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Developing a framework for higher education institution building maintenance via soft system methodology

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Abstract

Purpose – Inadequate strategic planning and maintenance budget may undermine the maintenance of the Higher Education Institution Building (HEIB). Studies have shown that a customised maintenance concept such as Soft System Methodology (SSM) can improve public building maintenance operations. There is a paucity of studies regarding public HEIB maintenance in Nigeria via an SSM approach. Therefore, the research investigated the state of public HEIB and developed a framework to improve public HEIB maintenance practices in Nigeria.
Design/methodology/approach – The research adopted SSM to understand Nigeria's public HEIB maintenance practices. The SSM permitted a substitute approach to improve public HEIB maintenance practices via a developed framework. Data were collated via virtual interviews with experts, and findings were presented in line with the SSM seven steps.

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Erratum: It has come to the attention of the publisher that the article, Ebekozien, A., Aigbavboa, C., Samsurijan, M.S., Rohayati, M.I. and Malek, N.M. (2023), "Developing a framework for higher education institution building maintenance via soft system methodology", *International Journal of Building Pathology and Adaptation*, Vol. 41 No. 6, pp. 184-200. https://doi.org/10.1108/IJBPA-03-2023-0030 incorrectly listed Mohamad Shaharudin Samsurijan's and Nor Malina Malek's affiliations as "School of Social Sciences, Universiti Pulau Pinang, Minden, Malaysia". This has now been corrected to "School of Social Sciences, Universiti Sains Malaysia - Pulau Pinang, Minden, Malaysia", in the online version. This error was introduced due to an error in the production process, the publisher sincerely apologises for this error and for any inconvenience caused.

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Findings – Findings show that besides the shoddy state of public HEIB maintenance, there is no public digitalised HEIB framework to improve maintenance practices across Nigeria's higher education institutions. The study developed a digitalised framework with the support of Computerised Maintenance Management System from the findings. It would reposition the public HEIB and stir up various agencies/departments/units managing maintenance for better service delivery via integrated delivery, practical, methodological and managerial aspects.
Originality/value – The research investigated Nigeria's public HEIB maintenance practices via SSM to identify the required document and propose a feasible framework to improve Nigeria's HEIB maintenance practices. Besides the developed conceptual framework, Nigeria's HEIB maintenance practitioners and higher institution chief executives can use the recommended framework as guidelines to improve HEIB maintenance practices.

Keywords Budget, Framework, Higher education institution, Maintenance management, Nigeria
Paper type Research paper

1. Introduction

Public building maintenance is a construction activity conducted to revamp a structure to an adequate standard via combining technical and managing maintenance operations (EN 13306) (CEN, 2001). The task is capital-intensive (Ebekozien, 2021). Mohd-Noor *et al.* (2011) and Ogunbayo *et al.* (2022) affirmed that the management budget for building maintenance operations is critical in progression. Omar *et al.* (2017) and Ebekozien *et al.* (2022a) asserted that the absence of a viable or inadequate budget might influence the success of building maintenance operations, including Higher Education Institution Building (HEIB). The state of a nation's HEIB may influence economic growth and sustainable development. Mohd-Noor *et al.* (2011) and Srivastava *et al.* (2020) opined that a feasible maintenance budget is critical to sustaining operational maintenance success. A feasible budget drives maintenance and operations in building projects (Srivastava *et al.*, 2020). For public HEIB, adequate building maintenance practices may have been a challenge. This possibly contributed to the research trend regarding deplorable public higher institutions' physical infrastructure, especially in developing countries such as Nigeria (National Universities Commission, 2006; Odediran *et al.*, 2015; Amoo, 2018; Olufemi, 2020). This is critical because higher education institutions (HEIs) are vital to national capacity and linked with global education trends.

In Nigeria, maintenance in HEIs may be experiencing changes related to budget cuts and financial crises to manage this physical infrastructure. The issue is compounded by fast-ageing insufficient physical infrastructure in HEIs, government budget deficit and education budget far below UNESCO recommendation (Enefola, 2016). Thus, there is a need for an effective and functional HEI to retain effective teaching and learning outputs (Odediran *et al.*, 2015). In developing countries, using Nigeria as a case study, a few studies (Gbadegesin and Aluko, 2014; Ofide *et al.*, 2015; Odediran *et al.*, 2015; Abdullahi and Yusoff, 2019; Aboginije and Thwala, 2020) have been conducted on facilities/maintenance management (MM) of public tertiary institutions. None is regarding developing a framework via Soft System Methodology (SSM) to improve public HEIB maintenance practices in Nigeria. Inadequate strategic planning and insufficient maintenance budget may undermine the maintenance of HEIB. Waeyenbergh and Pintelon (2004) asserted that integrated maintenance practices via a modular framework could mitigate the life cycle cost of buildings. This is absent in current Nigeria's HEIB maintenance practices academic literature and one of the study's motivations.

Arumsari and Sulistio (2022) and Ebekozien *et al.* (2022b) affirmed that customised maintenance such as SSM could improve public building maintenance operations. The system is a mechanism for tackling persistent, complicated issues (Checkland and Poulter, 2020). The lack of a functional building maintenance framework may have contributed to the lax MM in public buildings. The study's framework intends to guide HEI chief executives, policymakers, researchers and maintenance practitioners. Besides reducing the perceived limitations in the MM of buildings and filling the gap because of the paucity of academic literature, the framework will provide maintenance experts with how to manage the process. Likewise, the framework will identify key features to deliberate and promote customised maintenance to improve public

building maintenance practices across Nigeria's HEIs. The study's motivation is pertinent and timely with the recent global economic and health crisis and cutting down public building maintenance budget (Arumsari and Sulistio, 2022). Thus, the research investigated the state of public HEIB and developed a framework to improve public HEIB maintenance practices in Nigeria. This is the study's motivation and will be achieved through the following objectives:

(1) To investigate the state of the public HEIB maintenance practices in Nigeria.

(2) To develop a framework to improve public HEIB maintenance practices in Nigeria.

The study reviewed relevant academic literature to address these objectives, and an SSM was utilised for the collected data. The study is divided into six sections. The first section focuses on the background, including the study's research objectives and justification. The second section highlights related existing literature. This includes the background regarding building MM. Next is collecting data from 26 participants via in-depth interviews across the six geopolitical zones in line with the SSM seven steps. The fourth section is the analysed findings via SSM presentation. Followed is the discussion with related past findings. The sixth section focuses on the study's theoretical and practical implications. Next are the study's limitations and areas for further study. The eighth section is the conclusion section.

2. Overview of building maintenance management in higher institutions

MM, especially in public infrastructure in many developing countries, is an issue (Ebekozien, 2021). Arumsari and Sulistio (2022) avowed that the issue becomes compounded when there are slight financial challenges or impulses, leading to a cut down of the maintenance budget (under-budgeted) on public infrastructure. In Jakarta, Indonesia, for example, the rented public houses experienced maintenance budget cuts during the COVID-19 peak (Arumsari and Sulistio, 2022). The public HEIB is not exempted from this challenge. The role of higher institutions in the national building cannot be overemphasised. It constitutes an important part of the nation's assets (Ofide *et al.*, 2015), where scientists, future leaders, professionals, entrepreneurs and captains of industry are produced (Mat *et al.*, 2009). Abdullahi and Yusoff (2019) asserted that HEI is a platform for creating higher-level skills and proficiencies that are tailored towards knowledge economies. Physical infrastructure accessibility is critical in achieving this aim. Anderton (2016) avowed that HEIs with adequate physical infrastructure could assist in generating collective innovation assets. Thus, regular maintenance of such public physical infrastructure is pertinent to offer the best environment for teaching, learning, educational research and administrative events. However, Zulkarnain *et al.* (2011) and Ofide *et al.* (2015) found that the performance of HEIs in many developing countries regarding MM is below global practice. In Ghana, inadequate funding is critical to higher education development (Atuahene, 2014). Zulkarnain *et al.* (2011) emphasised that higher institution operators prefer responsive maintenance to preventive works. Ofide *et al.* (2015) affirmed that stakeholders needed to give building maintenance attention in the construction industry. It has resulted in practitioners and scholars promoting building maintenance awareness because of the increasing dimensions of maintenance issues.

MM is a systematic approach. Technical Information Document (2000) described it as activities that involve planning, organising, monitoring and assessing maintenance and their costs. A viable MM system coupled with competent and proficient maintenance personnel can avert or mitigate health and safety issues and environmental damage, produce longer assets life with cost savings in operations, and higher quality of life for the inhabitants and handlers (Technical Information Document, 2000; Ofide *et al.*, 2015). Getting the right mechanism to manage building maintenance, especially regarding HEIB is pertinent to improving the quality of products and possible global ranking. The maintenance supervisor or manager has a critical role to play concerning maintenance budget and funding system, maintenance strategies, response time, preventive maintenance plan, quality assurance, developing alternative

solutions to reduce costs and time, maintenance records, and improving efficiency and effectiveness of the maintenance programme (Technical Information Document, 2000). A maintenance budget is germane and should identify the quantum of funding a maintenance unit required to sufficiently proffer solutions to global standards in line with organisation's maintenance policy (Ofide *et al.*, 2015). The enabling environment in the maintenance manager's department/unit/section will influence the outcome of these functions. Barrie and Peter (2007) described the maintenance department/unit/section as individuals (in-house or independent bodies – consultants and contractors) responsible for the construction industry's organising, scheduling and maintenance activities implementation. Organisation (in this instance, HEIs) and staffing are critical factors influencing maintenance works (Wireman, 2005).

The maintenance department/unit/section structure varies from one organisation to another. In some HEIs maintenance departments, emergency and corrective work comprise at least 50% of the weekly work distribution (Wireman, 2005). Ofide *et al.* (2015) found the technicians' holidays, absenteeism and training as possible factors in the maintenance backlog. In most cases, there is an impossibility to accomplish proactive maintenance. Lee and Scott (2009) asserted that computerised maintenance management system (CMMS) is a management software that executes functions to manage and track maintenance events. The management software executes building asset management from commencement to building completion by tracking work orders and communicating preventive maintenance activities in detail via reporting (Ofide *et al.*, 2015). It is employed for honing building maintenance processes regarding cost savings in material and labour, storing maintenance procedures and technical documentation, and warranty information by component. The system can detect impending issues before a problem occurs. The mechanism reduces users' grievances and accomplishes a better proactive maintenance activity (Ofide *et al.*, 2015).

In Nigeria, public HEIs comprise post-secondary institutions or tertiary institutions owned by the governments (federal or state) as a document by the National Policy on Education (NPE as cited in Abdullahi and Yusoff, 2019). UNESCO (2006) reported that the student enrolment standard in HEIs per 100,000 residents shows an over sixfold increase, from 13 million in 1996 to 102 million in 2003. There is inadequate infrastructure in Nigeria's educational sector because of insufficient funding (Gbadegesin and Aluko, 2014; Enefola, 2016). From 1999 to 2014, the budgetary allocations were far below UNESCO's recommended 26% benchmark (Enefola, 2016). In 2019, the budgetary allocation was 7.02% (Amoo, 2018), and 5.6% for 2021 (Olufemi, 2020). The budgetary allocations over the years may limit the accessibility and availability of resources for higher education and research in Nigeria. Wentworth and Makokera (2015) asserted that many developing countries' governments could no longer tackle the infrastructure backlogs. In many developing countries, Nigeria inclusive, meeting the minimum infrastructure development in HEIs is critical. Abdullahi and Yusoff (2019) found that most Nigerian HEIs have low-quality facilities that cannot accommodate yearly student enrolment demands. Their study corroborated the Needs Assessment Report of Nigerian public universities (2012). The report stated that there are deteriorating and insufficient physical facilities, degenerated by lecture rooms/theatres congestion and insufficient accommodation facilities. The intervention by Tertiary Education Trust Fund (TETFund) may not have helped matters. On 6 April 2022, President Muhammadu Buhari signed Executive Order 11 on national public building maintenance (Agbakwuru, 2022). This is a good attempt, but implementation may be hindered because of the history and approach to maintenance. Records show lacuna in existing aged and new infrastructure regarding maintenance. Thus, embracing a systematic approach to address public HEIB maintenance through SSM is germane. It is a mechanism employed to proffer solutions to a complex problem. It has been used in related studies (Nguyen *et al.*, 2019; Arumsari and Sulistio, 2022; Ebekozien *et al.*, 2022b). Arumsari and Sulistio (2022) adopted SSM to comprehend public-rented flats management units better. It works out a procedure to reduce the maintenance budget via a developed framework that emerged during the process. Ebekozien

et al. (2022b) developed SSM framework for Malaysia's low-cost housing maintenance, while this study is developing a framework for HEIB maintenance in Nigeria. Thus, the study investigates the state of public HEIB and develops a framework to improve public HEIB maintenance practices in Nigeria using SSM approach.

3. Research method

3.1 Soft system methodology

SSM, as adapted in Figure 1, is a system software for tackling persistent and complicated issues (Checkland and Poulter, 2020). Checkland (1981) reported that Peter Checkland developed this mechanism in the late 1970s. It is a cyclic learning process that exploits models of human activity to discover the actors (building maintenance partners) in the real-world problem state (public HEIB maintenance problems) and their perceptions of that state and proffer feasible solutions through a developed framework. It is a qualitative method that can apply systems thinking to non-systematic states. The approach permits the researchers and the interviewees to view issue inclusiveness through action-oriented inquiry (Ebekozien *et al.*, 2022b). To take action to improve it, the SSM framework involves seven steps, as adapted in Figure 1 (Checkland, 1981). The study accomplished the SSM framework through virtual interviews conducted with building maintenance stakeholders across the six geopolitical zones of Nigeria. This includes directors, top senior officers in the physical planning/maintenance/estate and work department of the selected HEIs (universities and polytechnics), management staff of selected construction companies, maintenance/facility consultants, and policymakers from government agencies, as presented with detailed background in Table 1.

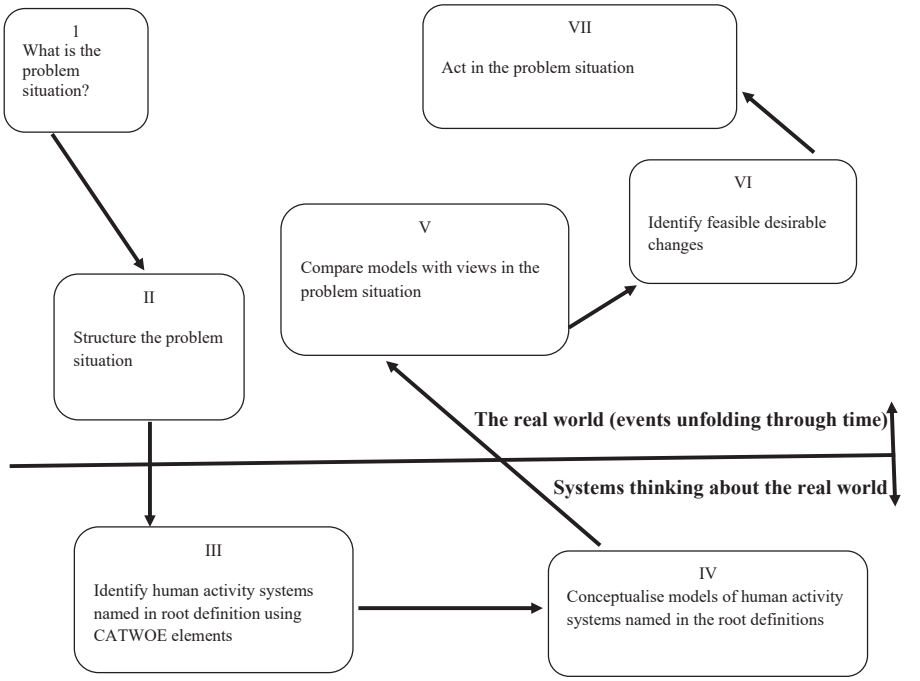


Figure 1.
SSM model

Source(s): Checkland (1981) and Arumsari and Sulistio (2022, *p.* 167)

In Table 1, the interviewees' rank and years of experience show they know about Nigeria's public HEIB maintenance. Purposive sampling technique was employed to identify the interviewees and ensure a good representation of each group aligned with Ebekozien *et al.* (2022b). The interview took place from August 2021 to November 2021 and took an average of 40 min. The researchers tailored the interview questions around the following. What is the state of Nigeria's public HEIB maintenance practices? What are the issues confronting public HEIB maintenance? Is there an existing framework guiding Nigeria's public HEIB maintenance practices? Can a public HEIB maintenance framework be available to guide stakeholders? What roles are expected from stakeholders to ensure a practical HEIB maintenance framework? If developed and implemented, what are the expected outcomes?

The research employed thematic analysis to analyse and present the collected data in line with SSM. The study saturation was established at the 26th interviewee when there was no evidence of "new theoretical perceptions" from the investigation. The investigators employed their contextual perceptions in analysing and explaining the collected data and established the study's saturation (Thorne, 2020). In generating the codes from the transcripts, the researchers manually analysed the 26 documents, and their findings were presented. The study's investigators read the 26 documents many times to capture the interviewees' perceptions concerning the phenomenon. This method aligned with Ebekozien *et al.* (2019)

ID	Organisation	Location	Years of experience	Rank/Firm
P1	Federal University	North	25 years	Deputy Director, Physical Planning Dept
P2	State Polytechnic	Central	21 years	Senior staff in Maintenance Dept
P3	Medium construction company		28 years	Head, Operation
P4	State University	North-East	20 years	Senior staff, Physical Planning Dept
P5	Federal Polytechnic		21 years	Senior staff, Physical Planning Dept
P6	Medium construction firm		22 years	Operational Head
P7	Federal University	North-West	24 years	Deputy Director, Physical Planning Dept
P8	State University		28 years	Director, Physical Planning Dept
P9	Medium construction firm		23 years	Director
P10	State University	South-East	20 years	Senior staff, Physical Planning Dept
P11	Federal Polytechnic		23 years	Senior staff, Physical Planning Dept
P12	Medium construction firm		35 years	Director
P13	Federal University	South-West	28 years	Deputy Director, Physical Planning Dept/ Academic Staff (Asso. Prof.)
P14	State Polytechnic		27 years	Director, Physical Planning Dept
P15	Large construction firm		32 years	Manager, Engineering Department
P16	State University	South-South	29 years	Director, Physical Planning Dept
P17	Federal Polytechnic		21 years	Senior staff, Physical Planning Dept
P18	Large construction firm		20 years	Head, Maintenance Contract
P19	FM consultant	Lagos	16 years	Ass. Director
P20	FM consultant		22 years	Operation Manager
P21	FM consultant	Abuja	17 years	Principal Partner
P22	FM consultant		19 years	Managing Partner
P23	TETFund staff	Abuja	15 years	Senior staff
P24	TETFund staff	Abuja	18 years	Senior staff
P25	NUC staff	Abuja/ Kaduna	20 years	Senior staff, a government agency under the Federal Ministry of Education
P26	NBTE staff		22 years	Senior staff, a government agency under the Federal Ministry of Education

Source(s): Authors' work

Table 1. Summary of interviewees' description

and Ibrahim *et al.* (2022), which applied the same technique to develop the initial coding scheme for their research. The first stage comprises coding the transcripts and grouping them into categories. The final stage engaged the categories, re-reading the transcript and discovering the constructs. The study's objectives that emerged from the categories and common patterns generated the themes aligned with Jaafar *et al.* (2021). The investigators employed triangulation, researchers' reflexivity and member checking as the validity methods of the collated data (Creswell and Creswell, 2018). Sixty-one codes were generated and rearranged based on reference, frequency and occurrence. The study developed eight sub-themes from the 61 codes. From the eight sub-themes, two themes emerged. The interview showed a sound opinion, Customer, Action, Transformation, Worldview, Owner, and Environment (CATWOE) analysis. The processes that led to the conceptual framework and the developed framework to promote public HEIB maintenance practices in Nigeria are explained in the following section.

4. Findings

The section explains the seven steps in line with CATWOE.

4.1 Steps 1 and 2: issue situation and structure

The first step is identifying the main issue in line with the SSM rules. The study aims to investigate the state of public HEIB maintenance practices and develop a framework to improve public HEIB maintenance practices in Nigeria. Developing a framework has become germane due to the persistent perceived public building maintenance practices, especially in HEIs where teaching and learning of the future generation take place. A critical and detailed perception was developed to structure the problem situation as an entity system, as illustrated in Figure 2. In Figure 2, the real-world problem can be identified from the

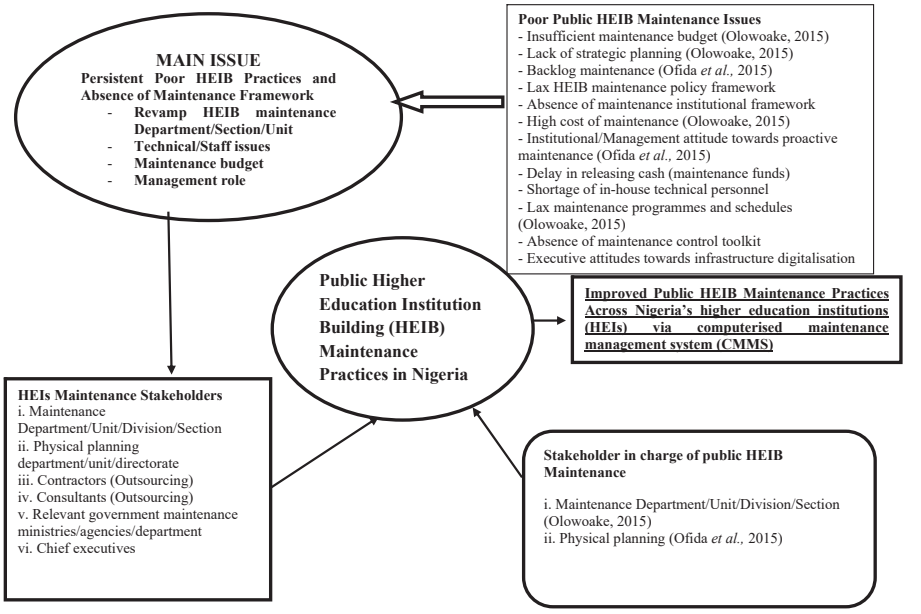


Figure 2.
Conceptual framework for public HEIB maintenance practices in Nigeria

Source(s): Authors work

complex state of the public HEIB maintenance scenario. Hence, identifying the critical features of the real issues, including the limit of the analysis, and building maintenance stakeholders/partners engaged, cannot be overstated. This aligns with Arumsari and Sulistio (2022) and Ebekozien *et al.* (2022b). They employed the same approach and identified the task the relevant maintenance parties conducted.

Referring to Figure 2, it can be described that the main stakeholder in charge of public HEIB maintenance is the management department/unit/division/section or physical planning directorate. The unit is sometimes structured based on the work maintenance backlog (P1, P4 and P13). Participant P13 says, "*. . . we have had the challenge of meeting up with maintenance backlog, especially in staff quarters because of inadequate technical staff and delay in releasing funds for maintenance materials unavailable in the store. Some of our staff in the quarters resolved to engage private tradesmen for emergency maintenance because of the delayed fear. This is not good for an institution. . . .*" Findings show that the scenario of Participant P13 cut across most of the HEIs with staff quarters to avert serious damage, especially if it is an emergency. Findings show that many maintenance departments face challenges that hinder them from achieving their primary objective (P16 and P24). This includes lack of training for technical staff, official leaves/vacations, inadequate technical staffers, delay in releasing funds for materials and absenteeism (P4, P8, P10, P15 and P17). Participant P17 says, "*. . . the possible outcome is maintenance backlog and, by extension, hinder proactive or planned maintenance. The available option is corrective maintenance, which is what majority practices . . ..*" The absence of a defined maintenance framework to manage the physical facilities may have compounded the process (P10, P13, P14, P22 and P26). Participant P14 says, "*. . . many of Nigeria's higher education institutions do not have a maintenance policy for physical facilities and hardly make a yearly budget to fund the activities. Where there is one, implementation is lax because of the absence of an institutional framework. Thus, create a gap for some chief executives in collaborations with the directors of the maintenance unit to divert the funds for other tasks with justifications . . ..*" Therefore, a maintenance framework is pertinent to guide critical stakeholders in their expectations and responsibility in an academic environment.

4.2 Step 3: root definition via CATWOE elements

At this phase, the research identified the duty expected of the stakeholders, as highlighted in the root definition via the CATWOE analysis. The CATWOE approach involves the major partners in HEIs maintenance. This includes the customers (staff, students and visitors), actors (stakeholders), transformation via CMMS, worldwide perspective, ownership, and environmental constraint in public HEIB maintenance practices were identified to view the scheme, as presented in Table 2.

4.3 Step 4: conceptual framework

The research proposed a conceptual framework via the CATWOE analysis mechanism at this phase, as in Figure 2 and Table 2. The framework was developed based on the "Transformation" construct in the CATWOE analysis. It shows that the maintenance department/unit/division/section and physical planning department/unit/directorate need to be overhauled via the proposed CMMS to bridge the gap between the reported time for the work and work done (Olowoake, 2015), as proposed in Figure 2. Maintenance backlog is the identified maintenance work that needs the technical team's attention but is handicapped or delayed due to workforce capacity or fund availability. Findings across the board agree that the chief executives' (Vice Chancellors and Rectors) attitudes towards physical infrastructure maintenance are key to improving maintenance practices. Participant P7 says, "*. . . chief executives should capture physical facilities maintenance as part of the vital mission statement.*

CATWOE customers	Public HEIB maintenance practices (users – staff, students and visitors of the institutions)
Actors	Maintenance department/unit/division/section, physical planning department/unit/directorate, contractors (outsourcing), consultants (outsourcing), relevant government maintenance ministries/agencies/department, and chief executives
Transformation	Maintenance department/unit/division/section and physical planning department/unit/directorate need to be overhauled via proposed computerised maintenance management system (CMMS)
Worldwide view	Public HEIB maintenance should be all-inclusive and supported by the chief executives. Many of these physical facilities are aged and overdue for renovation to meet the minimum standards expected within an academic environment. Higher education institutions' physical infrastructure cannot be obsolete and expect innovation and novelty breakthrough from such an environment
Ownership	Public higher education institutions
Environmental constraint	Maintenance backlog encourages corrective maintenance against preventive maintenance strategy. There is a large gap between the reported time for the work and work done (Olowoake, 2015). Many factors are attributed (Ofide *et al.*, 2015), such as absence of maintenance control toolkit, delay in releasing cash for maintenance, shortage of in-house technical staff, etc.

Source(s): Authors' work

Table 2. Summary of CATWOE analysis

Conducive learning in the 21st century can innovate integrated outputs in a smart environment, including buildings. This is presently missing. Besides our obsolete academic buildings, they are the absence of ICT compliance to drive novelty and research outbreak . . .." Participants P3 and P19 mention the absence of an institutional maintenance framework in many HEIs. There is lax implementation for a few higher institutions with a maintenance plan. It is as good as not having a plan (P12, P18, P20 and P23). Also, the proposed framework shows the perceived root cause of lax public HEIB maintenance and identifies vital stakeholders. Findings across the board identify insufficient maintenance budget, lack of strategic planning, backlog maintenance, lax HEIB maintenance policy framework, high cost of maintenance materials, delay in releasing cash, shortage of in-house technical personnel, and lax maintenance programmes and schedules as the issues that boost poor public HEIB maintenance across major higher institutions in Nigeria. These are critical to proffering solutions to improve building maintenance practices in HEIs. Bridging the gap between the work's reported time and the execution time can improve building maintenance practices across Nigeria's public HEIs.

4.4 Step 5: compare framework with perceptions of the problem situation

The amended framework is compared with the real problems. The research developed six constructs from the framework. They were analysed and compared with the real-life situation, as presented in Table 3. Table 3 illustrates the study's concise analysis.

4.5 Step 6: identify measures that can bring desirable changes

The persistent weak maintenance across Nigeria's public HEIs and the growing gap of backlog maintenance between identified maintenance work and the actual time of execution calls for concern (majority). Participant P14 says, "*. . . to replace the common Water Closet (WC) siphon in our staff office restroom is taking over three weeks because of the bureaucracy releasing cash to buy the material. We have been using the manual method in flushing the WC after use in the 21st century . . .*." Issues of chief executives' (Vice Chancellors and Rectors) attitudes towards building maintenance and digitalisation, insufficient maintenance budget

Revised framework	Real-issue situation
The chief executives should make resources (funds for materials and technicians) available to address not just corrective work but preventive work in line with the designed facilities' manual	HEIB maintenance is left in the hands of individual because most of the times the department is handicapped (no resources)
The maintenance department needs to be overhauled and ensure competent staff are engaged and supported with working tools	There are cases staff uses their personal money to buy materials for maintenance purpose
Public HEIB maintenance institutional framework should be all-inclusive and supported by chief executive to sustain new projects and revamp obsolete ones in the 21st-century friendly academic building. The old ones should be revamped and tailored towards smart buildings for novelty and innovation	Director/Head of maintenance unit/department finds it difficult action on staff request because of many factors. This includes inadequate staff and insufficient maintenance budget
Maintenance budget should be feasible and based on the maintenance manual	Majority do not allow for maintenance budget even with Executive Order 11. Where there is provision in few cases, it is inadequate, leading to abandoned maintenance works
The proposed CMMS will bridge the gap between maintenance backlog and the actual execution of the work	Gaps between maintenance backlog and actual execution of the work (Olowoake, 2015)
Proffer measures via CMMS to tackle maintenance strategy and technical issues such as situational and routine maintenance plans for each component/ element of the building. This approach enhances the preventive maintenance mechanism as the best global practice for physical infrastructure such as higher education institutions	Majority of the higher education institutions do not have building maintenance plan. Where it exists, there was evidence of lax implementation due to many factors such as chief executive maintenance attitude, delay in releasing cash, absence of maintenance control toolkit, etc. Majority focused on corrective maintenance

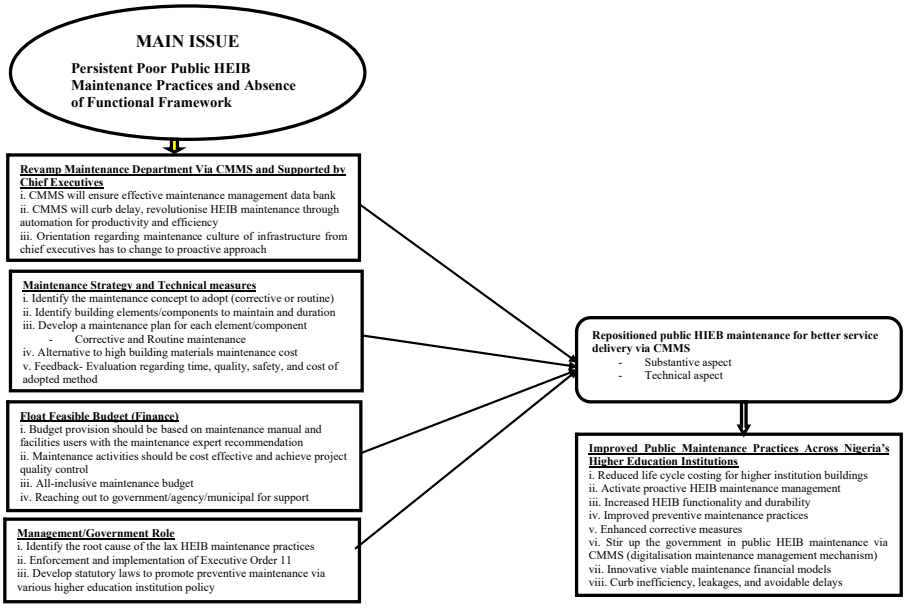
Source(s): Authors' work

Table 3.
Revised conceptual framework against the real problem

and lack of strategic planning in managing HEIs maintenance prompted a maintenance framework to improve the system (P2, P7, P11, P18, P20, P22 and P25). Revamp maintenance department via CMMS and supported by chief executives, maintenance strategy and technical solutions, float feasible budget (finance), and management/government role emerged as the sub-themes in developing a proposed framework to improve public HEIB maintenance practices in Nigeria, as illustrated in Figure 3.

4.6 Step 7: act in the issue situation

Each category emerged from analysed codes as summarised and highlighted under each category identified in Step Six. For example, enforcing and implementing Executive Order 11 in public HEIB maintenance (P1, P4, P9, P12, P24 and P26), developing statutory laws to promote preventive maintenance via various HEI policies (majority) and identifying the root cause of the poor public HEIB maintenance practices (P1, P2, P6, P9, P21 and P22) were integrated to generate "management/government role". One pertinent point is the proposed integration of CMMS into the developed framework to manage public HEIB maintenance. The software enhances the better performance of maintenance activities. Apart from the software's ability to improve building MM from inception to post-completion by tracking activities and scheduling work orders, the application can report preventive maintenance tasks (P25). Participants P23 and P25 affirm that the computerised system enhances preventive maintenance and saves construction costs and time with sustainable quality.



Source(s): Authors work

Figure 3.
Developed framework to improve public HEIB maintenance practices in Nigeria

Participants agree that public building maintenance digitalisation should be all-inclusive and supported by stakeholders. Participant P12 says, "*. . . we cannot be talking about global novelty via research without driving towards digitalisation in our operations, including building maintenance activities in the 21st century. These buildings and their maintenance operations should be smart-friendly to achieve the expected goal of a higher education institution to compete with others . . .*."

Concerning maintenance strategy, technical measures and floating of feasible building HEI maintenance budget, findings agree that these constructs will influence public HEIB maintenance success. Participants P2, P5 and P7 emphasise that the few directors/heads of maintenance units/departments that developed routine maintenance strategies are incapacitated regarding implementation because of a lack of funds and some chief executives' attitudes towards building maintenance. P2 says, "*. . . when I took over as the director, I developed a maintenance template and submitted a proposal to the Rector for consideration and possible onward submission to the Governing Council for rectification as part of the maintenance strategy policy to revamp the obsolete buildings and the way forward to maintain the new ones. It was an all-inclusive work that involved reasonable cost implications. The document did not move out from the Rector's office. Who will I complain to? It's the system. Thank God for the recent Executive Order 11 and hope machinery will be put in place to monitor implementation and enforcement so that our infrastructure can be sustained, especially the old ones . . .*."

Employing a preventive/routine maintenance practice becomes challenging because of the absence of a template/framework and financial backup (P2, P7, P13 and P16). The developed framework addresses these encumbrances. Public HEIB maintenance institutional framework should be all-inclusive and supported by the chief executive to sustain new projects and revamp obsolete ones in the 21st-century friendly academic building. The old ones should be revamped and tailored towards smart buildings for novelty and innovation

(P1, P5, P18, P23 and P25). Also, findings suggest that integrating CMMS into the framework will tackle maintenance strategy and technical issues, such as situational and routine maintenance plans for each component/element of the building. This approach enhances the preventive maintenance mechanism as the best global practice for physical facilities such as HEIs (P4, P12, P19 and P23). Participant P19 says, "... *maintenance managers should assiduously put in more to revamp the obsolete buildings via CMMS. Digitalisation will enhance reskilling and upskilling, empowering the technical staff with new skills. It will curb leakages, inefficiency, and avoidable delays in maintenance processes* ...."

Findings show that CMMS will enhance preventive/routine maintenance and should be encouraged. The outcome would restore productivity and efficiency (P2, P14 and P17). P14 says, "... *besides several benefits associated with preventive maintenance practices, life cycle costing is drastically reduced when adopted. This mechanism will perform better with the integration of CMMS to enhance inventory control, eliminate shortages from the erroneous forecast, and maintain optimal resources performance* ...." The developed framework emphasises a feasible maintenance budget based on the maintenance manual and expert's recommendation. This is germane to enhancing efficiency and competency. Insufficient maintenance budget and delay in releasing cash for maintenance materials have been critical challenges. Feasible measures are proffered in the developed framework, as illustrated in Figure 3. The framework emphasises two aspects repositioned via CMMS for better service delivery. This includes substantive and technical aspects. Regarding the substantive aspect, the all-inclusiveness of the chief executives and directors/head of maintenance, in conjunction with the proposed integrated CMMS into the proposed developed HEIB maintenance framework, will improve service delivery to HEIs across Nigeria's higher institutions. This is the beauty of collaboration via digital technology and is driven by an all-inclusive policy. Integrated maintenance delivery via CMMS will curb inefficiency, leakages and avoidable delays (P2, P5 and P12). The outcome will enhance the technical aspects.

5. Discussion

Public infrastructure maintenance, including HEIs, has been receiving attention across the globe, especially in developing countries such as Nigeria, but the problem persists. Findings reveal that besides the poor state of public HEIB maintenance, an integrated digitalised framework needs to be present to improve maintenance practices. Findings agree with Ofide *et al.* (2015), Olowoake (2015), Enefola (2016) and Agbakwuru (2022). Agbakwuru (2022) corroborated the submission of Enefola (2016). Ofide *et al.* (2015) raised concerns regarding lax building maintenance practices in public HEIs. They suggested CMMS without integrating a developed maintenance framework to revamp the obsolete buildings and sustain the new ones. Agbakwuru (2022) avowed that because of the poor attention to public maintenance of infrastructure, including HEIBs, President Muhammadu Buhari signed Executive Order 11 on national public infrastructure maintenance on 6 April 2022. This includes HEIs. A monitoring committee should follow up to ensure full implementation and enforcement. It is germane because of our history and approach to building maintenance, especially the management team (Ofide *et al.*, 2015). Thus, embracing a systematic and digitalised approach to address public HEIB maintenance through SSM is germane. This is one of the study's motivations.

Findings identified insufficient maintenance budget, lack of strategic planning, backlog maintenance, lax HEIB maintenance policy framework, absence of institutional maintenance framework, and high maintenance cost as the major issues hindering public HEIB maintenance in Nigeria. Others are management attitude towards proactive maintenance, delay in releasing cash (maintenance funds), shortage of in-house technical personnel, lax maintenance programmes and schedules, absence of maintenance control toolkit, and

executive attitudes towards infrastructure digitalisation. Findings agree with Ofide *et al.* (2015), Olowoake (2015), Enefola (2016) and Agbakwuru (2022). Agbakwuru (2022) reported that inadequate attention to physical infrastructure in Nigeria, including HEIs, facilitated President Muhammadu Buhari's signing of Order 11 on national public buildings maintenance. Olowoake (2015) identified delays in releasing cash (maintenance funds), low maintenance budget, insufficient adoption and planned preventive maintenance technique use. Ofide *et al.* (2015) found no CMMS besides corrective maintenance on HEIs in Nigeria. Digitalisation in the 21st century is a key variable for productivity and efficiency.

Findings reveal a proactive mechanism to revamp public HEIB maintenance practices via a feasible all-inclusive framework integrated with CMMS. Revamp maintenance department via CMMS and supported by chief executives, maintenance strategy and technical measures, float feasible budget, and management role are the four critical constructs that emerged and integrated into the developed maintenance framework to achieve improved public HEIB maintenance practices for better service delivery. With the support of integrated CMMS, the HEIB maintenance practices, in conjunction with the maintenance strategy and technical measures, will identify maintenance practices to adapt and develop a maintenance plan for each building component/element via a preventive/routine maintenance plan. Concerning preventive maintenance mechanisms as a component of the developed digitalised framework, findings agree with Ofide *et al.* (2015) and Olowoake (2015). Ofide *et al.* (2015) suggested that apart from CMMS enhancing a preventive maintenance mechanism, it allows for more flexibility in resource allocation for maintenance works. Olowoake (2015) found that developing a framework will make MM of HEIs facilities in Nigeria cost-effective and achieve project quality control.

On the management/government role, findings show that public HEIB maintenance practices need support via legislation to monitor the implementation and enforcement of Executive Order tailored towards maintaining public infrastructure, including HEIs in Nigeria. Implementing and enforcing the contemporary approach to best practices has always been an issue in Nigeria. For example, since the signed Executive Order 11 (Agbakwuru, 2022), implementation and enforcement have been scanty. In this regard, the government's role is to ensure that public infrastructure is given the necessary attention in line with the best global practices. The absence of strategic planning and maintenance programmes and schedules may hinder the implementation (Olowoake, 2015). Findings show that a feasible framework from the experts can revamp HEIs maintenance practices with the support of integrated CMMS. CMMS will enhance reskilling and upskilling in the developed framework, including empowering the technical staff with new skills and curbing inefficiency and leakages (Ofide *et al.*, 2015). The maintenance framework intends to stir chief executive officers of HEIs to activate policy or programme that will create a sustainable public HEIB maintenance framework and integrate the strategy into their mission statement. It will reduce HEIB life cycle costs regarding maintenance and improve HEIs sustainability. This is the approach many developing countries use for infrastructure maintenance (Ebekozien *et al.*, 2022b).

6. Theoretical and practical implications

Regarding the study's implications, besides the current academic literature on HEIs maintenance practices showing a lack of viable frameworks to improve the system, there is the absence of integrating digitalisation into the maintenance framework. Second, the adopted SSM's novelty cannot be overemphasised (Arumsari and Sulisto, 2022; Ebekozien *et al.*, 2022b). The method became significant because of past attempts to proffer measures to HEIs maintenance issues through quantitative techniques. The SSM offered the interviewees to proffer implementable measures via integrating CMMS into the framework from the worldview viewpoints. This study fills the existing gap and forms part of the theoretical contribution. Also, the study developed a conceptual framework that guided the developed

framework. This aligns with Checkland (1981), Arumsari and Sulisto (2022) and Ebekozien *et al.* (2022b), as presented in Figures 2 and 3. Thus, from a theoretical perspective, the study focuses on public HEIB maintenance and develops a framework with the support of CMMS to improve Nigeria's HEIB maintenance practices.

The research confirms poor public HEIB maintenance practices across Nigeria's HEIs from a practical viewpoint. This calls for concerns. The study developed an implementable maintenance framework integrated with CMMS to improve HEIs maintenance practices in Nigeria. The developed framework is inclusive and tailored towards productivity and efficiency in future maintenance activities (Ebekozien *et al.*, 2022b). Thus, findings in this study have some practical implications for chief executive officers, maintenance directors in HEIs, maintenance experts and policymakers because of some recommendations highlighted. This includes revamping the maintenance department via CMMS (Olowoake, 2015) and supported by chief executive officers, maintenance strategy and technical measures, and enforcement and implementation of Executive Orders via management/government role. The developed framework will provide an important direction for optimising HEIs maintenance practices. The framework will help stakeholders promote maintenance integration via CMMS across HEIs buildings' life cycles.

7. Limitations and areas for further study

The research has limitations. First, the study utilised a qualitative research design via SSM and covered selected higher institutions within the six geopolitical zones across Nigeria. Second, the study engaged 26 participants but did not influence the outcome of the findings. Thus, results could be adapted and utilised in other developing countries with similar HEIs maintenance practices challenges. Future studies should focus on extensive coverage and validate the developed framework quantitatively.

8. Conclusion

The study investigated the state of public HEIB maintenance practices and developed a framework to improve HEIB with the support of CMMS across Nigeria's HEIs through SSM. The study findings reveal that the hindrances connected with lax maintenance of public buildings are still persistent across major HEIs in Nigeria. Also, findings showed the need for a digitalised framework to proffer solutions to the persistent poor HEIs maintenance. The relevant authorities should tackle the threat to quality higher education for all on or before 2030 head-on. The study developed an all-inclusive framework and recommended framework that can be used by Nigeria's HEIB maintenance practitioners and higher institution chief executives as guidelines to improve HEIB maintenance practices, as presented in Figure 3. The developed framework will improve HEIs maintenance practices. It will improve the state of HEIs maintenance and reawaken the stakeholders, especially chief executive officers, heads/directors of maintenance units and policymakers, regarding revamping physical infrastructure in an academic environment to meet the minimum global best practices.

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