A Decision Approach for Analysing the Role of Modern Methods, Project Management and Integrated Approaches in Environmentally Sustainable Construction Projects

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Abstract

A global concern for a transition to a sustainable construction approach is imminent and highly important. This research aims to identify a justifiable strategy to improve sustainable construction success. To enhance the success rate of sustainability, important factors contributing to the cause such as project management, integrated approaches, and modern methods of construction (MMC) are studied. The core ideology is to understand the relational attributes of these factors, their significance, and the mediating effect of modern methods of construction (MMC) in sustainable project success. A deductive research approach is undertaken, by performing a web-based self-administered quantitative questionnaire survey with 5-point Likert scale. The survey adopts the snowball purposive sampling technique to collect data from construction professionals like project managers, architects, contractors, researchers, etc. The survey recorded a total of 149 responses, majorly from the UK, forming the base for several statistical data analysis techniques, supporting the formulation of research findings. Structural equation modeling is the cardinal analysis approach carried out to draw relational values between the principal research factors. The findings of the research highlight that both project management and integrated approaches display a significant positive relationship with sustainable construction project success. It is observed that project management and integrated approaches have positive impact on sustainable construction success with R=0.208 and R=0.569 respectively, at a significance value <0.05. Moreover, incorporating modern methods of construction as the mediating factor further enhances the project success rate. Thus, it can be depicted that in order to gain a maximum output from project management and integrated approaches to build the sustainable construction the role of modern methods of construction is critical. The research will help to bridge the gap between available extensive knowledge on sustainable construction and scant information on its successful implementation.

Keywords: Sustainable construction; project success; project management; integrated approaches; modern methods of construction.

1. Introduction

In most countries, the construction industry has been the primary source for the overall growth of the economy (Chen et al., 2017). With the constant increase in population, the demand for new construction in all sectors has been very high (Maqbool et al., 2022b). The traditional method of construction does not meet these growing demands; hence the industry leaders (Hochtief Aktiengesellschaft, China Communications Construction Group, VINCI, etc.) have switched to modern methods incorporating the latest technologies available to them.

The primary objective of any construction project is to complete the work on time and hand it over to the clients as scheduled. However, this has become a worldwide problem in the current period (Amu and Adesanya, 2011; Hussin, Rahman, and Memon, 2013). Project delay can be due to many factors such as issues in payments and improper financing for the works that are completed (Fugar and Adwoa, 2010), poor management of contracts, alterations in site conditions, changes to the initial design, limitations to available materials for construction, adverse weather condition, and natural causes (Maqbool et al., 2020). Previous studies have determined various factors that lead to cost elevation in construction projects (Subramani, Lishitha, and Kavitha, 2014; Enshassi et al., 2009). Some of the major issues leading to an increase in the estimated budget include lack of qualified workers, poor quality of equipment and materials, unavailability of materials, poor communication and coordination, poor management skills, lack of involvement from the stakeholders, etc. (Enshassi et al., 2009).

Improper waste management plan directly impacts the material shortage, productivity, and project completion time leading to a significant loss for the project stakeholders (Maqbool & Amaechi, 2022). In a construction project, the waste is approximately 30-35% of the production cost of the project (Forsberg and Saukkoriipi, 2007). Studies have illustrated that waste disposal can be made properly by applying appropriate waste management strategies and incorporating profound techniques such as lean construction, which has proved to reduce waste by a greater margin (Hussin, Rahman, and Memon, 2013).

In recent times modern technologies such as building information modeling (BIM), leadership in energy and environmental design (LEED), etc., are used as building environmental assessment tools. These tools have assisted the construction industry in reducing the amount of negative impact on the environment (Haapio and Viitaniemi, 2008).

These negative aspects of the building sector have driven many industry specialists to focus on alternative methods and strategies to the existing traditional method, paving way for the sustainable construction practices. To achieve sustainability in their projects, some of the industry leaders have adopted integrated approaches such as BIM, LEAN, etc. However, clear knowledge of these integrated tools and their benefits to sustainable construction and project management is minimal. Hence, there is a need to simplify this vast knowledge and provide a framework for understanding how integrated approach, project management practice, and modern methods of construction impact on sustainable construction project success.

The knowledge and awareness of sustainable construction are discussed in much research. A vast number of studies explain the importance of sustainable development and its benefit to the environment, economy, quality of life, etc (Maqbool & Wood, 2022; Maqbool et al., 2022a). However, the gap between knowledge and practical implication needs to be bridged (Hjorth and Bagheri, 2006). Another important factor discussed in the study is the role of modern methods of construction in satisfying sustainability goals. So the important questions for this study is, “Does sustainable construction success improve with the adoption of modern methods of construction?”.

Sustainable construction and construction project success are of utmost importance in research topics studied across the world, concerning the industry. Much of these research either focus on a single element responsible for sustainability or explain various general factors contributing towards sustainable construction goals. For example, some existing literature culminates on topics such as critical success factors for construction project success and sustainable construction (Ramlee et al., 2016; Gunduz and Almuajebh, 2020), BIM advantages in sustainable construction (Al-Ashmori et al., 2020; Mesároš et al., 2016), and MMC benefits in construction projects (Chen et al., 2010; Pan and Hon, 2020), etc.

The main objectives of the research are:

- To study the sustainability construction success factors.
- To understand major obstacles that reduce sustainable project success.
- To study project management practices and their contribution towards sustainability.
- To identify important integrated approaches and their impact on project success.
- To analyse the role of MMC towards sustainable construction success.

The culmination of the three important factors, project management, integrated approaches, and modern methods of construction operating in unison to exalt sustainable project success is yet to be explained in detail by the literature.

2. Literature Study

This section forms the base for this research paper, detailing important aspects of sustainable construction, project management, integrated approach, and modern methods of construction. Critical literature analysis is made on the relational effects of various factors controlling sustainable project success.

2.1 Sustainable construction

Sustainable development-based criteria are progressively affecting many aspects of construction enterprises' activities, from environmentally aware design and construction to sustainable sourcing, efficient project, and investment management (Akadiri et al., 2012). In recent times, with growing concerns for protecting the environment and creating a better quality of life, government and stakeholder's demands have influenced sustainable construction practices (SCP's) in the form of new legislative laws and policies, modified project briefs to adopt sustainable strategies, etc., in the UK (Qi et al., 2010; Rodriguez-Melo and Mansouri, 2011; Pan et al., 2019). The UK government had passed a rule that insists all new constructions should have zero-emission for heating and cooling by the year 2019 (Maqbool & Jowett, 2022).

The construction industry in the UK is a major sector that has a great amount of impact on the country's economy and environment. It creates employment for more than 3.1 million people for various positions and accounts for nearly 10.5 percent of the country's jobs, contributing significantly towards the gross domestic product (GDP) up to 8 percent (Office for National Statistics, 2012). Construction operations, on the other hand, can have a wide range of negative consequences. The sector is responsible for 50% of water usage, 50% of carbon emissions in the UK, 35% of waste dumped in landfills, and 13% of raw materials used for construction in the UK (DEFRA, 2007). These negative effects of the construction sector have put pressure on industry organisations to explore sustainability facets and environmentally friendly strategies (Maqbool et al., 2022c).

The traditional process of construction is driven by cost, performance, and quality goals, while sustainable design and construction also consider resource depletion, ecological damage, and the creation of a healthy built environment. The transition of building activities towards sustainable development is considered to be a new dimension for the AEC industry, that must put more importance on sustainable goals (Maqbool et al., 2022c). It is taken into account while making decisions at all phases of the facility's life cycle (Huovila and Koskela, 1998). Figure 1 represents the transition of the construction sector from the traditional approach to a sustainable approach and the objectives of sustainable construction practices.

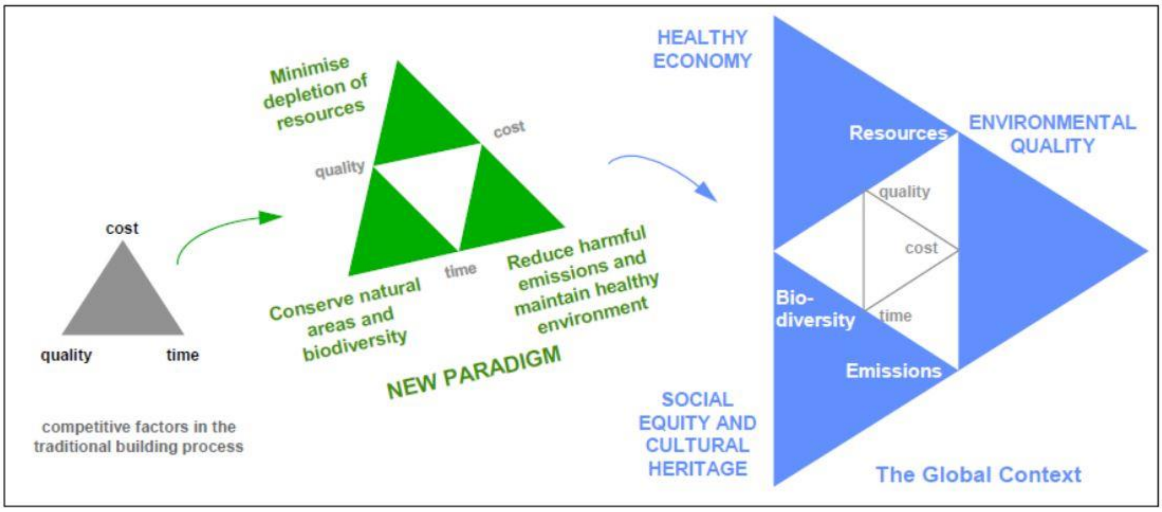


Figure 1: Objectives of sustainable construction (Huovila and Koskela, 1998).

2.2 Project management practices

Project management offers project managers various tools and techniques to ensure project success. These techniques include macro and micro cost estimation, bar charts, Gantt charts, network activity diagrams, techniques to schedule resources, etc. To attain successful project completion an integrated project management approach is adopted, that offers reinforcement of project management techniques and tools focusing on the strategic plan of the company (Wasileski, 2005).

The Project Management Institute (PMI, 2008), explains projects as a set of activities that has a life cycle, requires completion of aims and objectives, has a defined scope with a start and end period, and requires financial supplement. The project's success and quality are ensured by utmost precision, participation of important stakeholders, and adequate documentation at each stage (Project Management Institute (PMI, 2008)).

Green building and sustainable project management have multiple dimensions and meanings. The "green" terminology has been in existence for more than 40 years, due to a growing need to conserve natural resources and reduce environmental damage.

Research conducted to identify the difference between sustainable project management and traditional management at various stages of the construction process is explained in Table 1.

Table 1: Comparison of sustainable project management versus traditional project management approach (Robichaud and Anantatmula, 2011).

Project stages	Traditional approach	Sustainable approach
Feasibility and project requirement assessment	The scope and requirements of the project are determined based on market conditions, physical, and short-term needs.	Apart from traditional requirements, capital investment on sustainable initiatives, environmental criteria, and sustainability certifications will be considered.
Selection of project manager and team	The project manager and the team is selected based on in-house availability and type of contract.	A competent project manager with experience in all stages of sustainable construction will be hired. Other experts with technical knowledge will be interviewed and employed.
Selection of project site	Site selection occurs in a traditional way with limited involvement of the stakeholders.	All the stakeholders and the project team are fully involved and physically present during site selection.
Project bidding	Commonly 'hard bid' method is employed, where the project is awarded to the lowest bid and the contractor selects the sub-contractors in a closed-book approach.	An overhead open-book approach is recommended for sub-contracting in green building projects, that allows the owner to have access to all the estimated costs.

Contracting	Traditional contracting methods such as cost-plus-percentage or cost-plus-fixed fee are used.	The integrated sustainable project requires a new type of contract with agreement on performance and bonuses for adopting sustainable techniques. Energy star criteria and certifications must also be included in the contract.
Construction	The lead architect reports the weekly site inspection, with little communication among the project team on-site and sub-contractors.	The project commences with education on sustainability to the on-site workforce. The weekly meeting is attended by the entire team with regular training on sustainable principles.
Delivery and operation	Before the building is delivered for operation, limited testing is carried out.	The building commissioning authority is hired to carry out necessary testing to satisfy the client's requirements before leaving for operation as stated in the contract.

The literature study in the above section leads to the following hypothesis:

H1: Project management practices positively impact sustainable construction success.

2.3 Integrated approaches in construction project

The construction industry is blamed for underachievement and various other characteristics such as low productivity when compared to other industries (Chou et al., 2013). The common errors for which the industry is accused are poor quality, unsatisfied clients, cost escalation, poor relationship between different parties involved, and inefficient dispute management among others (Chen, 2015). Unlike other industries, the construction industry function in a different way, and work is highly fragmented among many stakeholders and teams.

The traditional construction method understands project success as the effort and satisfaction of an individual rather than focusing on its entire output (O'Conner, 2009; Lahdenpera, 2012; Maqbool et al., 2022d). Hence, there is a need to take an integrated approach to construction that could solve the issues of the traditional method.

2.3.1 Building information modeling (BIM), a tool for integration

The use of advanced technologies for construction has become more common in the present. Emerging software programs have provided a positive impact on construction projects by helping in reducing cost, design of structures, managing budgets, and creating detailed drawings (Mesároš et al., 2016; Gledson and Greenwood, 2017). From April 2016, The UK Government made it mandatory for all public sector constructions to adopt the BIM approach for their procurement in a vision to make a transition into sustainable construction (Barlish and Sullivan, 2012). The government in collaboration with professional bodies has suggested a BIM maturity index that serves as a reference for BIM implementation, outlined in Figure 2 (Bew, 2013; Alwan et al., 2017).

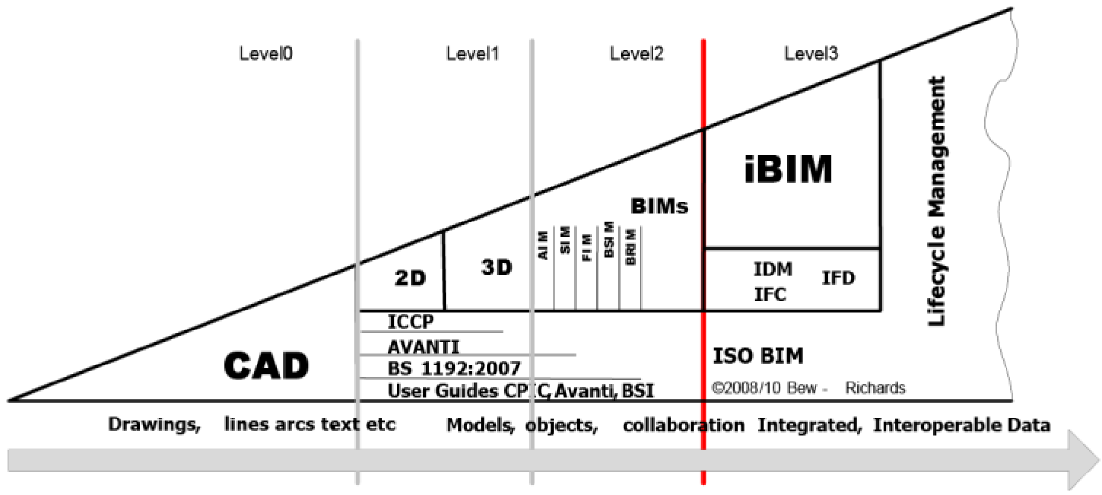


Figure 2: Maturity index of BIM implication (Alwan et al., 2017).

Apart from other benefits, BIM offers effective communication and connection between various members of the construction project through its advanced data sharing cloud technology (Radziszewska-Zielina and Rumin, 2016). Previous studies have identified the following as the major benefits of applying BIM technology as a project integration technique:

- Construction project management experiencing reduced cost,
- Lesser time consumed in documenting the project,
- Design stages and the entire project life cycle is completed in a shorter period,

- All the participants of the project have faster access to important information and documents,
- Productivity of the employee is enhanced,
- Financial control over the project is achieved,
- Decision-making process is easier and fast,
- Eliminates the errors in documents and increases documentation quality,
- Construction process has low errors and higher quality,
- Contractual revenues are increased.

2.3.2 Lean construction

The negative attributes such as poor relationship among the team, underachieving staffs, and low rates of profit margins are commonly being linked with the construction industry in comparison with other sectors (Sarhan et al., 2017). Lean construction (LC) has proved to efficiently resolve the issues of the construction sector and increase customer satisfaction by adding value, through a better understanding of the problems and the means to identify and remove many sources of waste in the design process and construction phase (Koskela et al., 2013; Sarhan et al., 2018).

Lean construction is often credited for the incorporation of the Transformation-Flow-Value generation (T-F-V) theory to the construction industry, although a common definition for lean construction is hard to propagate (Koskela, 2000). The entire project cycle has interdependent tasks, and this factor is identified by the flow (F) aspect of the theory (Sarhan et al., 2018), therefore the production management process is driven by the reduction of waste as its superior objective, whereas the customers become a primary focus in the value (V) generation aspect (Koskela et al., 2010). ‘Customer’ is not a general term in use, but the construction sector predominantly identifies clients and stakeholders as the most important terms (Sarhan et al., 2018).

As per Koskela (2000), the LC principles intersect with the sustainability goals in the following ways. To begin with, LC decreases pollution, material, and energy wastes during construction and maintenance by focusing on the notion of waste minimization (Maqbool & Akubo, 2022). On the other hand, LC might be advantageous to customers looking for commercial, environmental, and social success at the same time, because of the notion of 'value'.

Based on the above theories the following hypothesis can be tested in the research:

H2: Integrated approaches such as BIM and lean construction positively impact sustainable construction success.

2.4 Modern methods of construction (MMC) and sustainability

In the UK the terms off-site and on-site construction are typically associated with modern methods of construction. Offsite MMC refers to prefabricated structural components or pieces that are developed in a controlled factory setup, before being transported to the construction site. Manufacturing parts of structures on the construction site refers to onsite MMC (Kyjaková et al., 2014).

According to Chen et al. (2010), although MMC is known for its high productivity and good quality of products, it has other benefits such as low construction cost and time, better aesthetics, promoting healthier and safe working atmosphere, high durability of products, conservative use of materials, reduce waste during construction, reduce harmful emissions into the environment, and minimize water and energy utilization.

The national audit office, reports that MMC strives to achieve better quality products through structured processes. It boosts business profitability, customer happiness, environmental safety, sustainability, and delivery time predictability, all of which form the vital criteria for successful sustainable construction delivery. Hence, MMC and its benefits cover wider aspects of construction rather than just the product aspect (Kyjaková et al., 2014). Studies have classified MMC into off-site and onsite categories with various sub-categories as illustrated in Table 2 (Kyjaková et al., 2014).

Table 2: MMC Categories (Kyjaková et al., 2014).

	Categories
Offsite construction	Volumetric construction
	Hybrid construction
	Natural materials
	Paneled Construction
	Lightweight facades
	Sub-assemblies and accessories systems

Onsite construction	Prefabricated auxiliary structures (site assembled)

The above literature opens discussion on the following hypothesis:

H3: Modern methods of construction improve sustainable construction project success.

H3a: Project management practices positively influence modern methods of construction.

2.4.1 Modular integrated construction

Offsite construction (OSC) has had a rebirth within the industrialized building movement in recent decades, to surpass some of the failures of the traditional construction technique. The most common OSC method that involves the integration of high-value prefabricated components is known as modular integrated construction (MiC). Within the agenda of prefabricated construction, MiC has attained the highest level (Pan and Hon, 2020), nearly 80-90% of the entire building can be manufactured in a factory making it the most valuable form of OSC (Smith, 2016).

The concept of modularity and modularization are effectively incorporated into the construction activity through MiC, which is ground-breaking technology and construction, business model. According to Baldwin and Clark (2000), modularity can be defined as the methodical fragmentation of a larger system into distinct sub-divisions that engage with one another via standardized specifications and rules using advanced building integration systems such as BIM, etc. Hence, MiC can be explained as a construction method where parts of the building, fittings, components, and fixtures are created in a controlled facility having prefabricated advantage and are transported for installation to the site (Hong Kong Buildings Department, 2018). Reinforced concrete modules, steel frame modules, and hybrid modules are the most popular forms of MiC.

H3b: Integrated approaches positively impact modern methods of construction.

2.4.2 MMC role in project management and integrated approach towards SC

Diffusion of innovation theory (DOI) and technology acceptance model (TAM) argues that any innovation or new technology does not completely rely on its competency but, on the collaborative effort. The theory explains that various categories of people accept change based on certain criteria such as risk, investment, ideology, tradition, etc. The theory divides the population into innovators (2.5%), early adopters (13.5%), early majority (34%), late majority (34%), and laggards (15%), it is up to the marketing strategy that allows a new concept such as MMC in construction to get diffused into the system (Macková and Mandikac, 2017; Sartipi, 2020).

Modern methods of construction incorporate integration technology such as BIM to improve product precision, information sharing, and communication. The lean principles such as high product quality and reduced waste in manufacturing are in alignment with the MMC concept. Therefore, MMC achieves sustainable project success through adopting an integrated approach (Little, 2018). MMC faces a major drawback in terms of last-minute design changes, that impact the project completion time, which in turn increases the overall project cost. An effective project management strategy can solve this issue and increase the project success rate (Oyedele, 2016). Literature review leads to the following hypothesis:

H3c: MMC plays a mediating role between project management and sustainable construction success.

H3d: MMC plays a mediating role between integrated approaches and sustainable construction success.

2.4.3 Obstacles to MMC

According to the literature, frequent MMC hurdles, disadvantages, and problematic issues may be classified into eight broad categories: cost, experience and skills, culture and motivation, standards and tools, MMC market issues, industry obstacles, adaptability/flexibility issues, and project issues.

High initial cost: The cost of setting up MMC-based factories and necessary equipment for modular prefabrication is high at the early stages of the manufacturing process (Chiang et al., 2006).

Experience and skills: For the process of manufacturing MMC components in the factory and the installation of them on the site requires a highly skilled and experienced work team (Jaillon and Poon, 2010).

Culture and motivation: Due to the history of failures in MMC, many industry practices are doubtful of the performance of the concept (BRE, 2001). Organisations are unwilling to take up MMC due to this pre-conception and stigmatic mindset (Cooperative Research Centre for Construction Innovation [CRC], 2007).

Standards and tools: Major MMCs advancements and innovations have come into existence only in recent times. Traditional methods of construction are gradually being replaced by MMC in the present decade. This has led to the slower identification of the standardized design, appropriate quality assessment systems, and accreditations (Pan et al., 2011).

MMC market issues: The existing off-site manufacturers must rely on the small market available to them. This situation has impacted the rise in MMCs product cost, making the project expensive. Manufacturers tend to charge higher to make small profit margins. (Pan et al., 2011).

Industry-related obstacles: The communication factor is highly important for the successful operation and delivery of MMC products, throughout the project life cycle (Wong, 2000). However, the construction industry is fragmented in nature has limitations to communication that hinder standardized MMC design (HCA, 2010).

Adaptability/Flexibility issues: To produce MMCs components and parts, the construction design must be completed in advance and handed for manufacturing. This type of early design completion that MMC demands, does not favor design flexibility (Jaillon and Poon, 2010).

Project-Specific Issues: Construction site constraints such as smaller access paths or limited space for storage do not favor MMC, as certain parts of MMC are large and thus require more space and access (Jaillon and Poon, 2010).

2.5 Research framework

Based on the literature study and the proposed hypothesis, a research framework is drawn to understand the relationship between the independent variables, dependent variable, mediating and moderating factors as illustrated in Figure 3.

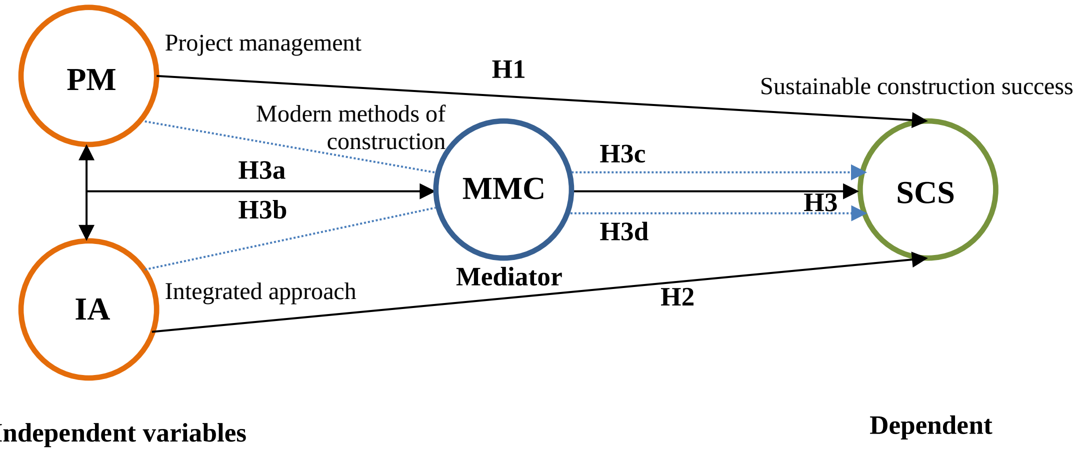


Figure 3: Research framework.

The framework suggests how the research variables are associated with each other and share influential relationships. The above-mentioned hypothesis, derived from the literature study is tested using statistical data analysis method using software to check its validity, and its results are described in section 4: Analysis and results.

3. Methodology

This section outlines the survey method adopted for data collection and describes the process of questionnaire adoption, sampling technique, sample size, region, and participant demographics.

3.1 Research method

The best suitable method for data collection and analysis for this research was identified to be the quantitative method. The notion of quantitative research is associated with the use of empirical statements and techniques in conducting social research (Cohen, 1980).

With a cautious approach to follow health and safety precautions, keeping in mind the existing situation of COVID-19, a web-based questionnaire survey method was adopted for attaining relevant data for the research. It enables the researcher to draw various relations and comparisons between population groups (Sukamolson, 2007).

From Figure 4, the deductive approach can be understood as analysing existing theories related to the research topic and formulating hypotheses based on the knowledge gained from the literature.

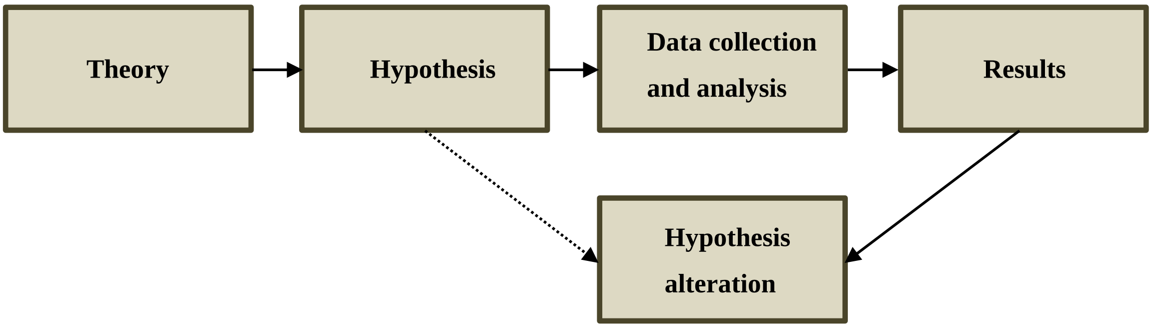


Figure 4: Deductive research method.

3.2 Questionnaire formulation

Buckingham and Saunders (2004) define a questionnaire survey as "creating organized questions to address the statistical information related to attributes of social science to the entire population or a specific group of the population". The questions in the survey were developed by adoption from existing literature and research papers that are related to the core constructs of this research as illustrated in Table 3. The questions were segregated into categories and sub-categories to fit the different variables and the intended research framework model.

Table 3: Questionnaire survey adoption.

Variable category	Items	Source
Project management practices	13	(Ling et al., 2008; Ogunde et al., 2017)
Integrated approaches	6	(Olawumi et al., 2018)
Modern methods of construction and their obstacles	9	(Pan et al., 2007)
Sustainable construction success factors	10	(Banihashemi et al., 2017)

A Likert scale contains four to five Likert items that provide a composite value when integrated with other similar items during data analysis (Boone and Boone, 2012). This method is mainly useful for quantitative research as the values from the survey can be used for calculating correlation and covariance among the variables through statistical analysis.

3.3 Sampling technique, size, participant demographics

The research uses snowball sampling that forms a part of the purposive sampling technique. The sampling method allows the researcher to choose the sample units from a particular group that shares similar characteristics such as experience, professional background, etc. This technique is adopted when the sample units have a high degree of relation with the research questions (Rai and Thapa, 2015). It is also known as referral sampling that allows the researcher to use their social network to find participants for the survey, who in turn circulates the survey among their network (Jawale, 2012).

The survey collected a total of 153 responses from a population sharing common professional experiences related to the construction sector. The participants were construction professionals predominantly from the U.K construction industry. The major respondents in the survey were construction industry researchers, construction project managers, engineers and architects with the total responses of 40, 30, 30 and 2 respectively. Moreover, the respondents having Masters degree were dominants with the total 112 responses, comparing to Bachelors and PhD degrees, which had 25 and 16 responses respectively. Furthermore, the average experience of the respondent was 5 to 10 years in the construction industry, which shows an accurate view of opinion towards sustainable construction project management.

4. Analysis and results

Various statistical analysis is conducted to establish the correlation between observed variables and constructs. Reliability and validity information from the analysis provides assurance, whether the data set is accurate for further study. The cohort of 153 responses was checked for errors such as missing values and outliers. It was discovered that the data set had no missing values. However, after studying the Z mean values of the constructs, through the SPSS statistics 27 software, 4 outlier cases were identified and removed. Outliers are known as values in a data set that deviates extremely in comparison to other values, whose presence incurs errors in the process of analysis (Kwak and Kim, 2017). So, after processing all the necessary checks a total of 149 valid responses were used for the data analysis to draw the inferences in this research.

4.1 Reliability, normality, and validity analysis

The initial data set after the process of screening, which includes the elimination of outliers and checking missing values, was assessed for overall consistency in SPSS statistics 27 software. It is also the method that measures the internal consistency of the questionnaire data set (Bonett and Wright, 2015). Since this research uses the five-point Likert scale measure for the survey, Cronbach's alpha is considered the best suitable reliability test. The Cronbach's alpha value $\alpha = 0.65$ to 0.7 is considered to be in an acceptable range and $\alpha \geq 0.7$ is in the good range (Griethuijsen et al., 2014).

With large data sets, it would be difficult to analyse the normality of the data, hence descriptive statistics are used to generate a summary to check its normality (Kaushik and Mathur, 2014). The skewness measure indicates the symmetry of the data set ranging from positive to negative skew, and kurtosis represents the distribution tail's heaviness. The skewness value can range from -2 to 2 and the kurtosis value is advised to fall within -7 to 7 (Hair et al., 2010). Table 4 indicates the results of reliability and normality tests, which illustrates the research data is reliable based on the values discussed above.

Table 4: Reliability and normality test.

Variable	Cronbach's α	Mean	Std. Deviation	Skewness	Kurtosis	Items
Project management	0.661	3.93	0.3371	0.246	-0.163	13
Integrated approaches	0.869	4.25	0.5113	-0.444	0.091	6
Modern methods of construction	0.709	3.98	0.4108	0.178	-0.217	9
Sustainable construction success	0.688	3.95	0.3794	0.442	-0.142	10

Convergent validity, a part of the construct validity informs how closely two or more variables that form a construct are related. The values of composite reliability (CR) and average variance extracted (AVE) are used to find the convergent validity. The general thumb rule for this validity is specified as CR>AVE>0.5. However, research also suggests that the convergent validity is still acceptable if AVE<0.5 if CR>AVE and CR>0.6 (Fornell and Larcker, 1981). Table 5 represents the construct validity of the data set.

Table 5: Construct validity of the data.

Factor analysis	**Values**	**Variables**	**CR**	**AVE**	**Items**
KMO	0.808	Project management	0.669	0.491	5
Bartlett test Chi-Square:	 228.787	Integrated approaches	0.846	0.527	5
df Sig	10	Modern methods of construction	0.799	0.500	4
	<0.001	Sustainable construction success	0.712	0.488	4

The construct validity of the variables was tested through factor analysis in SPSS. The Kaiser Meyer Olkin (KMO) value should stand between 0.5 to 1 for the suitability of this test (Malhotra, 2008). Furthermore, the Bartlett test of sphericity with a varimax rotation established a significant p<0.001 value (Maqbool et al., 2018). The results from factor analysis display a good construct validity of the data.

4.2 Correlation analysis

A bivariate analysis method that uses Pearson's correlation is used, as it provides coefficient values that represent the statistical association between continuous variables. It is the most suitable method to test the variance on X caused by a change in Y in a quantitative data analysis (Haining, 1991).

From Table 6, it can be understood that the correlations among all the specified variables are highly significant with p=0.000. The general significance rule states that the p-value must be p<0.05 to achieve a significant relationship.

Table 6: Pearson bivariate correlation matrix.

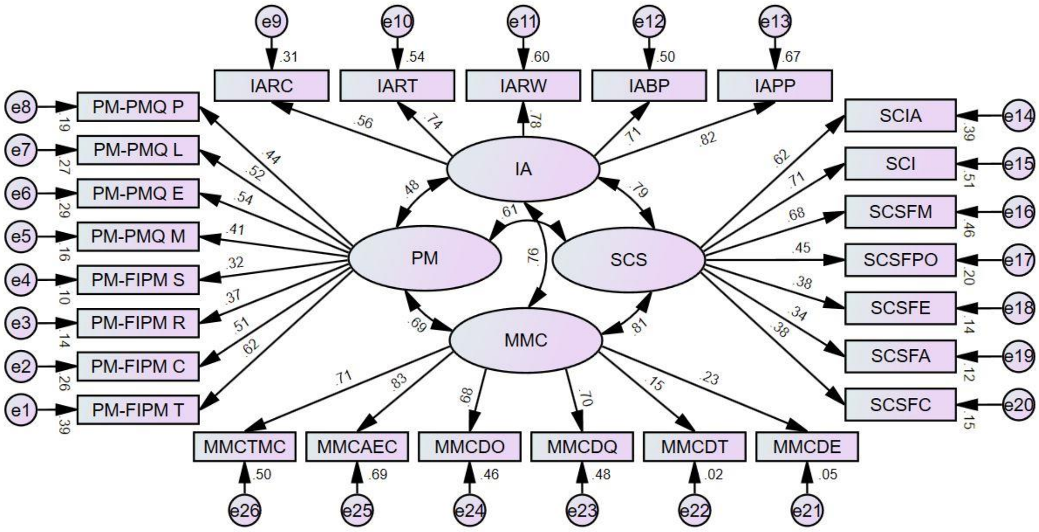
	PM	IA	MMC	SCS

Project management	Pearson Correlation	1	.427**	.474**	.432**
	Sig. (2-tailed)		.000	.000	.000
	N	149	149	149	149
Integrated approach	Pearson Correlation	.427**	1	.338**	.312**
	Sig. (2-tailed)	.000		.000	.000
	N	149	149	149	149
Modern methods of construction	Pearson Correlation	.474**	.338**	1	.540**
	Sig. (2-tailed)	.000	.000		.000
	N	149	149	149	149
Sustainable construction success	Pearson Correlation	.432**	.312**	.540**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	149	149	149	149

The correlation Table 6 suggests that a strong positive relationship exists between the variable's sustainable construction success and modern methods of construction with the correlation coefficient r=0.540 and p<0.001. This implies that any change in MMC will strongly impact SCS. However, there is a weak relationship between IA and SCS with the coefficient r=0.312, implying that only a small variance is noted in SCS due to IA.

4.3 Confirmatory factor analysis (CFA)

The confirmatory factor analysis was carried out using the AMOS 26 software. The main purpose of this analysis was to identify the correlation strength among the observed variables and to identify the relationship between its latent constructs. CFA analysis was done in two



stages. The first stage allowed the researcher to study the factor loading values of each variable with its latent construct. In the first stage, certain variables had to be removed from the model due to a low factor loading value. These variables with low factor loading will negatively affect the model fit and must be removed before proceeding to the next stage of analysis. Figure 5 illustrates the initial CFA model and Table 7 represents its model fit values.

Figure 5: CFA initial model.

Table 7: CFA initial model fitness index.

Items	Chi-Square	DF	CMIN/DF	p-value	GFI	CFI	RMSEA	SRMR
Values	489.912	293	1.672	0.000	0.797	0.832	0.067	0.079

The initial CFA model has a high Chi-square value of 489.912, ~~CFI<0.8,~~ and many factor loading values of observed variables less than 0.40, which does not satisfy the recommended model fit criteria. Hence, the CFA model was modified to the preferable model fit standard, recommended in the literature.

The factor loading value is the correlation coefficient for that variable in relation to its latent construct. Some researchers claim that a coefficient value above 0.5 represents a high degree of control of that variable over its latent construct. However, a value above 0.4 can be retained for the analysis if the model fit has significant values (Maskey et al., 2018). Figure 6 depicts the final CFA model after modifications based on coefficient values.

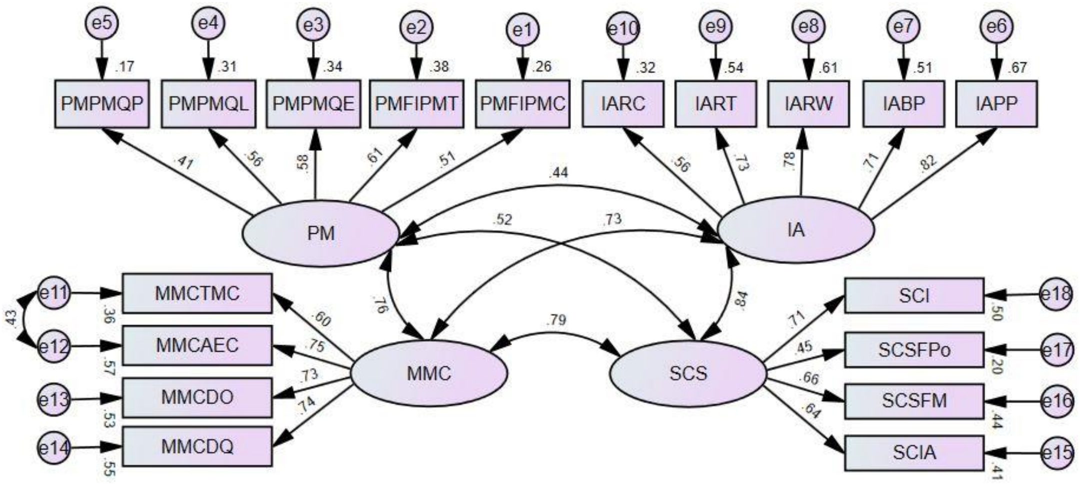


Figure 6: CFA final model.

After arriving at the final CFA model, the fitness test was conducted to assess the model fit based on the values of CFI, GFI, RMSEA, and SRMR. Research suggests that the values of CFI and GFI should be above 0.9 for a strong model fit. However, Baumgartner and Homburg (1996) explained in their research that the range for CFI and GFI>0.8 is acceptable as a good model fit. The values of RMSEA and SRMR must be <0.08 respectively to achieve a significant model fit (Fan et al., 1999). The following Table 8 illustrates the final CFA model fitness.

Table 8: CFA final model fitness index.

Items	**Chi-Square**	**DF**	**CMIN/DF**	**p-value**	**GFI**	**CFI**	**RMSEA**	**SRMR**
Values	236.128	128	1.845	0.000	0.858	0.893	0.076	0.071

The final model depicts a high correlation between MMC and SCS with a coefficient value r=0.79, also there is a significant relation between IA and SCS, having a variance of 0.84. The weakest relation was identified between PM and IA with a variance of 0.44. From the final CFA model, it can be concluded that the factor analysis derived through AMOS 26 meets the criteria for having a good model fit and factor loading values, with a significant p<0.001. Hence, the CFA model is used for the next step in formulating the SEM model.

4.4 Structural equation modeling (SEM)

To analyse the relationships between variables in a meta-analysis, a multivariate technique such as structural equation modeling is highly efficient. SEM analysis is typically used in a latent variable system where a construct displays a causal effect on the observed variables (Dimitrov, 2006). The SEM model is used in the research to observe the direct effect of the independent variables (i.e., project management, and integrated approaches) on the dependent variable (sustainable construction success) and to check their relationships after including the mediating variable (modern methods of construction). Hence, two SEM models were designed to check the hypothesis of this research.

The SEM analysis was the successor to the CFA analysis. After the CFA model was tested for its fitness and relational attributes, the SEM model was drafted using the SPSS AMOS 26 software. The basic structure of the SEM model was derived from the research framework model discussed earlier in this paper. The project management (PM) construct has five observed variables: cost management, time management, experience factor, leadership personality, and pressure tolerance. The integrated approach (IA) construct has five observed variables: project performance, building performance, reduce cost, reduce time, and reduce waste. The modern methods of construction (MMC) construct has four observed variables: quality, onsite duration, AEC adoption, advancement over TMC. The sustainable construction success (SCS) construct has four observed variables: industry acceptance, pollution control, project monitoring, technological impact. Each of the variables has its corresponding error terms ranging from e1 to e20. The initial SEM model in Figure 7 was designed to show the direct relationship between IV and DV, whose estimate values are depicted in Table 9.

Table 9: Regression weights for direct relationship in SEM.

	Estimate	S. E	C. R	p-value
SCS ← PM	0.208	0.121	1.714	0.047
SCS ← IA	0.569	0.091	6.216	0.000

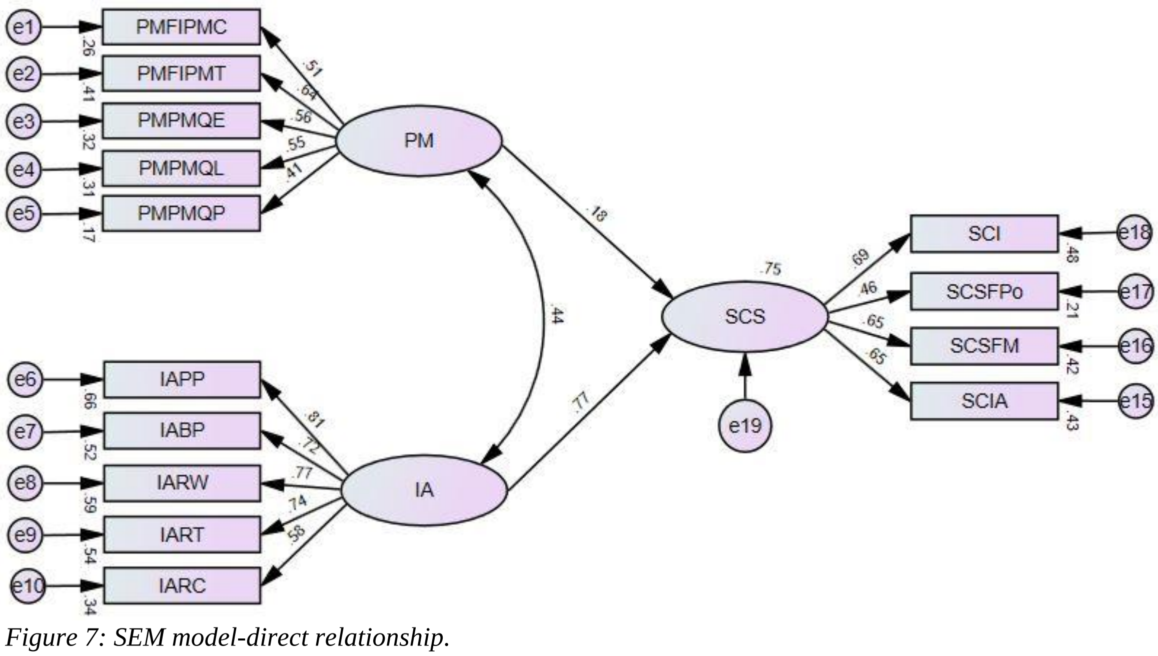


Figure 7: SEM model-direct relationship.

From the above direct relationship model in SEM, it is understood that project management has a weaker impact on sustainable construction success with R=0.208. However, since the relationship is positive and has a significance value <0.05 it can be coined that hypothesis H1 is valid. Since the data set is based on a public perspective and the overall sample size is 149, it can be argued that this relationship can take a higher positive curve with an increase in the data sample size and by increasing the number of observed variables in the construct covering other unique project management criteria. Whereas there is a strong positive relationship observed between integrated approach on sustainable construction success with R=0.569 and p<0.05, indicating the validity of hypothesis H2.

After interpreting the direct association through the first SEM model, the second SEM model with the mediating factor was assessed. This test provided insight into how the relational attributes between the variables change due to the inclusion of the mediating variable as modern methods of construction. Figure 8 and Table 10 highlights the variance in correlation and significance of the mediating variable.

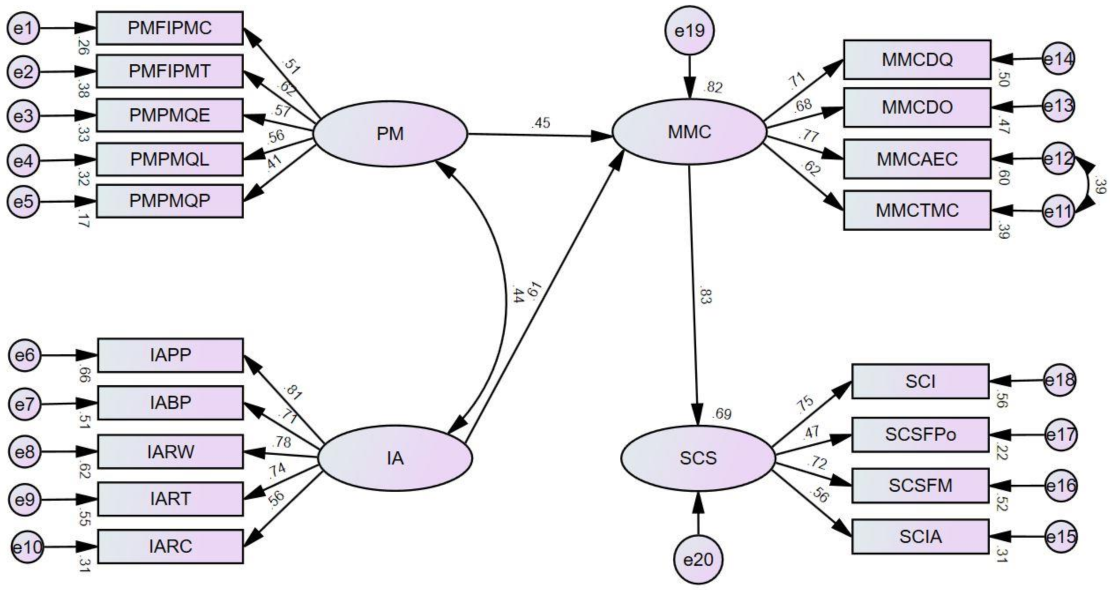


Figure 8: SEM model-mediating relationship.

Table 10: Regression weights for mediating relationship in SEM.

	Estimate	**S. E**	**C. R**	**p-value**
MMC 🡐 PM	0.515	0.140	3.671	0.000
MMC 🡐 IA	0.453	0.080	5.656	0.000
SCS 🡐 MMC	0.704	0.136	5.189	0.000

The SEM model when modified to fit the mediating variable MMC has provided clear information on its importance to the model fit. It has enhanced the relationship between the independent variables and the dependent variable. The strong positive association between the variables is derived from all the estimate values above 0.40 and a highly significant value of p <0.05. The strongest relation is observed between MMC and SC with R=0.704 and a less strong correlation is identified between IA and MMC with R=0.453. Also, a strong positive relationship is observed between PM and MMC. From the final SEM model, the hypotheses H3, H3a, H3b, and H3c can be termed as valid.

4.5 Relative importance index (RII) analysis

These questions were in five-point Likert scale criteria, which is most suitable to conduct relative importance index (RII) analysis. The Relative importance Index (RII) analysis was conducted for the ranking the obstacles to modern methods of construction (MMC), by using the following formula through MS Excel (see Table 11):

$$RII = \sum (W/A \times N)$$

Its values fall in between 0 to 1, whereas the highest value determine at the 1. According to Gebrehiwet and Luo, (2017), the ranking of any factor can be higher in case if its RII is higher comparing to other factors.

Table 11: RII for obstacles to modern methods of construction.

MMC obstacles	N	(1)	(2)	(3)	(4)	(5)	RII	Rank
Site constraints and logistics.	149	0	3	36	59	51	0.812	1
Higher capital cost.	149	0	3	29	79	38	0.804	2
Skills shortages.	149	0	9	38	67	35	0.772	3
Unable to freeze the design early on.	149	2	4	45	70	28	0.758	4
Fragmented industry structure	149	0	6	49	67	27	0.754	5
Lack of long-term coordination between project team.	149	0	6	54	68	21	0.741	6
Reluctance to innovation.	149	0	10	51	68	20	0.732	7
Manufacturing capacity.	149	0	15	47	69	18	0.721	8
Complex interfacing between systems.	149	1	8	56	76	8	0.710	9
Nature of the planning system.	149	0	30	45	61	13	0.676	10

N-total respondents, (1)-Strongly disagree frequency, (5)-Strongly agree frequency

Modern methods of construction suffer due to site constraints and logistics, and high capital investment with RII score >0.8 (see Table 11). These obstacles reduce the progress of MMC and restrict its use to organisations that can afford its high investment demand (Pan et al., 2007).

5. Discussion

The major findings of the research include practices and methods that must be appreciated and adopted by the construction sector in its transition towards achieving sustainability success. As discussed in the literature review section, the construction industry is heavily criticized for its underachievement and negative effects on the environment. This research focuses on stating effective ways to attain sustainable construction success through project management practices, integrated approaches, and modern methods of construction. It also specifies some of the important obstacles, that must be addressed to establish a sustainable construction practice.

5.1 Effect of project management over sustainable construction success

Research suggests that project management when integrated with sustainability principles will enhance the productivity of construction projects, whose primary focus is to reduce the environmental impacts (Robichaud and Anantatmula, 2011). To estimate the level of impact of project management over sustainable construction success, two analyses were conducted.

First, the bivariate correlation analysis was carried out in SPSS statistics 27, to find the degree of correlation between PM and SCS. The matrix output revealed that there was a strong correlation between the two variables with a coefficient value $r=0.432$, and this relationship is highly significant with $p=0.000$. Second, the structural equation modeling analysis through Amos 26, revealed that 21% of the variance ($R=0.208$) in sustainable construction success is accounted for by project management with a significantly strong relationship where $p<0.05$.

From these two analyses, it can be understood that project management has a positive and strongly significant impact on sustainable construction success, thus validating hypothesis H1. Gunduz and Almuajebh (2020) discuss in their research on critical success factors for sustainable construction, that project-related aspects such as project management, project location, and size, etc., is the main contributor towards successful sustainable project delivery.

5.2 Role of integrated approaches towards sustainable construction success

An integrated approach to construction has become a well-known strategy and is getting applauded by many construction experts. Literature suggests that integrated approaches have a significant impact on sustainable construction success (Lahdenpera, 2012). The construction strategy initiated by the UK Government in 2011, visualize to achieve 33% cost reduction, reducing the project completion time by 50%, lowering 50% of carbon emission, and increasing exports by 50%, by the year 2025 through the uptake of the BIM model (Dakhil et al., 2019).

SEM analysis and bivariate correlation analysis explained in section 4 suggest that integrated approaches have a significant positive (p=0.000) correlation (r=0.312) and account for 57% of the variance (R=0.569) in sustainable construction success. This result validates hypothesis H2, proving that integrated approaches display a vital role in assisting sustainable project success.

5.3 MMC role in project success, project management, and integrated approach

Modern methods of construction offer various benefits to sustainable construction such as increased quality, reduce pollution and waste, decrease environmental damage, improved sustainability, etc. These qualities of MMC have pushed researchers to study its impact on improving sustainable construction (Chen et al., 2010).

MMC relies on integrated approaches such as BIM and LC for attaining high quality and low error rates and seeks efficient project management plans to reduce the risk of late design changes. The association with PM and IA has driven MMC towards ensuring sustainable construction project success (Oyedele, 2016; Little, 2018). The report by Taylor (2010) on profit statistics in the use of MMC by 245 construction companies in the UK, estimated approximately 6% to 7% of the value that will potentially account for £4.8bn by 2013 (Vernikos et al., 2013).

The literature study suggests that MMC plays a mediating role between PM and SCS, and IA and SCS. The structural equation analysis was carried out to study this relation and its results reveal that both project management and integrated approach have a significant and positive influence on MMC with R=0.515 (p<0.001) and R=0.453 (p<0.001). MMC has displayed a very strong and significant positive relation towards sustainable construction success with R=0.704 (p<0.001), implying nearly 70% of the variance in SCS is accounted by MMC. The final SEM model with MMC as mediating variable has a better correlation, in comparison with the direct relational model without MMC. These results have depicted that the hypotheses H3, H3a, H3b, H3c, and H3d are valid. Robèrt et al. (2013), in their research on Framework of Strategic Sustainable Development (FSSD), states that MMC when incorporating an integrated approach (BIM), it massively improves sustainable development by reducing negative impacts of construction.

5.4 Obstacles to MMC

The Relative Importance Index (RII) was performed to measure the impact of different obstacles to modern method of construction (MMC). Modern method of construction (MMC faces ten significant obstacles based on literature, out of which two obstacles stand out with RII>0.8 (Pan et al., 2007).

1. The role of ‘Site constraints and logistics’ is considered to be the highest obstacle in the adoption of modern methods of construction (MMC) with its Relative Importance Index value at (RII=0.812). The issues related to a site such as access, on-site space, environmental aspects, etc., are counted as the major hinders in the adoption of the MMC method.
2. Similarly, the role of ‘Higher capital cost’ is found to be the second highest obstacle in the adoption of the modern methods of construction (MMC) with its Relative Importance Index value at (RII=0.804). The major issues arise as a huge investment required for setting up MMC factories and machines which reduce the uptake of these methods.

5.5 Research strengths and limitations

It followed a deductive approach, as it is one of the best-suited systems to test the hypotheses in a social science context. There are many elements that add to the strengths of this research, which makes it a useful set of information for further study related to this topic. These positive attributes are:

- Modern methods of construction and their impact on sustainable project success are provided.
- Several statistical data analyses (e.g., bivariate correlation analysis, structural equation modelling, relative importance index (RII), etc.) were performed to accept or reject the proposed hypotheses.
- Critical discussions were established based on the analysis results to logically and critically appraise. Moreover the findings were also compared with the earlier research works and proposed the best suggestions in the study setup.
- Obstacles to modern methods of construction are discussed.
- A framework for sustainable construction is proposed based on the research findings.

Few factors limited the extension of this research. Although the limitations did not significantly impact the research output, they did have some degree of control over the research findings. The barriers to this research are:

- One of the major limitations of this study is that, only two main integrated approaches (BIM, LC) are discussed in the research. However, for any future research on the same research theme more integrated approaches should be considered.
- Sustainable construction is a context-specific topic that has a drastic variation from country to country based on government, economy, etc., as suggested by the diffusion of innovation theory.

5.6 Recommendations

The research primarily focuses on three important factors contributing towards sustainable project success. However, there are several other factors that has a direct or passive influence on project success such as stakeholders' involvement, financial factors, employee commitment, government policies, etc., which are out of the scope of this research. Future research can be carried out by incorporating some of these relevant factors while studying the impact on sustainable construction project success. From this research, a conceptual framework is derived for achieving project success, depicted in Figure 9.

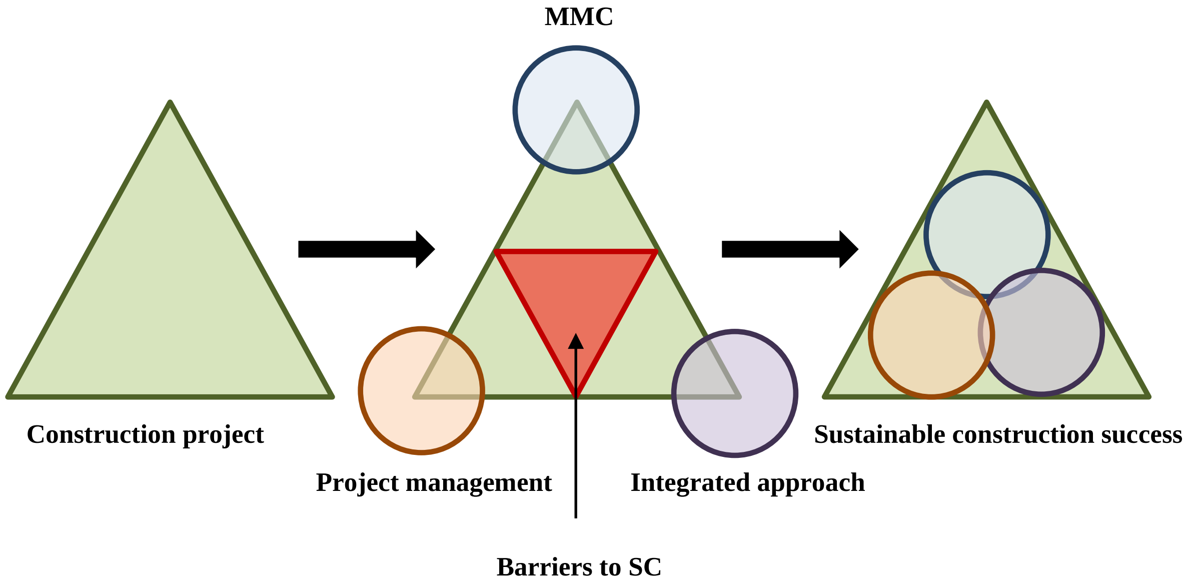


Figure 9: Conceptual framework for sustainable construction success.

The conceptual model illustrates the ideology of this research, that propounds, incorporating effective project management practices and integrating approaches, along with modern methods of construction (MMC) significantly improves the success of sustainable construction.

6. Conclusions

The research highlights the relationship between project management practices, integrated approaches, and modern methods of construction and its contribution to achieving sustainable construction success. To establish this relational attribute with sustainability, the project success factors were analysed through extensive literature study. The quantitative questionnaire survey method is adopted to extract relevant data for analysis through purposive sampling techniques such as homogenous and snowball sampling. The result from the analyses explains a strong positive relationship between project management and integrated approaches with sustainable construction project success. This proposition will encourage industry professionals who are investing in sustainable projects to improve their project management strategy and incorporate project integration technologies to achieve a high success rate. The mediation analysis through SEM revealed that modern methods of construction significantly increase sustainable construction success when integrated with effective project management and project integration technologies such as building information modeling, lean construction, etc. Literature reveals that MMC is gradually being adopted by many construction organisations by the means of diffusion of innovation theory. Although certain challenges such as site constraints, high capital cost, and skill shortage must be addressed for effective implementation of MMC. The research categorises several important obstacles to modern methods of construction through RII analysis, providing valuable information on which of these barriers is most significant and needs to be addressed to amplify the success rate of sustainable projects. Overall, the research details a lucrative strategy to escalate sustainable construction project success by the means of project management, integrated approach, and modern methods of construction.

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