime emphasis is to explore the external environment to gather appropriate data relevant to the research topic selected. Further, to use of data for analysis is an adequate factor within a philosophical procedure. Research philosophy consists of two main types, i.e., interpretivism, positivism, etc. (Furqan et al, 2021).

### Interpretivism

It shows how human subjects perceive a particular wonder to explore as by including human subjects in research studies, in-depth knowledge of the research problems can be obtained (Burns et al,2022). Researchers' adequate emphasis is to explore research questions by including respondents within a study. A study by Darby et al (2019) shows that human thoughts, mental perspectives, and thinking capabilities are different from each other; therefore, by including various participants, adequate viewpoints can be obtained to include within research. Research findings of Van der Walt (2020) conclude that researcher further interprets participants' perspectives within a study based on their own learning and understanding to conclude expected outcomes. Research problems under investigation require, i.e., practical research, in-depth analysis, and collective thoughts based on which logical arguments can be introduced within studies.

### Positivism

A study by Verhaegh (2020) shows that the positivist school of thought indicates secondary information extracted from secondary sources. Scientific knowledge collected from authentic secondary sources indicates a positivist approach. Secondary data collected within experimental labs under observations describe the positivism philosophy. Research by Hwang (2019) proposed that with scientific evidence, secondary results are obtained that can be included in secondary analysis.

### Justification of interpretivism philosophy

In this study, interpretivism philosophy is selected to explore the research objectives under examination. The rationale for considering interpretivism is that researcher needs to investigate the topic by including various perspectives related to sustainable construction practices. By using various secondary research articles, an in-depth understanding can be obtained on the topic.

## Research approach

It indicates the research direction adopted by a researcher to analyze research questions. The research method is considered, and the data collection procedure used, etc., is included within the section of the approach. The process utilized to extract information, analyze and interpret within research indicates the approach adopted within research. The following are two main types of approaches, i.e., inductive, deductive, etc. (Mulisa, 2022).

### Inductive approach

Research by Bingham and Witkowsky (2021) concludes that inductive reasoning is a prime emphasis of researchers when research objectives are to explore from the initial stage or ground level. Researchers consider an inductive approach when no past social theory secondary information is available. The researcher is limited to a topic to examine so as to obtain appropriate information and logical reasoning to include in a study; in-depth analysis and quality evaluation are needed (Teru et al,2020). To generate social theory as end results are the primary emphasis in the inductive approach. A study by Lovrić et al (2020) indicates that no hypotheses statement and variables are used to validate a study. Inductive reasoning requires adequate research based on which logical arguments can be developed.

### Deductive approach

It includes using past social theory relevant to the topic to investigate by extracting variables; hypotheses statements are generated to validate further within research. To validate past social theory used is prime rationale in deductive reasoning (Grinchenko and Shchapova, 2020). Research by Pandey (2019) concludes that to investigate the nature of the relationship among variables, researchers conduct observations and in-depth analysis to determine how dependent and independent variables are related to each other.

### Justification of inductive approach

In this study inductive approach is used to examine research questions. The rationale for considering the inductive approach is the researcher’s own particular choice of assumption and topic selected for investigation. To identify valuable insights about the existing sustainable approach adopted by project managers within construction businesses, inductive reasoning has been considered.

## Research design

It provides an overall research strategy to consider within the course of study. It involves a research approach to be used, data collection technique, data analysis procedure, etc., through which expected outcomes can be obtained. Types of research designs used in a study, i.e., qualitative, quantitative, etc. (Sileyew, 2019).

### Qualitative design

It includes the usage of words, definitions, terms, concepts, etc., to explore the research problem under examination (Tomaszewski et al, 2020). By conducting an in-depth analysis, logical arguments are introduced within research studies. The findings of Stenfors et al (2020) show that with descriptive analysis, a researcher is able to elaborate their findings based on the topic among readers through which their own understanding, particularly on research, can be developed. Qualitative studies are exploratory and descriptive in nature. Researchers avoid the usage of numbers, facts, and figures while generating results.

### Quantitative design

These studies are more focused on the usage of numbers, facts, and figures, as the researcher’s prime emphasis is to investigate the research problem within statistical analysis. With factual information, logical arguments can be included in studies through which expected outcomes can be obtained. A research study by Hodge (2020) concludes that by using graphical illustration, mathematical representation, visual formation, etc., readers will get to know about the research findings obtained in a study. By using graphical and statistical methods, a researcher is able to describe and explain their data findings through which the rationale of the research can be obtained (Fischer et al, 2023). Quantitative studies avoid using words, concepts, etc., as researchers avoid using in-depth explanations, as more emphasis is on displaying a visual representation of data findings.

### Justification of qualitative design

In this study, a qualitative research design is used to evaluate the research problem. The rationale for considering qualitative research design is that researcher will explore past research articles relevant to the topic to understand how sustainable practices can be maintained within construction projects and how collaboration can be performed.

## Data collection process

Selection of appropriate data collection techniques to extract appropriate data sets for a study. The selection of the data collection method depends on the researcher’s choice of the pattern in which results are to generate. Types of data collection processes, i.e. primary, secondary etc. (Mazhar et al, 2021).

### Primary data collection process

First-hand data collected from participants describe primary data as to collect information from respondent’s various primary data collection procedures used through which appropriate information is collected (Bjärkefur et al, 2020). Including participants' perspectives within studies are essential to obtain a quality amount of information. For a collection of primary data following are used i.e., interviews, surveys, focus groups, etc.

#### Interview

In qualitative studies, primary data is collected by using an interview approach by conducting in-depth interview sessions, i.e., face-to-face, etc., and participants' perspectives about the research problem can be determined (Adeoye‐Olatunde and Olenik, 2021). To gain detailed participants' perspectives, an interview is used as the primary data collection procedure in research studies.

#### Questionnaire

To collect primary data in quantitative studies closed-ended questionnaire approach is used through which relative responses of the participants on the research topic are collected (Shrestha, 2021). To fill out questionnaires, both online and physical procedures can be used.

##### Data collection instrument

The data collection instrument used within a closed-ended questionnaire is a 5,7-point Likert scale technique through which the strength of responses is identified (Kusmaryono et al, 2022).

### Secondary data collection process

With qualitative studies, secondary data is collected by using authentic secondary sources, i.e. research articles, books, magazines etc., through which published secondary information is collected to include (Ruggiano and Perry, 2019). To obtain secondary data selection of appropriate secondary sources is performed by a researcher to obtain quality outcomes within the research.

### Justification of secondary data collection process

For the current study secondary data collection procedure is used to investigate research objectives. Rationale for selection of a secondary data collection approach is that the researcher wants to identify traditional practices adopted by project managers within construction businesses. By using various research articles, relevant information can be obtained through which the topic can be examined in a detailed manner.

## Data analysis

To analyze data sets, various methods are used to interpret primary or secondary information collected within research. To analyze primary data within quantitative studies, SPSS software is used through which statistical analysis of data is performed (Pallant, 2020). To analyze primary data in qualitative studies, thematic analysis is conducted based on which common themes are identified within the responses of the participants. To analyze secondary data within qualitative studies, content analysis is performed (Stobaugh et al, 2019). The selection of the analysis method depends on the research design selected and the data collection procedure through which relevant information is extracted to include within the research.

### Justification of data analysis

For the current study, content analysis is performed based on a secondary data set collected to interpret research objectives. The rationale for considering secondary analysis is that extracting quality secondary information from various research articles is substantial to obtain appropriate information about the research topic under investigation based on which expected outcomes can be generated.

## Ethical consideration

Maintaining ethical implications within research is a prime responsibility of the researchers as while including participants within research, their informed consent needs to be considered, for which an ethical consent form is to provide to obtain their authorization within research (Hancock et al, 2020). Within secondary studies, the usage of authentic secondary sources is necessary to extract published secondary data through which quality information can be obtained to include in the study. By using authentic secondary sources, i.e., google scholar, etc. significance of secondary data can be maintained. Moreover, the best five research articles are extracted that consist of the last five years.

# Chapter:4 Results

The section on results provides an in-depth understanding of the research problem by using various research articles relevant to the topic. With secondary analysis, findings obtained by researchers, particularly on the topic of construction projects, have been determined within the below section.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Research title** | **Reference** | **University** | **Research Method** | **Findings** |
| Implementing lean construction techniques and management methods in Chinese projects: A case study in Suzhou, China | Xing, W., Hao, J.L., Qian, L., Tam, V.W. and Sikora, K.S., 2021. Implementing lean construction techniques and management methods in Chinese projects: A case study in Suzhou, China. *Journal of cleaner production*, *286*, p.124944. | Hefei University off the technology, China | Comparative analysis, i.e., case study (interview), questionnaire. | This research paper aims to investigate how construction businesses in China have adopted lean principles within their functioning. By evaluating a case study on a construction project conducted in Suzhou, China, an in-depth understanding of lean practices is extracted. It has been determined within the study that implementation of lean construction practices was executed by project stakeholders after the year 2005 when project managers identified the significance of implementing agile practices to accomplish project deliverables. This research paper focuses on including project stakeholders and lean experts whose experience and knowledge assist in better understanding the relevance of using the lean process. The findings of the study determined that lean principles involve the usage of, i.e., the Kanban model, last planner system, just-in-time mechanism, continuous improvement principles, the internet of things, quality assurance dimensions, etc. Based on the survey questionnaire and interviews conducted with respective stakeholders, it is concluded that the execution of agile and lean processes within the construction phase enables in reduction of waste and assists project handlers in minimizing, i.e., inventory, lead time, defects, etc., within the production process. Further, it is identified that the feasibility of completion of the project within the allocated time scale is possible with the integration of quality improvement dimensions. However, challenges determined involve, i.e., lack of knowledge and expertise for effective implementation of lean practices within construction projects. Inadequate communication patterns and huge dependency on traditional practices. Construction project conducted in Suzhou has attained significance with the execution of lean practices as it delivers real-time benefits to the project in terms of, i.e., time schedules, workflow processes, quality assurance dimensions, health and safety measures, minimizing on-site waste production, and risk management. The implication of 3D visualization, digital technological patterns, IOT mechanism, etc., assist project managers in handling the deliverables of the project. It enables the implication of lean practices within future construction projects in China. |
| A conceptual hybrid project management model for construction projects | Lalmi, A., Fernandes, G. and Souad, S.B., 2021. A conceptual hybrid project management model for construction projects. *Procedia Computer Science*, *181*, pp.921-930. | University of Coimbra, Portugal | Secondary analysis | This study aims to highlight the significance of hybrid models within construction projects rather than the execution of traditional practices to eliminate waste and improve quality production within the operational phase of the project. To reduce the impact of failure within construction-based projects and for effective management execution of lean practices has been determined to be essential based on which stakeholders' expectations can be accompanied. The study evaluates how the concept of lean and agile has been introduced by Toyota company within its manufacturing procedure, and with increased relevance, its adoption has been performed within the construction industry globally. The findings of the research explore the significance of agile training among team members based on which their performance practices can be enhanced. By conducting regular meetings, project team members who are to perform various production functioning are to provide strategic guidance related to the project life cycle. Project designing, execution, integration, etc., require timely planning through which the cost and time of delivering project milestones can be reduced, and quality improvement techniques can be executed. The implication of total quality management dimensions is an integral element within construction projects through which operational constraints can be determined, and adequate solutions can be performed. To strategically guide workers at on-site locations, the implementation of visualization tools is significant for project managers. Moreover, it assists execution of safety precautionary measures based on which hazards and damage can be reduced. The usage of scrum methodology is a new concept within construction businesses through which risks can be minimized and construction tasks into achievable milestones. Nowadays, construction businesses have been transformed with the usage of lean and agile functioning as project efficiencies can be maintained. Moreover, to fulfill stakeholders' expectations and enhance the customer satisfaction ratio, continuous improvement practices are performed based on digital construction mechanisms. |
| Provide a Lean and Agile Strategy for an Antifragile Sustainable Supply Chain in the Construction Industry(residential complex) | Sadeghi, S., Akbarpour, A. and Abbasianjahromi, H., 2022. Provide a lean and agile strategy for an antifragile sustainable supply chain in the construction industry (residential complex). *Cleaner Logistics and Supply Chain*, *5*, p.100079. | Aria University of sciences and sustainability Iran. | Quantitative survey-based analysis by using a questionnaire approach, i.e., Hierarchical Fuzzy Best Worst method, Grey Vikor etc. | This study aims to determine the significance of implementing sustainable supply chain practices within Didas company. The study highlights challenges faced by Iranian construction companies during pandemics as research suggests methods to overcome considerable operational constraints faced by supply chain managers in managing inventory and raw materials for the production process. Didas, which is one of the construction contractor enterprises, is to overlook its procurement and supply chain strategies for the construction of affordable housing schemes for stakeholders. The findings of the study proposed that lean and agile mechanisms are appropriate and ranked as a priority to enhance supply chain practices within construction businesses. To construct smart models within construction businesses, the usage of key performance indicators is suggested to be prominent to evaluate constraints and to ensure the effective implementation of project deliverables. The implication of lean practices is proposed to be effective in reducing operational costs and waste within supply chain procedures. The usage of agile manufacturing enables minimizing energy costs and assists in contributing towards environmental concerns. To improve performance at the operational phase, the execution of lean, effective project management strategies is required, which is an essential phase of the project life cycle. By using Hierarchical Fuzzy Best-Worst Method and Grey Vikor approach, agile and lean mechanisms are ranked and valued to utilize within construction projects for managing supply chain activities. For adequate estimation of raw materials to be used within construction projects, for accurate projects of inventory required in construction phases, training of construction workers who are operating at on-site locations, integration of quality assurance mechanism, etc., are applicable with the execution of the sustainable approach. Results of the study proposed Didas company utilizes an integrated model of the supply chain through a competitive edge that can be maintained within the construction industry as to invest in manufacturing technologies, strategic partnerships with suppliers, timely monitoring of environmental costs, performing standards of procedures, etc. are required to enhance flexible construction practices. |
| Practices Driving the Adoption of Agile Project Management Methodologies in the Design Stage of Building Construction Projects | Chathuranga, S., Jayasinghe, S., Antucheviciene, J., Wickramarachchi, R., Udayanga, N. and Weerakkody, W.S., 2023. Practices Driving the Adoption of Agile Project Management Methodologies in the Design Stage of Building Construction Projects. *Buildings*, *13*(4), p.1079. | University of Kelaniya, Srilanka. | Qualitative analysis | The study aims to identify the significance of using agile project management procedures within construction businesses as the execution of agile methodologies within the designing process is determined to be relevant through which expected outcomes of the project can be attained. This research focuses on suggesting relevant project management models to one of the architectural consultancy firms. Usage of backlog mechanisms, running sprints, and execution of cross-functional teams across construction projects are essential practices based on which agile functioning can be obtained. The significance of agile project management methodologies has been improved; however, the waterfall approach is one of the most common project management practices adopted within construction businesses. To execute the continuous designing phase, maintain flexible scope, manage uncertainties, and accommodate stakeholders' expectations, effective communication between the project manager and workers' execution of agile methodology is essential. The designing procedure within construction-based projects includes large-scale challenges for project managers; however, the execution of building information systems is determined to be a relevant approach as it enables the implication of sustainable solutions within the construction of building designs. With digital simulation practices used in the designing phase of the building, 3D visual representation is demonstrated among stakeholders within the pre-construction phase to make them timely informed about how actual construction will be performed. The findings of the study determined architectural consultancy firm needs to utilize BIM solution while adopting an agile methodology based on which deliverables of construction projects can be obtained. By using agile software within an operational phase of the construction-based projects, i.e., effective management of inventory, strategic guidance is delivered among front-line construction workers, stakeholders are timely informed about project deliverables, etc., through which project objectives can be accomplished within the expected time scale. The results of the study demonstrate that agile practices enable the execution of continuous improvement procedures through which operational efficiencies can be obtained within construction projects. Integration of waste management practices and cost-effective approaches are relevant while practicing agile methodology. |
| An Assessment of Lean and Agile Principles in Building Life Cycle Phases | Taş, E.F., Bulğan, J., Turkyılmaz, A.H., Bozdemir, S., Akarcalı, G.Z., Akin, F.D., Şimşek, E., Kızılkaya, Ş.B. and Ergin, A., 2020. An assessment of lean and agile principles in building life cycle phases. | Istanbul Technical University, Turkey. | Secondary analysis | The study aims to determine the significance of the lean and agile approach within construction-based projects. Based on challenges that project managers encounter while adopting traditional practices in construction projects significance of digital business models has increased. This study highlights the significance of lean and agile mechanisms within various phases of construction projects, i.e., initiation, designing, planning, maintenance, recycling, etc. The concept of lean has been adopted from the operational phase of Toyota as they have implemented an agile mechanism to manage raw materials and to manage excessive production. With value streaming, continuous improvement dimensions can be performed at the initial stage. By eliminating waste at the initial stage of construction projects, the feasibility of its completion can be increased. Integration of automated digital models is pointed to be essential for minimizing operational costs and overhead expenses. High training costs for construction workers are identified to be a broader challenge for project managers in terms of obtaining the necessary deliverables of the project. Productive maintenance practices are essential to minimize waste and enable project handlers to manage inventory to use within construction projects. The findings of the study highlight that lean practices enable a sub-categorizing project into different project tasks based on which project teams are developed and project milestones are assigned. With a proper storage system, inventory/raw materials can be preserved to be used within the construction phase. The implication of the deconstruction mechanism that involves, i.e., re-usage of materials can be adequate based on which environmental contribution can be maintained. Integration of automation and optimization principles is appropriate for minimizing operational waste and enhancing productivity dimensions. Quality assurance practices, risk management procedures, resource planning, labor training, etc., are crucial functions that demonstrate the agile mechanism. The findings of the study proposed that both methods, i.e., agile, lean, etc. are essential for implementing project management life cycle within the construction industry as they enable in effective execution of designed project deliverables to obtain based on construction procedures adopted. |

# Chapter:5 Discussion

The section of discussion demonstrates each research objective that is a prime emphasis in this study to investigate.

## Role of collaboration and adaptability in the sustainable construction industry

A study by Stanitsas et al (2021) shows that an increased number of construction-based projects globally has raised the significance of quality improvement dimensions to practice by project managers. Reduction in operational costs and the implication of waste management dimensions are two prominent aspects to contribute to environmental degradation concerns (Serra-Majem et al, 2020). Integration of green building practices, sustainable policy framework, etc., are determined to be considerable dimensions to minimize waste and improve production practices within construction-based projects. Research by Wuni et al,(2023) concludes that traditional phases within construction processes have increased lead times, operational overhead costs, etc., as accommodating stakeholders' expectations and clients' value has become a broader challenge for project engineers. The usage of a just-in-time mechanism has been determined to be adequate to ensure continuous improvement procedures within the construction- projects.

Construction companies have major responsibilities towards environmental concerns, economic stability, social contribution, etc., that require effective utilization of project management techniques for the effective accomplishment of project deliverables (Stanitsas and Kirytopoulos, 2023). To manage stakeholders' expectations have become a prior concern for construction-based companies as to manufacturing of highly sustainable business models is required to ensure client satisfaction. Implementation of agile dimensions has been adopted from Toyota’s manufacturing procedures as with continuous improvement techniques, quality assurance principles can be practiced within construction mechanisms (Francis and Thomas, 2020). Research findings of Hussein et al (2021) conclude that i.e. selection of construction sites, training of laborers, inventory management, etc., are essential elements through which sustainable construction practices can be performed. The waterfall approach and the Kanban model are the two most common sustainable project management techniques executed by project managers within complex phased projects (Marques et al, 2023). However, with time the significance of agile and lean procedures has increased, creating ease for project handlers.

A study by Hossain et al (2020) shows that effective utilization of resources is an appropriate aspect of minimizing environmental waste. Evaluation of storage units where inventories are preserved and production units where raw materials are evaluated need to be timely monitored and evaluated. With the implication of waste management practices, construction sites can be overlooked by project managers to identify defects within production procedures. Assembling of raw materials to be used within the manufacturing process require strategic planning (Yang et al, 2021). By conducting team meetings, teams allocated with construction tasks are to align with construction procedures to obtain. It is the strategic responsibility of project managers to overlook the manufacturing phase and to deliver timely information and knowledge among construction workers to manage the feasibility of projects (Hasan and Kamardeen, 2023).

Construction contractors, project engineers, architectures, project managers, etc., are to schedule project deliverables by conducting strategic meetings to meet project goals. By reporting daily based activities to stakeholders effectiveness of projects is maintained (Lin et al, 2019). Arrange skilled labor, renewable raw materials, quality equipment, etc., are essential components within the construction of highly sustainable business models. To maintain accuracy and precision within construction projects, production reports are required to evaluate by project supervisors to identify lacking within construction procedures (Zhao et al,2019). To evaluate the performance of construction workers, the usage of key performance indicators is performed by well-reputed construction companies to identify efficiencies delivered by labors who are working on-site. By providing labor training, the technicalities needed for sustainable construction are obtained (Forcael et al, 2020). Based on lacking in productivity, appropriate knowledge is delivered to enhance performance rate.

With the implication of digital technological patterns, wastes are eliminated, and the feasibility of a project can be determined based on which effective production procedures are to adopt. By using 3D simulation models, a visual representation of construction projects is delivered among stakeholders through which the effectiveness of smart construction is performed (Pan and Zhang, 2023). Changing the design of the construction based on the priorities of stakeholders is strategically possible with 3D models through which defects can be predicted and eliminated within a timely manner (Ahn et al, 2023). By tracking defects, construction supervisors are able to minimize risks and challenges that might create certain delays in the accomplishment of project deliverables.

## The implication of lean construction dimensions in the sustainable construction industry

A study by Alkaraan et al (2022) shows that the significance of lean manufacturing procedures has become relevant within construction companies as to fulfill stakeholders' expectations, the adoption of an agile mechanism is relevant. With digital technological patterns, on-site supervision is applicable, and labor health and safety can be maintained (Hou et al.,2020). By predicting risks and manufacturing defects secured centralized model is proposed through which quality assurance measures are utilized. Safety audits, i.e., operational costs, operational performance, environmental hazards, construction risks, etc., are managed by project managers (Yiu et al,2019). Many construction companies within emerging countries are relying on traditional methods of construction that include quantity production rather than the emphasis on quality, due to which extent of project risks are greater (Yap et al, 2019). However, many of the well-reputed construction companies have adopted agile mechanisms and lean functioning to organize and manage the construction of sustainable models to practice within construction procedures.

Avoid over-production, manage inventory, obtain project milestones within the allocated time scale, etc., and require sustainable project management strategies to obtain project goals. By allocating a labor force who have certain expertise to perform consistently on construction sites extent of production risks is minimized (Sukhorukova et al, 2020). Research by Newman et al (2021) indicates that construction plans are not constant, as there can be a requirement to alter the strategic plan proposed based on challenges and risks encountered by project managers. With pre-forecasting procedures, operational risks are controlled, and high costs are reduced (Kumratova, 2021). Well-defined schedules generate expected productivity margins based on which feasibility of projects are maintained. With effective communication between stakeholders, flexible workflow procedures are performed and executed. The findings of Nwaki and Eze (2020) conclude that extent of defects and construction risks are minimal by using lean principles as continuous improvement dimensions enable practicing innovation. However traditional approach involves operational challenges for construction managers.

A research study by Opoku et al (2019) indicates that construction companies have major responsibilities to contribute to environmental concerns as the adoption of sustainable practices is required to manage environmental degradation. The usage of lean procedures is identified to be significant for the effective implementation of a cost-effective approach. With increased competition, construction companies are more strategically aware of performing sustainable procedures within the operational phase to minimize operational costs and manufacturing risks (Huiling and Dan, 2020). Arranging renewable raw materials, preserving inventory within ware houses, training workers, quality assurance practices, performance evaluation, etc., are a few of the many aspects needed within sustainable construction projects. The phenomena of just-in-time enable construction managers to accomplish project deliverables within the allocated time scale (Alzoubi, 2022). The usage of digital practices, i.e., IOT applications, machine learning procedures, artificial intelligence mechanisms, etc., has improved techniques through which sustainable construction dimensions are performed. With standards of procedures, improvements within efficiencies are maintained. Defect identification, overproduction, decrease in performance, increase in lead times, etc., are managed based on lean principles (Gonzales, 2023).

Research by Helmold and Terry (2021) shows that the usage of quality improvement procedures, risk management strategies, etc. are adequate principles to minimize operational challenges. Many of the project managers have a huge dependency on traditional approaches due to a lack of knowledge and expertise to utilize agile procedures that pose strategic challenges for the execution of lean practices within many of the construction projects (Bakar et al, 2023). To avoid the usage of the traditional construction management approach, effective communication is needed between stakeholders and project managers who have certain expertise to handle complex construction-based projects with the execution of lean dimensions (Singh et al, 2023). Evaluating raw materials while purchasing from suppliers can be performed based on agile procedures through which renewable resources can be obtained for construction projects.

# Chapter:6 Conclusion

From the above analysis, it can be concluded that sustainable construction models require the implication of a lean management approach and agile dimensions to obtain quality principles within complex phase construction projects. Traditional practices adopted by project managers involve certain challenges, i.e., delays within construction deliverables, high operational costs, lack of expertise among project handlers, inadequate skills within the labor force, and lack of technology, etc. that put-forward complications to obtain sustainable project outcomes. However, the agile process is adequate for managing resources and for the effective implementation of project objectives. With scrum methodology, project tasks are accomplished within the allocated time scale, and by distributing milestones among project team members, operational risks and challenges are minimized. The section on methodology provides readers with an overview of the research strategy being adopted in the study. With qualitative research, the design researcher emphasizes investigating the research problem. Moreover, by using the secondary data collection process, an in-depth understanding of the significance of lean construction dimensions and agile processing are determined. It is evident from the study that project managers can implement lean principles within construction projects to reduce environmental waste and contribute towards ecological dimensions. To fulfill stakeholders' expectations implication of sustainable business models is needed within construction-based projects globally.

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