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The purpose of the *Kuveza neKuumba - Zimbabwe Ezekiel Guti University Journal of Design, Innovative Thinking and Practice is* to provide a forum for design and innovative solutions to daily challenges in communities.

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Planners, engineers, social scientists, business experts, scholars and practitioners from various fields.

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Construction for Successful Project Delivery in Zimbabwe: A Critical Analysis

VENGAI TABINGA[1] AND MATHIAS RUPI[2]

Abstract

This study seeks to critically evaluate the role and efficacy of modern methods of construction (MMC) in enhancing successful delivery of projects in the context of the purview and dynamics of time, quality and costs. This research inquiry stems from the background of continued construction overruns affecting time of delivery, costs and quality in several construction projects in Zimbabwe. The main strand permeating this research is aimed at establishing the relationship or nexus between MMC and the delivery of construction projects in terms of time, costs and quality. If MMC are the panacea to the achievement of the mentioned three variables, it could be asked; why is that the uptake is still low? The study is informed by pragmatism philosophy and adopts the abductive approach and the sequential exploratory design in sync with the adopted mixed methods paradigm. The major findings of the study are that MMC ensure quick delivery of housing units, offer low-cost material, faster construction, high savings, involve low labourers, are environmentally friendly, are energy saving due to the walls, are safer with reduced risk easily accessible materials, and are sustainable. However, if MMC are adopted within traditional and fragmented project delivery methods, project overruns in terms of costs, time and quality will still be experienced. The study also brings to the fore the fact that though the construction industry is privy to the benefits of MMC, the clientele is still stuck

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in Traditional Methods of Construction (TMC), the use of brick and mortar. There is need for government to promulgate a policy which enhances the uptake of MMC. The construction industry must adopt MMC within Integrated Project Delivery (IPD) and other contemporary delivery processes. This will ensure that all parties to the construction are involved from the onset of the project up to its delivery.

Keywords: design, build, construction management, risk, integrated project delivery, overruns

INTRODUCTION

Project failures and overruns have become a conspicuous phenomenon the world over, with governments and private land developers failing to deliver projects to the owners within the *dies induciae* or stipulated time period. While the introduction of MMC has been premised as the panacea to effective and efficient delivery of projects, no research has been done to confirm such and, as such, the uptake of MMC in Sub Saharan Africa which experiences a crisis in construction, overruns has remained low.

In their study in the United Kingdom (UK), Shibani (2021a) and Ahmed and El-Sayegh (2021) aver that the progression in construction materials has not been consistent with the development in Project Delivery Methods (PDM) and by outlinig this argument, they bring into the corpus a dimension that even if MMC are adopted, there is also need to improve the PDM within which the MMC are executed. To this end, they argue that the advantages of MMC over TMC may be considered 'rhetoric' 'if modular housing, among other technologies, are done within the traditional realm of PDM. Their argument corroborates the assertion that modular materials in Zimbabwe, if used where there is a poor financing plan, planning

inadequacies, inadequate consultancy supervision and inadequate contractual management, among others, project delivery processes will not quicken the delivery timeline (Bonga and Nyoni, 2017; Kakono, 2020). Moyo and Chigara (2022) weigh in with the same argument and argue how poor processes, not materials, have led to project overruns in projects that include and not limited to Harare and Bulawayo Joina City projects, Gwayi-Shangani water project and the Kunzvi Dam.

The problem of processes, not materials, is also lamented by Zvavirima (2021) in the Zimbabwean context. He argues how in 2013, nine out of 10 projects had between 50 to 100% overruns due to poor work coordination and methods of construction. During this problem, no literature exists to ascertain that MMC are the panacea to quality, affordable structures that can be delivered in time. Zvavirima (*ibid.*) points to the need for Building Information Modelling (BID), while Marabuka (2013) advocates for efficient project planning as solutions to timely project delivery. The above chronicled contestations bring to the fore an existing research gap as to whether MMC are the connoisseurship to timely project delivery in terms of the desired quality, eco-development, endogeneity of structures, costs and timelines. This, therefore, necessitates the inquiry to ascertain the correct role of MMC on project delivery. The continued lack of knowledge on this phenomenon has the propensity to maintain the *status quo* of construction overruns in terms of quality, cost and time. There is a risk of the country experiencing an accommodation crisis, when there is untapped solution in MMC or in a particular PDM. To address the research gap, the study seeks to address three research objectives: to evaluate the extent to which MMC have been

adopted in Zimbabwe; to determine the challenges in the implementation of MMC in Zimbabwe; and to ascertain the benefits of MMC in the delivery of construction projects in Zimbabwe.

CONCEPTUALISATION OF MMC AND PDM

In this section, the central conceptual nodes and grids underpinning this study are laid out and fleshed out. In a simple conception, MMC refers to the manufacture of house parts off-site in a specially designed factory and the major constituents to this process are panels and modules. Panels that include ready-made walls, floors and roofs are manufactured offsite and then transported to the site for assembling within a short time. Modules are ready-made rooms, that can be pieced together to make a whole house or flat (Lovell, 2012). Commonly used materials in MMC include steel, wood and concrete.

While the construction revolution has continued to evolve up to Construction 4.0, derived from the 4th Industrial Revolution in Germany, the change in construction materials has not been changing consistent with delivery methods, thus this has continued to negate on the efficacy of the PDMs (Ahmed and El-Sayegh, 2021). Up to early 1990s, the most prominent project delivery method was Design-Bid-Build (DBB). This conventional method involved the owner of the building to be constructed issuing out two contracts, one for the design phase and the one for a contractor doing the actual construction. However, the discontinuity and lack of cohesion between the two in most cases, led to alterations and increased costs and subsequent overruns. With technological advancements, the DBB was then followed by the Design Build (DB) method in that the design

and the construction work was done by a single entity. The Construction Management (CM) method also thrived during the same period as the DB. The CM involved the owner hiring the designer and the contractor in the pre-construction phase. The Construction Manager at Risk (CMR) provided for multiple roles on the construction manager, thus being a coordinator and executing the construction itself. This was considered the best in terms of costs and quality and the delivery period (AbouDargham, 2019). However, current delivery systems, termed the Integrated Project Delivery (IPD) methods, involve the integration of systems, business structures and people in a synergic relationship which combines talents of all the stakeholders to the construction to reduce costs, waste and encourage efficiency from the design stage, the fabrication and construction stages (Osunsanmi *et al.*, 2018).

The purpose of tracing the evolution of PDMs up to the modern IPD, is aimed at exposing the evolution gap between the MMC and the PDM in terms of quality, costs and the delivery timelines. To this end, the assertion by Ahmed and El-Sayegh (2021) of lack of consistence in the construction revolution between the MMC and PDM, is corroborated by Green (2022) who argues that while the delivery methods were progressing on the other side, the owners, contractors and designers remained stuck in the TMC involving the use of blocks and bricks, thus affecting delivery of the project. Given this argument, it cannot be taken on face value that the TMC have been negating delivery timelines, costs and quality, but it requires an interrogation to ascertain the relationship existing between the methods of construction and the costs, quality and timelines of completion. The influence of MMC, as an independent variable to the dependent variables, costs, quality and timelines must be

ascertained, lest conclusions are made, yet there could be extraneous or confounding variables that might be affecting the quality, costs and time in the PDM other than the MMC.

The African continent, despite arguments in the preceding paragraphs to the effect that MMC are more viable in sub-Saharan Africa, it has remained rooted in TMC. Eja and Ramegowda (2020) aver that Nigeria has continued to witness government and private project failures over the years owing to several factors that include materials used in the construction process. The lack of revenue owing to the expensive traditional materials such as bricks, has been cited as one of the negating factors to timeous delivery. In the case of Egypt, the government is alleged to have failed to deliver the Toshka New Valley Project worth $90billion (Okereke, 2017). In Ghana, the government is reported to have failed to deliver projects worth over $100 million between 2009 and 2011. While the causes of failure to deliver the projects have been shown to be relative, one conspicuous cause has been the use of traditional materials, poor designing and contracting. This overview is indicative of the traditional methods of project delivery still in use in Africa, the efficacy of that is compounded using TCM.

THEORETICAL FRAMEWORK

This segment of this research output maps the theoretical grids on which this study is anchored or premised. The study is informed by the Theory of Construction Management as the overarching theory and supported by the Build Information Theory. Both theories emphasise the need for coordination amongst parties to the construction through effective information sharing. However, certain theoretical gaps in these theories led to the development of a conceptual framework.

The study is informed by the Theory of Construction Management by Radosavljevic and Bennett (2012). The theory reflects the relationship that exists between the Economic Production Theory and construction projects. The present study argues that the way a production company produces goods and delivers those to retailers, is that same process that construction companies build and deliver buildings to the owners. Radosavljevic and Bennett (*ibid.*) argue that the process of delivering a project would entail, and not limited to, interactions of different stakeholders, organisations, relationships, processes, learning, performance and products. To this end, this theory resonates well with the processes involved in the PDMs. The PDMs involve interactions among different stakeholders that include the owner, the designer, the contractors, the legal and financial stakeholders, to the project, thus the theory reflects the processes that are involved in project delivery. As corroborated by the authors, the focus of the theory is on communication, feedback loops and internal and external relations among stakeholders, so that the product, that is, the building or structure, is produced with the standard quality and delivered within the stipulated time frame.

The theory hinges on six variables termed Inherent Difficulty Indicators (IDIs) which are used to determine the most appropriate strategy to the successful delivery of projects. These are the establishment of relationships, the fluctuations of relationships and the quality of relationships, the configuration of relationships that then differentiates the traditional PDMs and the IPD, performance variability and, lastly, the level of external interference. The latter variable is in sync with project alterations and adjustments that have led to project overruns, the alterations either coming from the designer, the bidder or the owner. This, therefore, necessitates a fluid relationship to

the process so that there is coherence of activities. While the theory articulates the construction process from the design stage to the delivery stage, it does not delve into materials used in the construction process. Neither does the theory capture the methods of construction and their role in the process. It, therefore, leaves a theoretical gap with regards to the conceptual position of TMC and MMC. To this end, a holistic theory that not only looks at construction management, but also the methods of construction, needs to be found. The theory is also devoid of the associated costs when TMC are implemented, *vis a vis,* MMC and the associated quality and timelines therefrom. This is a conceptual lacuna that warrants a holistic model that captures these concepts. However, the applicability of the theory to the study is seen in the challenges that it exposes which lead to construction overruns which is in sync with the objective that seeks to unearth challenges to the implementation of MMC.

The Theory of Construction Management argues how the interrelations and coordination of parties to the construction influence the delivery of projects in terms of time and costs. A convergence on this argument is seen with the Build Information Theory (Zhang and Gao, 2013). The theory asserts that the process of coming up with a structure involves different professionals who meet during the planning, designing and construction of the structure in a 3D model. These include professionals like the architect, the engineer and the construction manager. The data obtained during this information sharing is necessary for stakeholders and owners to make decisions well before the structure is constructed to avoid alterations that may affect the duration of construction and bring about construction overruns.

The data allow stakeholders and owners to make decisions before or even after a structure is constructed (Lorek, 2018). It is important to note that the fundamental ingredient to the theory is human collaboration but, at no time, does the theory talk of the nature of materials which must be used whether prefabricated, onsite construction using bricks or wooden materials. The theory is also devoid of the fundamental nexus that exists between the construction methods in terms of materials and the methods of delivery. The literature provided by the theories still present a conceptual lacuna as how one can locate or situate MMC in traditional and modern PDM. It, therefore, in the context of Grounded Theory (Glaser and Strauss, 2008) warrants an inductive development of a holistic theory which can then inform the role of MMC in the delivery of projects. The BIM Theory, just like the Theory of Construction Management, has inherent weaknesses, which makes it amorphous to stand alone as the informing theory for the study as indicated in Figure 1.

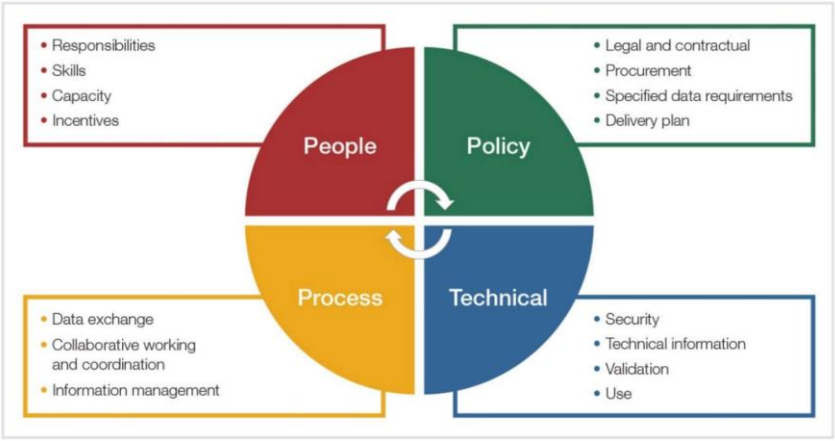

Figure 1. *The fields necessary for effective implementation of BIM* **(**Ilka *et al.*, 2017)

Despite the highlighted facets in Figure 1 presenting certain weaknesses, the BIM has its own advantage in terms of costs, because the cost of alterations is high during the planning stage against the traditional PDM alterations which can then be done during the construction phase, the major cause of cost overruns, a variable which is under scrutiny in the study. The fact that the theory mitigates cost overruns, makes it relevant to the study though not addressing quality and materials. While Zhang (2012), Storms (2020), and Talebi (2020) argue that there is a positive relationship between BIM implementation and the cost of project delivery, the Zimbabwe scenario does not present such correlation (Zvarima, 2021). The discussed relationship is presented graphically in Figure 2.

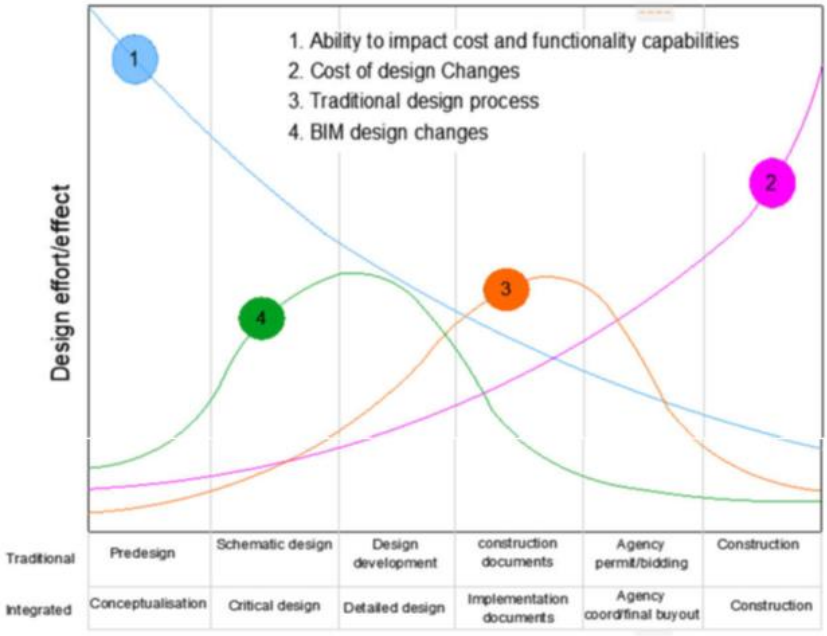

Figure 2: *Effort-time Curve* **(**Talebi, 2020)

CONCEPTUAL FRAMEWORK

The theoretical review exposed gaps that can be addressed by

factoring in missing variables through the construction of a plausible conceptual framework. The conceptual framework guiding and informing this study is premised on MMC versus TMC within traditional or IPD towards attaining cost effective, timely and high-quality buildings as shown in Figure 3.

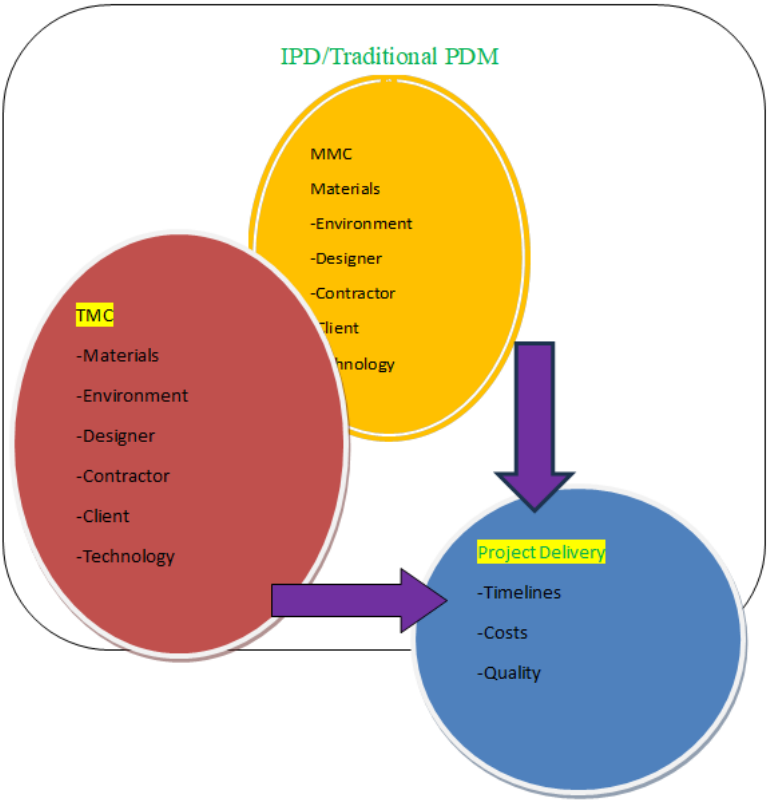

Figure 3: *TMC and MMC interaction within the IPD and Traditional PDM and the resultant effect on quality, costs and timelines* (Authors, 2024)

Figure 3 exposes and brings to intellectual light the relationship that was interrogated by the study. Are MMC effective when employed through traditional methods of project delivery? Are

the TMC effective when employed within the realm of IPD? What are the externalities in terms of MMC or TMC on the environment? What are the roles of the contractor, the designer and the client in ensuring quality, cost effective and timely delivery of projects. The conceptual framework provides the basis for research questions which participants and respondents had to answer so that the connoisseurship of MMC on quality, costs and timely delivery of projects could be brought to the fore.

REVIEW OF RELATED LITERATURE

In this section, the study sketches out and critically reviews pertinent literature available in the research body of knowledge related to the ensuing discussion.

The adoption of MMC has been seen to be dependent and anchored mainly on the following factors, that include appropriateness of existing business models; critical technology; low cost of materials; quick delivery time; environmentally friendly materials; demand by the residents and the corporate world; high quality buildings; easily accessible materials; move with technological advancement in the construction industry; and ability to communicate confidence to demand (Shibani, 2021b). In the context of Martins (2024), the adoption of MMC is no longer something that is optional but a necessity. The adoption of such methods will improve the speed with which construction companies can deliver their projects. In this regard Martins further argues that MMC empower construction companies to elevate speed, quality and environmental performance of their buildings (*ibid.*). In terms of time, cost and quality, the use of the right technology, by construction companies can streamline construction processes and, at the same time, ensuring quality. One other fundamental aspect of MMC is the use of digitalisation of construction management which improves collaboration, communication and

transparency among all the stakeholders involved. This is in sync with the Construction Management Theory by Radosavljevic and Bennett (2012) and the conceptual framework developed which puts emphasis on coordination of all stakeholders involved so that duties are streamlined and corrections can be made at the onset, rather than altering the buildings halfway into construction.

Martins (2024) also posits and quite clearly, the fact that that the process of project delivery needs to move with time where cloud-based systems, management software, digital platforms, have improved the degree of accuracy and productivity. One of the modern digital tools which has revolutionised project delivery is the use of the R-Drive. The platform provides real time information about the project such as drawings, plans and schedules, ensuring that all team members are apprised of their roles or duties in time. The success of the software has been seen in the timely delivery of the ICD Brookfield Place and Roxy Cinemas Dubai Hills Mall. The other tool contributing to MMC is the use of the Open Space, which allows for the provision of 360-degree imagery of the construction sites so that construction managers constantly monitor progress and quickly monitor potential problems and resolve them at an early stage (*ibid.*). The use of Building Information Modelling (BIM) has been seen to improve project delivery. This has the potential to improve coordination, reduce errors and improve the overall efficiency of the construction process. The argument presented by Martins (*ibid.*) indicates that rather than materials and processes, the adoption of MMC entails the use of advanced technology in construction management.

The construction industry in Zimbabwe has witnessed a low uptake of MMC. The main MMC used world over include Precast Flat Panel System, 3D Volumetric Modules, Flat Slab

Construction, Precast Cladding Panels, Concrete Wall and Floors, Twin Wall Technology, Precast Concrete Foundation and Concrete Formwork Insulation. In a paradoxical way, delays, failures and disappointments are a conspicuous phenomenon in the construction industry the world over. As argued by Manyepa (2014), Zimbabwe lacks the financial resources to fully embrace MMCs. He further argues that the government since 2008 has embarked on low-cost units such as the Kuwadzana Extension project. Manyepa (*ibid.*) is clear on the fact that low-cost housing units must be defined in terms of the materials used and efficient designs that are environmentally friendly. It can be seen from the foregoing that the government has not fully embraced MMC, preferring to reduce the size of building to the detriment of quality and comfort by the residents.

Political turmoil and economic meltdown as a result of sanctions were also cited by Manyepa (*ibid.*) as other stumbling blocks towards the adoption of MMC. Adoption of MMC entails huge investments in sourcing the technology and human resource capacitation. Similarly, continued belief in the traditional methods of construction and shunning MMC has been predominant in the Zimbabwe construction industry, albeit with adverse effects on the sector. This traditional approach breeds miscommunication among stakeholders, resulting in alterations, counter alterations, budget failures, poor structures and project overruns. This, therefore, brings to the fore a conceptual gap between delivery methods and construction methods that needs further exploration to ascertain if it is the construction method which affects project delivery, or it is the method of management or PDM which affects the quality and timeframe of the project. Sardinia *et al.* (2010) state that modern construction techniques are suggested to deal more effectively with the ambiguity inherent in conventional construction techniques, such as costs, time,

deficiencies, safety, environmental impact, profits and overall performance of the life cycle.

The objective of this study seeks, largely, to bring to the fore the extent to which MMC have been embraced in Zimbabwe. It is the focus of the study as it seeks to reveal the magnitude of MMC use in the country. Despite digging very much into literature, no such literature talks about the implementation of MMC in Zimbabwe, but in other countries such Nigeria and the UK, thus the review cannot give an answer to the objective but pointers as to how the issue must be investigated. Through literature, the study helps to determine the parameters of implementation, associated fields, stages, associated features or stakeholders to the construction process, both in MMC and TMC, the benefits and the enablers (Succar, 2009; Chudy, 2017; Chan *et al.*, 2019). This led to the development of a conceptual framework as discussed earlier on. Thus, there exists a conceptual, knowledge and implementation gap with regards the use of MMC in Zimbabwe.

The effect of MMC, as they relate to the timeous delivery of projects, has also been observed in Southern Africa. In the context of South Africa, Aiyetan and Das (2022) argue that major projects in the country have failed to meet the delivery time in the last decade owing to many factors, including the use of bricks and blocks, lack of financial resources, poor designing and uncoordinated ways of project and delivery which has been blamed on the owners of the projects and the contractors themselves. To this end, South Africa remains with a dire crisis of accommodation. In Zimbabwe, the use of MMC is yet to be adopted, with the latter in most cases being considered substandard or a sign of poverty. This has negatively affected the delivery of accommodation by the government and private land developers. Ngendakumana and Kakono (2020) perceive that the use of modular prefabricated models has remained

unpopular in the country with several would-be homeowners preferring to have blocks or bricks. The study further asserts that the expensive TMC, their inadequacy, project variations and traditional PDM, have contributed much to the failure to deliver homes and other structures within the stipulated time frame.

MMC, also referred to as sustainable construction practices bring with them quite an array of benefits also related to the environment current construction practices and must not disadvantage future generations. However, they have been many barriers to the adoption of MMC. These have been summarised by Osuizugbo *et al.* (2020:155) to include and not limited to the following:

- Cultural change resistance owing to, *inter alia*, the following variables; poor government support for sustainable construction;
- fear of the cost of adopting sustainable construction/fear of higher investment costs;
- lack of professional knowledge;
- lack of relevant laws and regulations to drive sustainable construction;
- no local green certification available;
- lack of financial incentives;
- lack of skilled personnel;
- long pay back periods from sustainable practices;
- tendency to maintain current practices;
- lack of demand for sustainable construction from clients;
- lack of strategy to promote sustainable construction;
- higher initial cost;
- low level of awareness of sustainable construction;
- lack of knowledge about the concepts of sustainability;
- lack of training among engineers and professionals who are involved in the construction process;
- lack of culture on sustainable concepts; inadequate

institutional structures at the local level;
- reluctance by all parties involved in the construction process to try new ideas owing to the risk factor;
- lack of labelling; and
- Weak enforcement of building codes

These are some of the variables noted in the constitution of the foregoing research problem which this research output seeks to address.

In the context of Rahman (2014), the benefits of adopting MMC are enormous but their uptake in the global south remains low. The barriers to their implementation have been grouped by the study as cost related, lack of experience and skills by designers and contractors, issues of culture and motivation, lack of tools and standards and an underdeveloped industry and market for MMC. It can, therefore, be seen from the forgoing that while there are benefits to the use of MMC, the world has not progressed in line with this technological development, thus there is inconsistence in the use of MMC with the contemporary construction discourse still rooted in the traditional management and traditional materials. This variation, therefore, breeds a conceptual and implementation gap which must be addressed so that the project management conforms to the use of MMC, the economies and cultures and the configurations of the industry and the market to allow for MMC to thrive.

One conspicuous issue that comes out during the review, relates to costs in implementing MMC. The factories which manufacture the components and modules require high capital to produce such (Rahman, 2019). While this assertion was confined to Scandinavia and Germany, Eja and Ramegowda (2019) corroborated this argument in the case of Nigeria. However, such assertion has not been raised in the Zimbabwean context, thus bringing in sight a geographical gap in the use of MMC. However, there are high chances of such

obtaining in the whole of sub-Saharan Africa. Cultural orientations to the use of MMC have always played a negative role, especially in the developing world. The materials are often light, leading to the belief that they are of poor quality, less durable and require frequent refurbishing (Rahman, 2019). In their study on what causes project failure in Zimbabwe, Ngendakumana and Kakono (2020) also argue that cultural and traditional orientation to certain methods of construction and material use have contributed negatively to quick project delivery. This brings an area of convergence between the two but with a variation as the Zimbabwean context relates to project delivery without specifically talking of MMC.

The implementation of MMC the world over has also been hampered by lack of tools and standards (Nadim and Goulding, 2018). This is because these are relatively new innovations as alternatives to traditional construction methods, thus lack design standardisation (Pan *et al.*, 2019). Many of the different forms of MMCs are relatively recent innovations. The other issue with MMC, as they relate to standardisation, is the lack of universal structures and materials that are designated to be modern. The use of modular housing or prefabricated houses is a common phenomenon in the Western world but in Africa, the use of poles, reeds and other ecologically friendly materials, is deemed MMC (Eja and Ramegowda, 2019). This, therefore, brings a nomenclature gap as to what really is MMC.

Lovell (2022) perceives that the use of MMC in the UK has had a positive impact in terms of low costs as compared to TMC, environmental benefits, the increased industry capacity, the quality of the houses, public acceptance and the associated safety and health. From the foregoing, the argument brings to the fore the possibility of quick delivery of the housing units, but this becomes an analysis generated from the said benefits which leaves the argument with a factual lacuna to clearly argue that the use of MMC would reduce overruns. It is also not clear from the argument whether these MMC are being used in

the realm of traditional or modern delivery methods. This brings a conceptual and implementation gap of the MMC.

Using MMC for faster construction on site, ensures that they are time saving and call for less labourers. In countries such as the western world with dwindling labour force, this is beneficial but for Africa with its large labour force, it is not (Lovell *et al.* 2023). However, the level of skills that is needed for onsite assembly is not known and it is believed that it could require so much expertise, unlike in brick-and-mortar construction. In the context of Nyoni (2019), the failure of project delivery in Zimbabwe has also been attributed to lack of skills by designers, engineers and the contractors. This brings about a contestation with Lovell's beneficial aspect of MMC. In the context of Nigeria, the lack of relevant skills to the MMC paradigm has militated against its uptake (Eja and Ramegowda, 2019)

In the context of Lovell *et al.* (2023), there has been arguments that MMC are environmentally-friendly. MMC houses tend to be energy efficient, especially in the West. However, there still remains a gap in whether they also reduce waste. Evaluating the environmental benefits of MMC to be environmentally friendly in terms of waste reduction might be subjective in that it is difficult to attribute reduction to MMC alone. It, therefore, needs further interrogation.

It is envisaged that houses built using MMC typically require less energy to heat because of the level of insulations on the walls and roof. There is also increased insulation such as in the Structural Insulated Panels (SIPS). These are pre-constructed walls that combine structural support materials and insulation. Air leakage is also reduced because the materials are designed in a factory environment with high quality-controlled environment (Shiban *et al.*, 2021; Lovell *et al.,* 2023).

Contestations also arise from this argument where the harsh

weather conditions that are characterised by moments of very high temperatures, heavy rains and extreme cold can then take this point as beneficial. In the context of Ekanayake *et al.* (2019), weather conditions have also negated the adoption of MMC in Africa.

RESEARCH METHODOLOGY

The study is informed by pragmatism and adopts an abductive approach which informs the mixed paradigm or Inter-paradigmatic Research (IPR). The sequential exploratory design is adopted and combined with a case study of construction companies in the Harare Metropolitan Province. Data were gleaned through in-depth interviews for the qualitative strand (n=10), while a 5-point Likert scale was used for the quantitative strand (n=90). Qualitative and quantitative data were analysed thematically and through SPSS, respectively. Figure 4 shows the design-analysis nexus embedded in a quali-quanti sequence as informed by the sequential exploratory design.

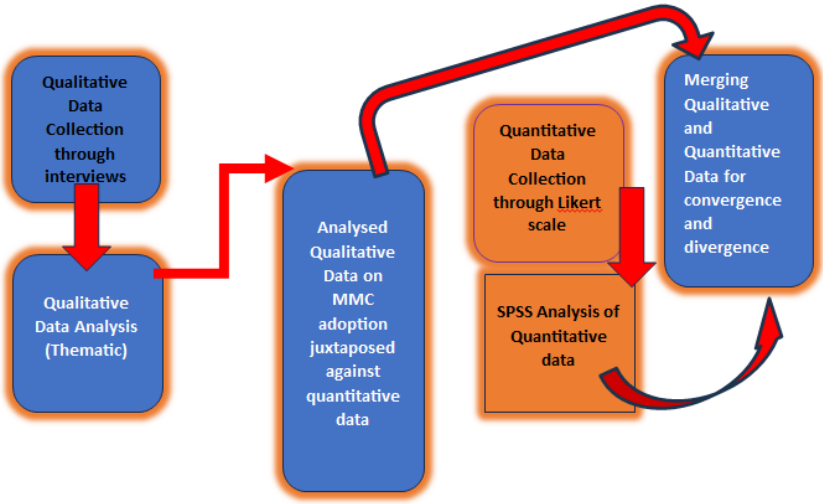

Figure 4: *Sequential Exploratory Design on the impact of the adoption of MMC on project* (Authors, 2024)

FINDINGS

In terms of conceptualisation of what MMC are, the study comes to the realisation that MMC are a phenomenon that entails the adoption of modern processes of project delivery, such as IPD, BIM and the inclusion of all stakeholders from the process of design to completion of the structure and the use of all the offsite assembled materials. The submission by these participants dovetails well with the argument by Sardinia *et al.* (2010) who argue how modern construction techniques are suggested to deal more effectively with the ambiguity inherent in conventional construction techniques, such as costs, time, deficiencies, safety, environmental impact, profits and overall performance of the life cycle. They encompass the processes and structures which include Precast Flat Panel System, 3D Volumetric Modules, Flat Slab Construction, Precast Cladding Panels, Concrete Wall and Floors, Twin Wall Technology, Precast Concrete Foundation and Concrete Formwork Insulation. In the Zimbabwean context, the definition of MMC hinges on the tabulated variables in Table 1:

Table 1: Zimbabwean definition of MMC

Variable	**Description**
Precast Flat Panel System	Mass produced offsite e.g. Toll gate buildings, the Chidziva Primary School construction using concrete panels in Mutare.
3D Volumetric Modules	Prefabricated Prefinished Volumetric Construction (PPVC) involves the stacking of rectangular factory-finished modular components on-site to form a complete building, similar to bricks e.g. the Gweru City Mall.
Flat Slab Construction	Reinforced concrete slab supported by concrete columns directly, without the support of the beams e.g. Harare Gardens shops
Precast Cladding Panels	Made of concrete pre-formed via moulding or exterior decorative mouldings (known as precast concrete wall panels) into the required panel shapes or tiles e.g. Rainbow Towers in Harare.
Concrete Wall and Floors	Vertical structure used for support or separation, while a concrete floor is a horizontal structure used as a base or platform e.g. Avondale shopping mall in Harare.

Twin Wall Technology	A hybrid of precast and in-situ concrete walls and floors e.g. the Twin Towers along Enterprise Road in Newlands, Harare
Precast Concrete Foundation	A reinforced concrete element made up of a tied rebar beam cage incorporated within a semi-precast concrete element that acts as formwork e.g. the Haddon and Sly building along Leopold Takawira.
Concrete Formwork Insulation	Are forms used to hold fresh concrete that remain in place permanently to provide insulation for the structure they enclose
Methods of Project Delivery (Both Traditional and Modern)	Design-Build (DB) Design-Bid-Build (DBB) Construction Management-at-Risk (CMAR) A Guide to Construction Project Management Methods. Job Order Contracting (JOC) Construction Management Multi-Prime (CMMP) Integrated Project Delivery (IPD)

On the extent of adoption of the MMC, both industrial and household uptake are still very low. Though the construction industry sees the benefits of such adoption, the clientele is still stuck in TMC, the use of brick and mortar. The adoption of the MMC has been very minimal, with much of these technology and processes being implemented by the Chinese construction companies, especially on mega government projects such as the construction of the National Defence University, the Parliament building and other construction sites involving Chinese construction companies. Though the uptake is so minimal, the findings indicate that where MMC have been adopted, factors that have encouraged such uptake include, and not limited to, low cost of material; quick delivery time; environmentally friendly materials, demand by the corporate and household clientele; and adoption and adaptation of contemporary construction technology.

The adoption of MMC was found to reduce project overruns in terms of time and costs. It also improves the quality of the

construction project because of the materials and technology involved. Under the same sub-theme, the study sought to establish the effect of Project delivery methods on the adoption of MMC, which is to ascertain whether MMC would maintain the same benefits if they were to be adopted within a fragmented project delivery method, where parties to the construction are not coordinated. In this regard, it was established that the use of materials that are assembled off site and shipped to the site for construction, though cheap, may lead to construction overruns in terms of quality, time and costs if used within a fragmented and traditional method of delivery. This is because certain traditional delivery methods do not involve all parties to the construction and do not allot specific tasks to these parties, thereby leading to alteration of projects midway through and lack of resourcing as well. To this end, the effectiveness of MMC on quality, costs and time will depend on the adoption of contemporary PDM such as IPD, where all parties to the construction process, the owner, designer, engineer, contractor, the line managers and others are involved from the onset. Their argument corroborates the assertation that modular materials in Zimbabwe, if used where there is poor financing plan, planning inadequacies, inadequate consultancy supervision and inadequate contractual management among others, project delivery processes will not quicken the delivery timeline (Bonga and Nyoni, 2017; Kakono; 2020).

Factors that have militated against the adoption of MMC in Zimbabwe include, but not limited to, high costs of construction; lack of experience by the designers; culture entrenched in brick and mortar; lack of awareness of the benefits; lack of tools and standards; poor marketing of MMC; high capital requirement for industry that produces materials; lack of universal structures; lack of standard design; and

unwillingness of the government to adopt MMC as seen in the absence of a policy framework on MMC. One other aspect at play is lack of coordination at the construction site characterising most constructions in Zimbabwe. This stems from an uncoordinated PDM, where different parties to the construction are not involved from the onset and may appear halfway into the construction, causing alterations and delays in completion.

CONCLUSION AND RECOMMENDATIONS

The study sought to critically evaluate MMC as a solution to reduced construction costs, improved quality and timely delivery of construction projects. From the historical chronologies, the development of construction methods has been seen not to be in tandem with the delivery methods, thus MMC have been used within traditional and fragmented PDM to the detriment of quality, cost and time. In terms of adoption of MMC, Zimbabwe has experienced a very low uptake with most clientele preferring the brick-and-mortar accommodation. In terms of benefits, MMC reduce costs, time and improve quality of the building. However, for this to be achieved, they need to be executed in a PDM, which involves all parties to the construction from the onset, where each one, including the owner, knows his or her role so that they are in picture of the construction progress and are quick to highlight where there is need for adjustments. It is, therefore, recommended that to improve the uptake of MMC, the government must come up with a policy that encourages the adoption of MMC. The construction industry must also make extensive marketing to change attitudes of the clientele. There is also need for the construction industry to adopt modern methods of project delivery such as the IPD, where there is coordination of all parties to the construction from the design of the structure up to completion.

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