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Asset Information Model Management-Based GIS/BIM Integration in Facility Management Contract

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Abstract: Achieving efficiency success status inside an organization's built environment and obtaining a positive return on investments need robust and comprehensive asset management and maintenance processes based on the efficiency of contract information documents within the built asset lifecycle. This paper aims to highlight the appropriate interactive approach for construction projects to build the information flow scope of asset facility management contracts based on GIS (Geographical Information System) and BIM (Building Information Modeling) integration processes and sustainability standards, and project as-built contractual documents to support owners and stakeholders with the intent of improving asset management processes. Expert interviews and contract information flow types in several facility management processes conducted in both local and international facility management organizations were used to assist the information flow scope method. The study classified and built significant integrated information and data flow models for a case study to serve as contract guidelines, including efficiency performance measures and indicators for monitoring procedures, technical evaluation, and financial issues in order to provide high-performance service quality in facility management applications.

Keywords: asset management; sustainability management; Geographical Information System; Building Information Modeling

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1. Introduction

Organizations need to maintain and develop agreed-upon services to improve the effectiveness of their primary activities, such as Life Safety, and reduce maintenance costs by 3.3% via the integration of processes of facility management (FM) platforms [1,2]. The FM market, which represents about 5% of the global market, is considered to be horizontally oriented towards human resources, information technology, real estate functions, and organizational assets [3–5]. FM applications within and outside the built environment include several disciplines and integrate people, places, processes, and technology to enhance and improve the safety, comfort, and functionality of the built environment [6,7].

Facility management (FM) scope in construction projects is a resource for strategic direction and daily operational objectives by providing applications to maximize value and minimize costs, while offering services to maintain environmental sustainability. It is supported by both local and significant international associations, i.e., IFMA (International Facility Management Association), to help resolve facility issues like tracking changes, identifying risks, taking corrective actions, and maintaining the built environment safely and efficiently [8–11]. Furthermore, FM is an interdisciplinary activity that provides estate strategies, asset spaces, renovation, refurbishment management, retrofitting master planning information provision, transport maintenance, and sustainable cleaning [12,13]. FM programs and courses are of severe concern for universities and specialist organizations, which design and launch a lot of specialist accreditations, programs, and courses for people and buildings [14,15].

Building Information Modeling (BIM) is a holistic process for creating and managing information for built assets. It is based on an intelligent model, and is enabled by a cloud platform. BIM integrates structured, multi-disciplinary data to produce a digital representation of an asset across its lifecycle, from planning and design to construction and operations. BIM is an interactive approach to designing, constructing, operating, and maintaining building projects. It uses digital modeling to provide better design visualization and digital simulations throughout the construction process. BIM is a 3D model-based process that provides architecture, engineering, and construction professionals with the insight and tools needed to efficiently plan, design, construct, and manage buildings and infrastructure [14–16]. It also develops asset information for construction disciplines, i.e., structural (walls, roofs, floors, etc.), mechanical, and electrical components, by collecting the required information and utilizing computerized maintenance management system like MMS (Maintenance Management System), BMS (Building Management System), EAM (Enterprise Asset Management), or ERP (Enterprise Resource Planning) as building management systems and preventive maintenance scheduling systems [16,17]. GIS (Geographical Information System) and BIM (Building Information Modeling) form a robust information system that uses data and software to manage facilities, allowing them to analyze data and metadata to make better decisions to improve performance management by supporting analytical capability applications with the intent of facilitating workflows in managing internal and external building infrastructure. This provides full operational awareness throughout the facility lifecycle [18,19].

Types of FM include hard facility management, soft facility management, integrated facility management, performance-based contracts, termination clauses, and legal compliance. The major information content within traditional facility management contracts consists of the service provider's main responsibilities, time, quality management, payment, compensation events, use of equipment, plant and materials, liabilities, and insurance. Inadequate and inaccurate facility information content is often caused by outdated processes, which lead to extra work and slower operations. Therefore, the negative influences of weak technical contract information inside facility management contracts include increased costs due to unplanned periodic maintenance expenses, missing correct data to support decision making, inefficient facility compliance between alternatives, unplanned routine maintenance, disrupting communication flow, wear and tear of facility buildings and equipment, discrepancies in understanding contractor duties, and contractual conflicts [19].

The facility management market's scope encompasses a wide range of services and solutions that influence business efficiency, making it a mature and growing market. The five main bidding documents for facility management scope include the bill of quantities, specifications, drawings, and general/special conditions. With the growing number of infrastructure development projects across Saudi Arabia contributing to its economic growth, facility management services are expected to grow considerably. The top facility management companies in Saudi Arabia are segmented by type (in-house facility management and outsourced facility management (single FM, bundled FM, and integrated FM)), offering type (hard FM and soft FM), and end-user (commercial and retail, manufacturing and industrial, government, infrastructure and public entities, and institutional). Market sizes and forecasts are provided in terms of USD value for all the above-mentioned segments. The Saudi Arabia Facility Management Market size is estimated to be USD 28.87 billion in 2024, and is expected to reach USD 50.31 billion by 2029, growing at a CAGR of 11.75% during the forecast period (2024–2029) [19,20].

This study opens the gate for various studies on the asset quality value and the flow of facility management assessment information in construction project processes as a practical approach to vital contract management. Therefore, the key research questions are given in succeeding lines.

How do we gather and manage the information for asset management contract documents for bidding? How can we build a robust five-contract document for asset management bidding (bill of quantities, specifications, drawings, and general/special conditions)?

What is the proper integration between software to support gathering and classifying the information in the asset management contract document? What are the proper information documents adopted at the asset management execution stage? How can we build robust information contract documents based on individual, group, and organization experts for accurate contract asset management information? How can we describe the distribution matrix between asset management service scope and each construction discipline? How can we benefit from the integration advantages of software based on GIS/BIM to enhance, build, and facilitate robust information for asset management contract documents to all construction discipline assignments in the execution stage? How can the decision-makers in the asset management field benefit from this study? Table 1 shows the study abbreviations.

Table 1. Study abbreviations.

Code	Description	Code	Description
GIS	Geographical Information System	IWMS	Integrated Workplace Management Systems
BIM	Building Information Modeling	CAFM	Computer-Aided Facility Management
KFU	King Faisal University	FMS	Facility Management Solution
FM	Facilities Management	IoT	Internet of Things
IFMA	International Facility Management Association	CMMS	Computerized Maintenance Management System
MMS	Maintenance Management System	FMX	Facilities Management Express
BMS	Building Management System	webTMA	Web-based Total Maintenance Authority Software Application
EAM	Enterprise Asset Management	WFS	Web Feature Service
ERP	Enterprise Resource Planning	WMS	Web Mapping Service
NRM3	New Rules of Measurement	WCS	Web Coverage Service
FMI	Financial Market Infrastructure	IFC	Industry Foundation Classes
RICS	Royal Institute of Chartered Surveyor	COBie	Construction Operations Building Information Exchange
ICT	Information and Communications Technology	GBXML	Green Building XML Schema
HR	Human resources	SCADA	Supervisory Control and Data Acquisition
GJTA	Global Job Task Analysis	HMI	Human–Machine Interface
PPP	Public–Private Partnership	O&M	Operation and Maintenance
SIM	System Information Model		

The study has identified a gap in the available literature regarding methods that empower organizations to effectively categorize and organize the information essential to their official FM contracts. This is achieved by merging descriptive narrative and spatial allocations, resulting in a project utility information matrix. This is executed by integrating two software programs and the services of specialist FM organizations available in the market. The structure of the study method flowchart encompasses the objective, case study, analysis software, systems utilized, effects, and results.

The study delineates a process for creating five contract asset management information documents using specific software, asset service organizations, and expert interviews. These documents allow organizations to provide detailed descriptions and precise spatial allocations for facility management contracts. The study focuses on modeling construction project information, and utilizes two software programs, leading to a more comprehensive and accurate asset management plan. By following this outlined process, organizations can create highly effective asset management plans that will provide them a competitive edge in the current market. Whether you are a facility management professional, a contractor, or a project manager, this study is a must-read for anyone looking to improve his/her asset management strategy.

1.1. Asset Facility Management in Construction Projects

Facility management (FM) has several definitions that could be presented as follows: (A) providing all required services to manage and maintain the buildings to increase their value; (B) supporting project maintenance management during the lifecycle of the building; (C) integrating multi-disciplinary activities within the built environment to control their influences on the workplace and people; (D) providing support services for organizations with professional management procedures focusing on efficient and effective deliverables; (E) integrating people, place, process, and technology within the built environment in organizational functions to improve the quality of life of the people and their productivity [13,20,21]. The term asset refers to the component of the entire building, element, system, and sub-elements. Asset classifications can be a portfolio, estate-level assets (e.g., offices and schools), or specific maintainable assets (e.g., boilers). It may be an individual item of a plant, a system of connected equipment, a space within a structure, a piece of land, the infrastructure of an entire building, or a portfolio of assets [17,18]. Asset types encompass human assets, intangible assets, financial assets, and physical assets. Physical assets include distinct value to the organization, including any software code critical to the asset's delivery function [18,20]. The built asset is defined as built infrastructure, e.g., roads, railways, pipelines, dams, docks, etc., that are the subject of a construction project, or where the asset information is held in a digital format [21,22]. Asset management is defined as developing, operating, maintaining, upgrading, and disposing of an asset using the most efficient and effective means besides providing a further overlay to FM, formalizing the building maintenance regimes [23,24].

FM organizations, i.e., FMI (Financial Market Infrastructure) and the FMI Commission, with input from over 3300 professionals spanning 93 countries and individuals, identified a common goal to elevate the facility management profession as well as to advance the careers of facility professionals, since the Body of Knowledge includes four main functional FM knowledge areas and five cross-functional competencies required of today's facility professionals. The five cross-functional competencies in the FM Body of Knowledge are communication, sustainability, quality, collaboration, and innovation. Four main functional FM knowledge areas include asset management competencies, which describe the behaviors, attributes, and underlying knowledge necessary to apply core technical knowledge and skills, i.e., strategic planning, compliance standards, and occupant services. Figure 1 shows cross-functional competency areas in facility management [25,26].

The main FM Knowledge domain principles of FM clients and professionals include the following:

(1) Professional competence through lean practice service products and dependability-driven quality service processes to gain a competitive advantage for clients.
(2) Sustainability-oriented resource efficiency with effective service procurement and provision through the lifecycle in suitable practical actions.
(3) Keys and booking system, security, fees and pricing, hours of operation, and programming.
(4) Quality, safety, and asset maintenance plan.
(5) Multiple uses with management agreements.
(6) Strong justification according to standards, e.g., BS 6079-1:2010 Project management [27]—Principles and guidelines for the management of projects (BSI, 2010), and RICS (Royal Institute of Chartered Surveyor, London, UK) facilities management as guiding principles of asset management [26,28].

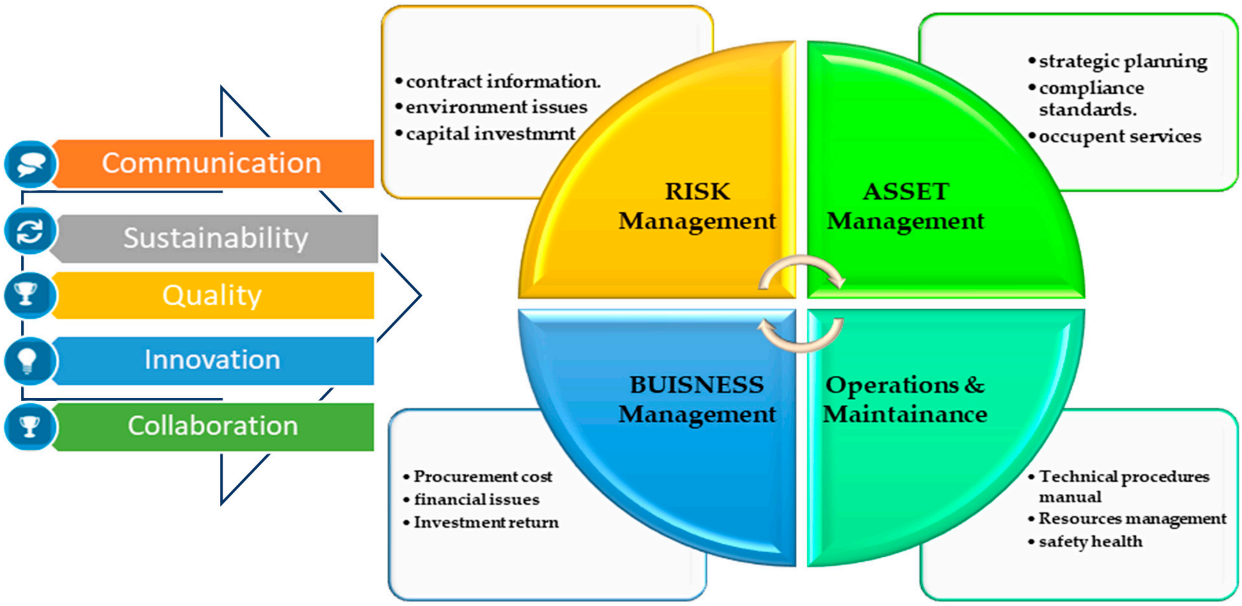

Figure 1. Cross-functional competency areas in facility management.

Facility management is divided into two essential areas: hard facility management (hard FM) and soft facility management (soft FM). Hard FM deals with physical assets such as plumbing, heating, cooling, and elevators. Soft FM focuses on tasks performed by people such as custodial services, lease accounting, catering, security, and groundskeeping [29]. The first area of FM refers to the physical built environment and infrastructure, e.g., planning, design, workplace, construction, lease, occupancy, maintenance, and furniture. The second area refers to people and organizations, and is related to work psychology and occupational physiology, e.g., catering, cleaning, ICT (Information and Communications Technology), HR (human resources), marketing, and hospitality [30,31]. IFMA launched an updated global job task analysis (GJTA) initiative in order to determine the most critical roles and responsibilities for modern-day facility management based on 62 countries' responses to facility managers. IFMA established 11 core modern facility management competencies. The updated terminology, expanded responsibilities, knowledge, skills, and abilities encompass the full scope of facility management as follows [32]:

- The Leadership and Strategy field illustrates how to align the facility's strategic requirements with the entire organization's requirements. It also illustrates how to lead, inspire, and influence the facility organization.
- The Operations and Maintenance field illustrates how to manage/supervise the acquisition, installation, operation, maintenance, and occupancy services. It also illustrates how to monitor the usage and performance of all facility systems, equipment, and grounds.
- The Finance and Business field deals with developing, recommending, managing, and overseeing the facility (expense, operational, and capital).
- Sustainability involves managing/overseeing the entire organization's commitment to sustainability through the lifecycle process.
- Project Management defines details about the projects (purpose, size, scope, schedule, budget, and user needs).
- Occupancy and Human Factors include how to create a healthy and safe environment that is conducive to innovation, and provides security meeting the facility's needs.
- The Real Estate field illustrates how to manage/supervise the real estate portfolio.
- The Facility Information Management and Technology Management field illustrates how to align facility management technology with organizational information technology. It also illustrates how to evaluate, implement, and operate integrated workplace management systems (IWMSs).

- Develop risk management and emergency management plans and procedures in the field.
- Manage a facility management communication plan.
- Develop and review performance metrics for facility management services as well as audit and document compliance with codes, regulations, policies, and standards.

1.2. Facility Management Systems, Software, and Metrics

Enterprise facility management software competes with world-leading products, and is a leading IWMS/CAFM (Computer-Aided Facility Management)/FMS (Facility Management Solution). It is a contemporary solution that works with businesses to provide a complete perspective on facility operation by integrating space, people, assets, and maintenance into a single system [33].

Facility management also refers to facility management systems and software with vast amounts of data—often called Internet of Things (IoT)—generated by built environments through sensors, meters, gauges, and smart devices [34]. Based on many factors, including ease of use, flexibility, scalability, and the selection of features, there are 20 software solutions, which include Hippo CMMS v 9.4 2024 (Computerized Maintenance Management system), Prod smart v 2.0, FMX v2.8 (Facilities Management Express), Quick Base, iLab Core Facility Management v 1.0., Skedda Bookings, Office Space Software, AiM v9.1 Space Management, ARC v 3.6. Facilities, Infraspeak, 360Facility v 6.0.11, WebCheckout, ARCHIBUS V.2023.04, Rosmiman IWMS v1, RecTimes v 2.1.2., and webTMA (Web-based Total Maintenance Authority software application) v WebTMA7. Such software solutions can allow access to up-to-the-minute data for space management, move tracking, facility maintenance, asset tracking, security and visitor tracking, and mailroom management systems. Facility managers must track data of all processes and operations to make the best determinations based on the most accurate information. To outline the specific measurements, every professional of the facilities must collect, understand, and track some data, including real estate costs and terms, space utilization, everything about every asset, the team's performance in the facilities, sustainability goals, optimal space usage, and the quality of space. The metrics used to achieve this include sustainability goals, maintenance costs, and productivity costs [35,36].

According to Esri, a Geographic Information System (GIS) is a framework for gathering, managing, and integrating data. Rooted in the science of geography, it integrates various types of data, analyzing spatial data location, and organizes layers of information into visualizations using maps and 3D scenes, consequently revealing more profound insights into data, such as patterns, relationships, and situations, helping users in making more intelligent decisions [37]. GIS can build a data model that encompasses geographic layers, i.e., soils, geology, vegetation, land use, buildings, highways, infrastructure, and social layers. Therefore, GIS is considered as a resource for facility management users, irrespective of having GIS-CAD-BIM data interchange, data formats, OGC, web services including WFS (Web Feature Service), WMS (Web Mapping Service), and WCS (Web Coverage Service), and Building Interior Space Data Model (BISDM) [38,39]. Building Information Modeling (BIM) is an intelligent 3D model-based process that provides architecture, engineering, and construction professionals the insight and tools to plan, design, construct, and manage buildings and infrastructure more efficiently. Integrating BIM into facility management software systems leads to better asset quality and standardized data and information stored within BIM, including schedules, blueprints, cost, location, service life, carbon impact, maintenance, spares, re-ordering, substitution, serial number, warranty details, and more. This integration supports sustained information flow for the efficient operational stage, and avoids performance gaps by offering information efficiencies in management across the building asset lifecycle application, i.e., mobile localization of building resources, digital assets with real-time data access, space management, renovation/retrofit planning and feasibility studies, maintenance studies, energy analysis and control, and safety/emergency management [40–43]. The success of integrating these two domains (GIS and BIM objects) is an excellent achievement toward solving problems in the architecture, engineering, and construction specialist facility management (FM) as well as disaster management (DM) sectors because it will be able to subscribe to access GIS information layers within software such as Autodesk's Revit [42,43]. This process generally involves extracting and transforming information required by each stakeholder in the relevant project. GIS and BIM are similar in model spatial information and shared use cases, i.e., location-based municipal facility information queries and management. Data and workflow integration across GIS and BIM enables the realization of greater efficiency, sustainability, and habitability of cities, campuses, and workplaces as well as supporting the building of a robust context model, where geographic information and infrastructure design data help in understanding that better assets interact within the context of a real place and geography, and move data seamlessly from one system to another [43,44], using data exchange models in the building industries, i.e., Industry Foundation Classes (IFC), Construction Operations Building Information Exchange (COBie), and Green Building XML schema (GBXML). A Green Building XML schema contains a structure combination of geometric and non-geometric data [43–45]. In BIM's Level of Detail LOD 500, which forms as-built documents, elements are modeled as constructed assemblies for maintenance and operations. In addition to actual and accurate size, shape, location, quantity, and orientation, non-geometric information is attached to modeled elements [46,47]. Figure 2 illustrates integrating BIM and GIS to make workflow data seamlessly, using data exchange between as-built information documents and potential BIM lifecycle and GIS solutions for facility management [47].

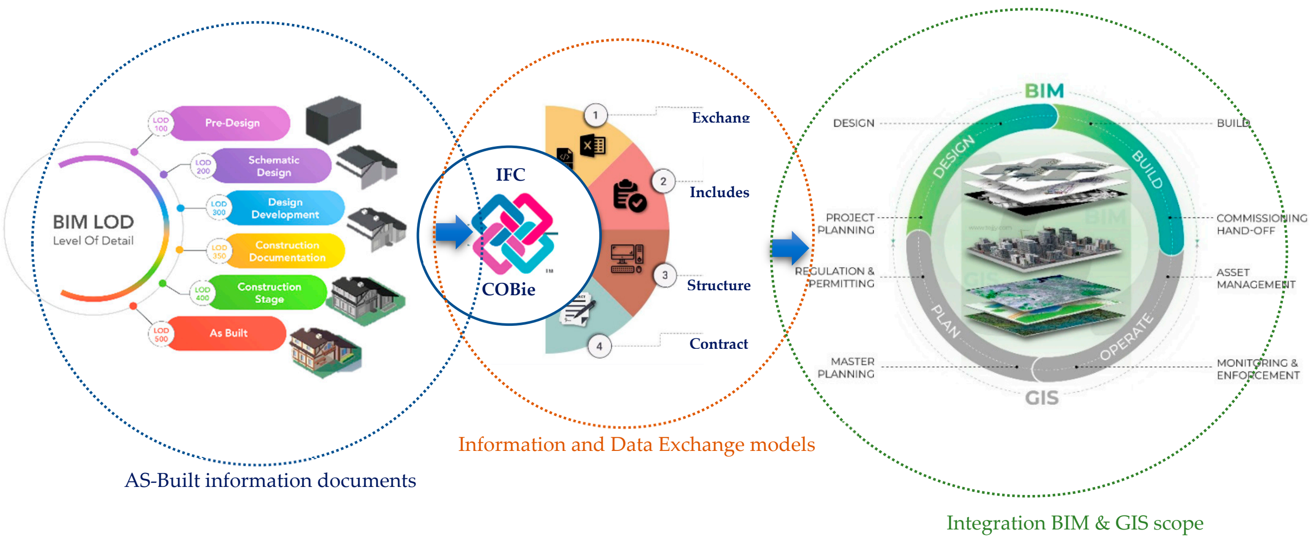

Figure 2. Integrating BIM, GIS, and data exchange to make facility management workflow information.

Project management is the use of skills, knowledge, tools, and techniques in supervising all activities related to a project. The project manager's role is to ensure that the project's objectives are achieved. Project management processes fall into five groups: Initiating, Planning, Executing, Monitoring and Controlling, and Closing. Project management knowledge draws on ten areas: Integration, Scope, Time, Cost, Quality, Procurement, Human Resources, Communications, Risk Management, and Stakeholder Management. The project management information system (PMIS) is part of the environmental factors that provide access to tools, such as a scheduling tool, a work authorization system, a configuration management system, an information collection and distribution system, or interfaces to other online automated systems. Automated gathering and reporting on key performance indicators (KPIs) can be part of this system [48].

A Building Management System (BMS) is a system that facilitates advanced control, providing automatic monitoring of all systems, equipment, machines, and devices via field controlling units and a workstation in the control and monitoring room of each building.

It allows for faster operation and monitoring of all systems, equipment, machines, and devices available in all buildings and support facilities of the university campus [49]. Figure 3 illustrates the BMS scope in the construction project. Supervisory Control and Data Acquisition (SCADA) is a system of software and hardware elements that allows industrial organizations to control industrial processes locally or at remote locations. It also allows industrial organizations to monitor, gather, and process real-time data, directly interact with devices such as sensors, valves, pumps, motors, and more through human–machine interface (HMI) software, record events into a log file, maintain efficiency and smarter decision processes, and communicate system issues to help mitigate downtime [50]. Figure 4 illustrates the SCADA scope in the construction project.

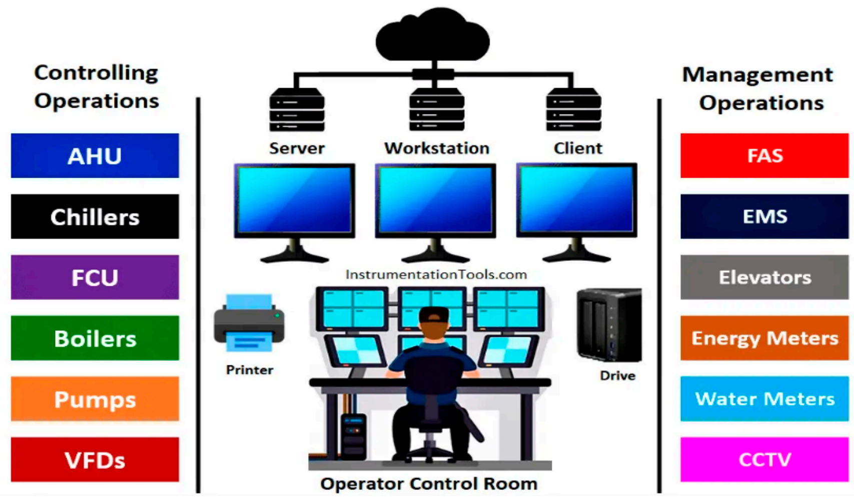

Figure 3. BMS scope for asset management in construction projects.

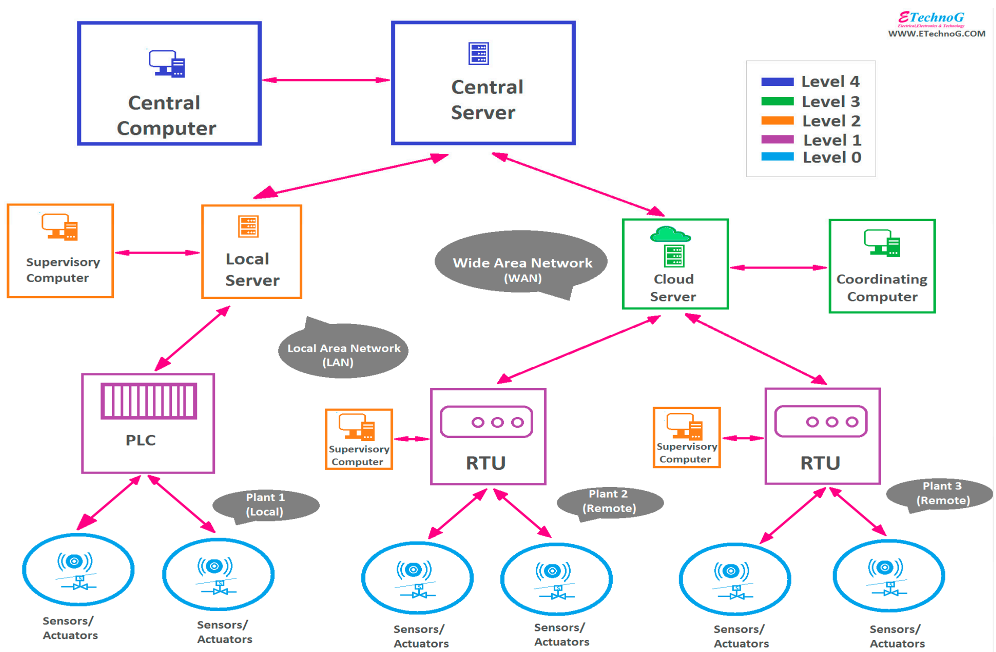

Figure 4. Scope diagram of SCADA system for asset management in construction projects.

2. Materials and Methods

2.1. Facility Management Contracts and Organization Types

Typically, the functioning of facility management services can be carried out in three layers: the Strategic Layer, Tactical Layer, and Operational Layer. The Strategic Layer defines the strategy objectives or direction, and makes the decisions. The Tactical Layer acts as a delivery vehicle to meet the strategic goals, and the Operational Layer utilizes the capabilities delivered by projects and programs [51,52]. At the early stages of any construction project, the owner, with his/her engineer or consultant, prepares the necessary documents for the tender process, which will be included in the contract. These documents are called contract documents, which include general conditions, special conditions, drawings and specifications, bill of quantity (B.O.Q), letter of acceptance, and contractor bid [53]. There are seven contract types that are integrated into three larger groups of contracts: (1) fixed-price (Firm Fixed Price (FFP), (2) cost-reimbursable, and (3) Time and Material Contracts (T&M) [54].

Typically, FM might be split into two areas of service: hard and soft services. The hard services relate to the actual fabric and building systems, and might also be considered the more traditional PM services. Soft services relate to the nature of the environment and culture of people and organizations. Typically, five models of delivering FM services can be illustrated as follows [55]. (A) In-house FM department means that the organization has a dedicated management team and in-house employees to provide all FM services by specialists, in case there is no expertise in the company, as illustrated in Figure 5. (B) Out-tasked service contracts mean that an organization has an in-house team of FM professionals, who procure and manage a series of outsourced contracts, as illustrated in Figure 6. (C) Outsourced working agent works via FM contract for all services on contracts on the behalf of the company, as illustrated in Figure 7. (D) Outsourced managing agent works on FM contract structurally. (E) Total Facility Management (TFM) contract is a development of the managing contractor option, whereby the FM supplier will deliver all or most FM services to the client organization through strategic partnerships, joint ventures, subsidiary companies, or in-house resources.

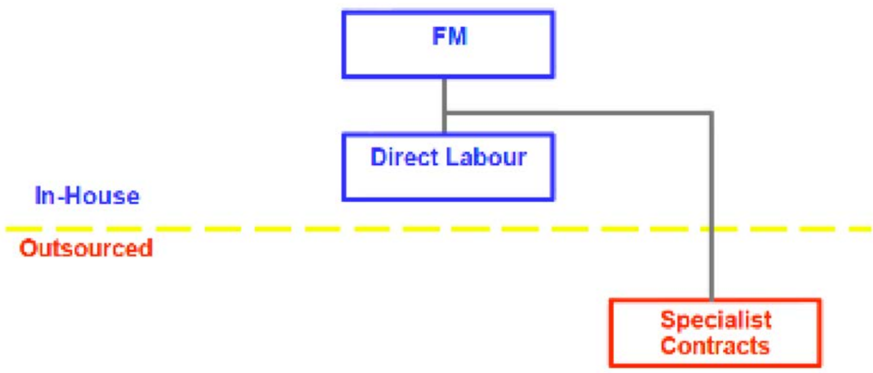

Figure 5. In-house FM department.

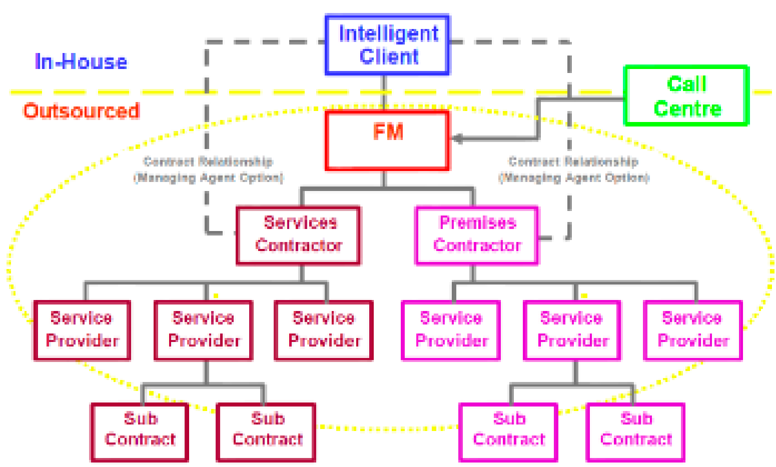

Figure 6. Out-tasked service contracts.

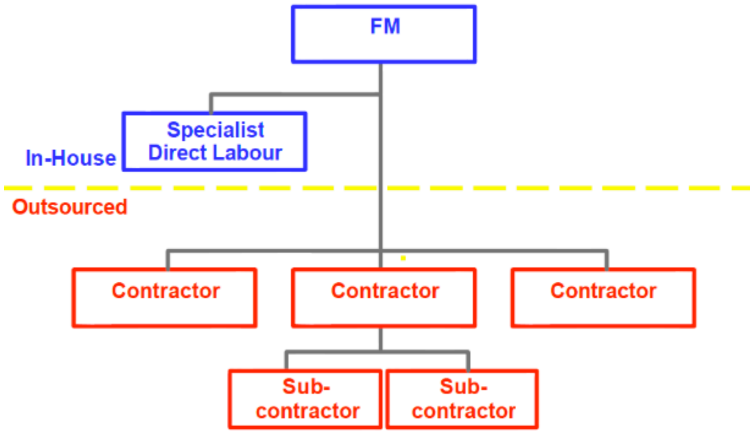

Figure 7. Outsourced managing agent FM contract.

Several phases in the lifecycle involve planning and design, construction, operation and maintenance (O&M), and demolition. For organizing all these phases, the BIM platform is used to manage the data during the entire lifecycle of the construction process, starting from the design phase. GIS platforms are sources connecting project information-based geography to provide the spatial data details on the specific location of all project utilities by applying coordinates. By integrating these two platforms (BIM platform and GIS platform), BIM data and GIS spatial data represent all project utilities in the real world. The integration of BIM data and GIS spatial data can be accomplished using three options: (a) extract data from the BIM system into the GIS system, (b) extract data from the GIS system into the BIM system, and (c) extract data from both systems (BIM and GIS) into another system [56].

Asset data location in 3D space provides the most essential integrating approach linking the new digital data, i.e., sensor data for room temperature. Therefore, adopting BIM as exchange flows through the project lifecycle with GIS as a computer-based information system to capture, model, store, retrieve, share, manipulate, analyze, and present the asset management information geographically can provide a high-level information inventory to the asset facility management contract for each building infrastructure detail for specific projects. Supporting advanced information management in the digital built environment underpins the integrated digital model development of the built asset [57,58]. The building's SMART IFC standard is an open standard data model for BIM to be shared and exchanged through software applications to create interoperability. This is considered a fundamental key in the integration solutions, i.e., ArcGIS GeoBIM, for managing data by automatically geo-referencing BIM documents, issues, and projects into hosted feature layers and visualizing geographic features and BIM objects in ArcGIS web maps and web scenes to find detailed asset BIM information in a geographic context, coordinating decisions across project teams [59,60].

2.2. *Scope of International Facility Management Firms*

The international facility management scope for higher education service and facility management framework could be explained as follows [55,61]:

- HVAC and MEP Maintenance: American Society Heating Refrigeration and Air Condition Engineers (AHSRAE), SFG20 Guidelines & Standards, APPA Maintenance Standards, and OEM recommendations.
- Cleaning Services, Housekeeping services, in compliance with BICSc Standards and APPA Custodial Standards, and material cleaning as per specifications.
- Laundry Services, Risk Analysis, and Bio-contamination Control standards.
- Security Services, ISO 18788:2015 [62] and as per local requirements, laws, and regulations.
- Waste Management and Shredding Services, Standards/Guidelines in line with local regulations.

- Pest Control Services, National Pest Management Association Guidelines and Standards.
- Catering and Hospitality Services, Hazard Analysis and Critical Control Points (HACCP) Standards and ISO 22000 [63], Performance Management.
- Office Support Services (Mailroom, Porter, and Reception Services) as per facility requirement.
- Landscaping and Grounds Maintenance, APPA Grounds Standards Professional Grounds Maintenance Society standard.
- Specialized Vendor Management for Critical Key Assets (UPS, Air Compressors, etc.) as per OEMs/Manufacturing Guidelines and local laws and regulations.
- Third-Party Testing and Certification (frequencies are defined by statutory requirements such as elevators, BMU, and water testing—bi-annually, air quality tests—monthly, and sewage tank—quarterly).
- Transportation and Fleet Management (per facility and in-country requirements).
- Energy Management ISO 50001 [64]—Energy Management System Certification; energy performance indicators (EnPIs).

The global standard for facility management includes APPA (American Pet Products Association), SFG20 (Industry standard for building maintenance specifications), HTM (Healthcare Technology Management), BICSc (The British Institute of Cleaning Science), NHS (The National Health Service), NEC (National Electrical Code), ASHRAE (American Society of Heating, Refrigerating, and Air-conditioning Engineers), WHO (World Health Organization), SIRA (Securities Industry Regulatory Authority), HACCP (Hazard Analysis and Critical Control Points), and JO (Maintenance of air traffic control communication services).

The membership and certification for facility maintenance include IFMA (International Facility Management Association), MEFMA (Middle East Facility Management Association), BSC (Bachelor of Sciences in facility management), ISO (International Organization for Standardization), and USGBC (U.S. Green Building Council).

Centralized support services include Learning and Development, Legal and Compliance, IT, IMS, Supply chain and Procurement, Intelligent command cancer CAFM, HR—Competency, Industrial, and Finance.

2.3. Analysis of Existing KFUFM Contract

The facility and asset management contract for the King Faisal University project is one of the vast projects that serves about 35,000 students, 1500 faculty, and administrative members on an area of 4.5 km^2. It contains 76 academic, service, and administrative buildings, 270 villas, and 24 residential buildings in operation. This contract represents about 75% of the project's total size without adding future areas, in addition to the general site areas of open and shaded spaces under operation, currently representing about 80% of the total project size for the infrastructure, including future regions. The information on the King Faisal University facility management contract (KFUFM) includes a project paper document and the approved procedure submittals for the company, responsible for carrying out facility management execution for daily routine work or responding to the space occupant's call.

The project paper document includes the main items, such as general conditions, particular conditions, work scope covering required maintenance/type of equipment with manufacturer catalogs, and layout drawings. Table 2 illustrates contact information items for the existing King Faisal University facility management. The way to execute and monitor KFUFM with the assigned company for routine work depends on the number of laborers, equipment, and tools for the following work [65,66]:

- Cleaning the internal and external spaces as well as fixed and mobile furniture components.
- Repairing equipment faults for the building or layout with the under-call procedure only. It means that if anyone calls about something wrong with the equipment, the company responsible for the repair of the equipment will fix it. This contract type has several disadvantages with reference to information scope, which are given below [67]:
    - ➢ Imprecise account list for the fixed and mobile furniture and its suitable locations;

- ➢ No FM Classification for the procedure, tools, and schedule for each internal and external entity and space;
- ➢ No approved checklist form based on specific information to monitor the FM procedures between the representative client technical teams and the company.

Table 2. Contact information items for existing King Faisal University facility management.

Contact Information Document				
General conditions (Word doc.) document	Special conditions (Word doc.) document	Work scope (Word doc.) document	Layout drawings AutoCAD (dwg.) software.	Bill of Quantities POQ (Word doc.)
39 items in 13 pages in the narrative include: • Governmental and organizational conditions.	Two pages in the narrative include: • Required technical engineer/labor List	56 pages in the narrative include: • Equipment and maintenance method • Manufacturers' catalog black and white	Document includes: • As-built drawings for buildings and landscape operation	Lum sump or lowest price includes: • Table of items' price
Execution information through Maximo software				
1. Request form in Maximo software via KFU web	2. work corrections based on guarantee document and FM team expertise.	3. There are no follow-up forms	4. Close the task in Maximo software	5. Invoice payment each month after penalties

The roles of project management (PM) and facility management (FM) may share some similarities, but they are ultimately distinct. While PM is focused on overseeing a project from its initiation to its conclusion, FM is responsible for the continuous management and provision of resources to maintain a building. The key differences between the two include the following: (a) PM is temporary with a clear timeline, while FM is ongoing, and involves a broader range of activities and objectives; (b) PM's main objective is to complete the project on time and within budget, while FM is there to support an existing facility; (c) PM involves more responsibilities than FM; and (d) PM uses various methodologies, whereas FM relies on inspection, maintenance, and space management [43,50,54].

2.4. Literature Review

The study in [8] described the creation and testing of a template and guidance document for employers' information requirements (EIRs), which is intended to meet the needs of both clients and facility management (FM) in the Building Information Modeling (BIM) process. The study called for specific guidance to help clients and facility managers prepare key BIM documents like the EIR. The study in [10] examined the level of awareness and usage of Building Information Modeling (BIM) for facility management (FM) among FM companies in a case study. It highlighted the importance of increasing awareness and promoting the adoption of BIM in FM practice, and suggested a low level of awareness and adoption of BIM for FM in the study area. To address this challenge, the study in [10] introduced a framework for information quality assessment (IQA) of BIMs for FM uses. The framework is then rationalized through the development and evaluation of information quality (IQ) tests using BIM model-checking tools across three projects with different levels of detail and complexity. The study in [18] provided a comprehensive review and analysis of the development of state-of-the-art research and industry standards that impact BIM and asset management within the operation and maintenance phase. A systematic review of more than 700 articles on asset management was conducted in [19]. The research focused on strategic aspects, and analyzed the nature of strategic asset management research. The study confirmed that asset management strategies align with different levels of organizational strategy. In [23], a new classification scheme for multi-unit systems was established based on essential features such as diversity of assets and intervention options. The study also identified differences in characteristics between cross-component and cross-asset interactions. Three types of potential multi-component dependencies were selected, including performance, stochastic, and resource, and their notions were extended to apply to multi-asset systems. The study in [26] identified six principles of facility management (FM) through a TRIZ process, supported by case studies and an extensive literature review. These principles are based on industry standards, professional guidance, and best practices related to FM. Another study [28] assessed FM organizations in the private sector, focusing only on management-level personnel. The standard categories of FM services proposed are single service, bundled service, integrated facility management, total facility management, building-related service, user-related service, and single–multi-service. A questionnaire was designed based on the literature and previous research to gather the required information. Furthermore, the study in [32] showed that adopting Building Information Modelling (BIM) in FM can improve the quality of life (QOL) in the workplace, by integrating people, place, processes, and technology to ensure higher functionality of the built environment. In [40], the authors provided a conceptual review of the key issues in defining facility management. They also critiqued these definitions in the context of the common perception of facility management as a way to generate cost savings through outsourcing. This is an emerging and generally accepted model of facility management. In [43], the authors described how incorporating GIS can play an innovative and effective role in asset and space FM. They implemented an integrated GIS solution in the information system, which includes spatial data acquisition, database development, and a system for FM. In [45], the authors presented a theoretical framework for digital system integration of virtual models and smart technologies. They proposed integrating the process in a centralized BIM-GIS (Geographical Information System) information management system, which allows for a scalable representation of the information supporting facility management processes in terms of assets and supply chain management as well as monitoring from a spatial perspective. In [48], the authors aimed to appreciate the contribution of BIM in optimizing the processes conducted conventionally within the FM practice. They concluded that BIM-based FM processes have the potential to shed new light not only on the FM sector itself, but also on the perception of the whole industry, being based on a collaborative approach towards the delivery of intelligent facilities. The study in [48] suggested a framework that combines BIM and facility management systems (FMSs) to create an FMM system. This system can automatically schedule maintenance work orders (MWOs), which improves decision making in FMM. The study also provided examples to demonstrate the feasibility and effectiveness of the proposed framework. A study [57] conducted on SCADA (Supervisory Control and Data Acquisition) systems suggested that this model could be applied to the building and plant field. Twin proposed the integration of this model within the SCADA system for better data acquisition and processing. This can help link the digital twin, which transforms from a static and parametric model to a dynamic and informative one. In [58], a literature review was conducted to gather information about the origins of the digital twin concept as well as current best practices related to bridge structures. The review also highlighted the significance of Building Management Systems (BMSs) in ensuring the safe operation of bridges and maximizing investments in bridge maintenance.

The study reviewed all of the available literature and found that there is a lack of studies on methods that enable organizations to merge descriptive narrative and precise spatial allocations for the all-information matrix in the official bidding context for facility management contract documents, based on the integration of two software systems. The main focus of the existing literature is on modeling construction project information. The current study aimed to fill this gap in the context of asset management processes by developing a robust information guideline for the asset management contract document. The study utilized accurate and valid FM information sources based on BIM and GIS integration, and focused on the needs and satisfaction of clients and stakeholders to achieve successful asset management execution during the construction project lifecycle. Based on its results, the study recommends establishing a five-contract bidding document for asset management in line with future clients, stakeholders, and project managers utilizing BIM/GIS platforms in asset management construction projects. The study outlines a methodology for creating a data and information framework for the asset management contract of King Faisal University assets (KFUA). The methodology involves five project management processes, with eight application areas identified for the scope of work. The Facility Management Contract for KFUA includes five documents containing details and patterns of data and information specific to the scope of the contract: General Conditions, Special Conditions, Work Scope, Monitoring and Follow-up for each scope aspect, and Financial for each scope aspect. These documents serve as bidding documents for contractor competition, rather than the previous contract's three-document image.

3. Methodology

A comprehensive analysis was conducted to assist a client from King Faisal University (KFU) in Saudi Arabia. The analysis aimed to help match facility management contract documents with the client's needs and requirements. The study was conducted from 2020 to 2022 on a desert university campus, based on 15 interviews with asset management experts from the client team and independent organizations in Saudi Arabia. The goal of the study was to establish Integrated Asset Information Model Management (AIMM), which involved analyzing all available key asset management information sources, which included contract document information from local and international asset management organizations, best practices for installing and procedures of contract information from regional and local facility management firms, and details of the contract document information of the existing KFUFM case study contract. The committee, detailed for analyzing complete information, identified all weaknesses and strengths in the contract document, such as the bill of quantities, drawings, specifications, and general/special conditions. Lessons learned from previous applications were also considered for the integration of GIS/BIM to store, analyze, and retrieve numerical and spatial asset management information throughout the contract lifecycle. The main objective of this analysis was to classify all the required information for asset management according to the client's needs in order to improve the contract information skeleton and supervise procedures for all disciplines in the execution stage throughout the contract lifecycle. To achieve this, an adapted matrix for the contract scope, divisions, and document of asset management inside the case study was implemented. Table 3 explains the information type and responsibilities for expert interviews and the updated contract results. Figure 8 illustrates the study method flowchart, which includes the objective, case study, software for analysis, systems used, effects, results, and expert interview analysis position.

Table 3. The information type and responsibilities for experts' interviews.

Organization-Committee	Information Type	Responsibility	Updated FM Contract Document
• Client technical members	• Gathering and classifying existing FM contract document • Preparig all as-built document	• Document classification • Classification	• Drawings—bill of quantities
• Facility management consultant	• Document information lack • Updated FM services scope	• Register and classify • Register and classify	• Drawings—bill of quantities

Table 3. *Cont.*

Organization-Committee	Information Type	Responsibility	Updated FM Contract Document
• BIM specialist team	• All as-built information document (doc./pdf/dwg., etc.) with Rivet software	• Manipulate the KFU as-built document	• Drawings-bill of quantities
• GIS specialist team	• All as-built information documents from Rivet software format with ArcGIS software	• Manipulate the BIM output document	• Drawings—bill of quantities
• KFU maintenance and operation project manager	• Lesson learned • Obstacles to operation procedures • Existing contract information gap	• Document register • Develop information support	• Drawings—bill of quantities • Supervision templates
• Private facility management firm	• All FM services' scope and requirements • The FM hierarchy organization team	• Coordinate with study author and client • Job skills and qualification description	• bill of quantities—specifications • General/special conditions
• Study author as coordinator	• BIM/GIS document integration • Preparation of updated FM document	• Manipulate with GIS specialist team and BIM specialist team. • Coordinate with the client's technical team	• Drawings—bill of quantities—specifications General/special conditions

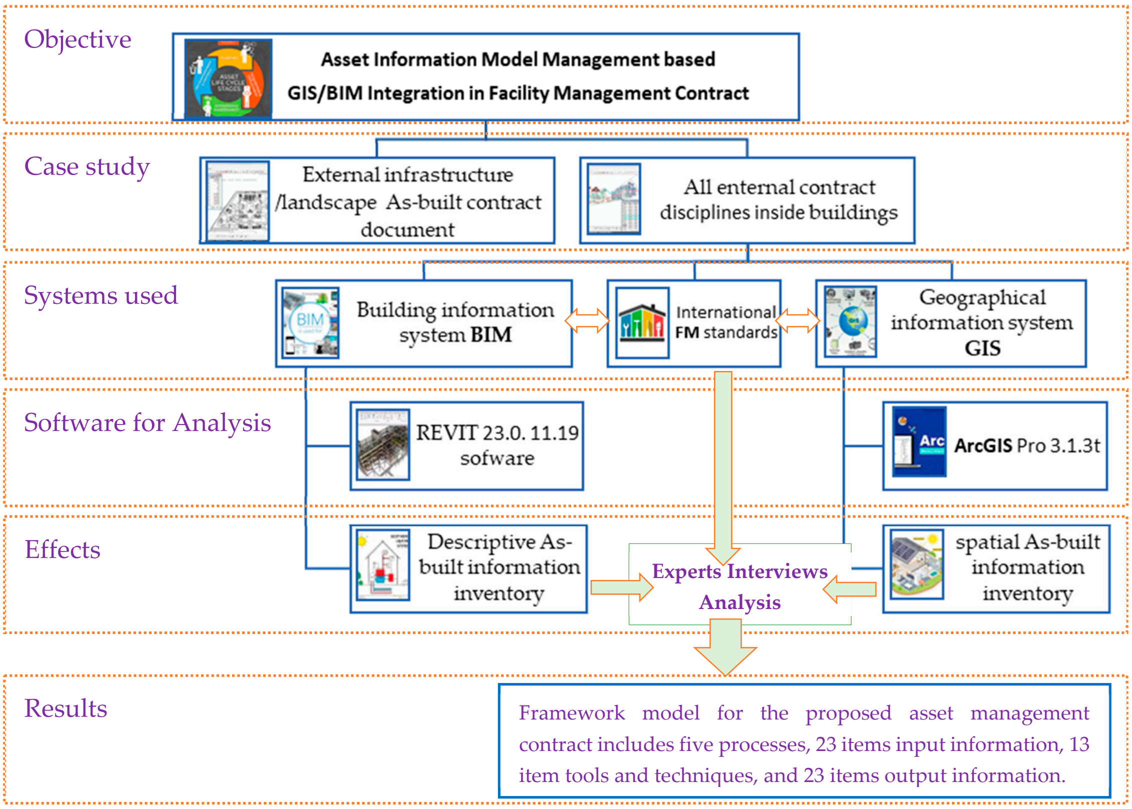

Figure 8. Study method flowchart.

4. Results

The organization's asset management needs to plan and build the quality of the contact information for the facility management in its construction projects, which continually affects the quality of performance and monitoring procedures within the project operation lifecycle. The facility management information encompasses buildings, spaces, equipment, devices, and layout infrastructure items to ensure the benefits in the form of return on investments made as well as to improve the health and end-user fitness quality. This study is based on the integration of GIS, BIM, BMS, and SCADA software along with extensive interviews with experts to achieve an interactive asset management contract model. AIMM has been built, including a comprehensive information flow for facility maintenance management for the King Faisal University KFU campus, with an area of 4.5 km^2. This model can accurately reflect the financial and technical aspects, appropriately containing all the details as an integrated information guide, with the company's expertise and international standards specialized in this field. Applying this model to King Faisal University achieved significant results through five consecutive phases: initializing, planning, execution, monitoring and controlling, and closing. It contains 23 items as input information, 13 items as tools and techniques to analyze the data, and 23 items as output information. The scope of the eight-facility management operation was thus selected, including HVAC and MEP maintenance, cleaning, security, waste management and shredding, pest control, landing and garden, specialist vendor management for critical key assets (UPS, air compressors, etc.), and energy management (lighting fixtures, fire testing, boards, and BMS management). The technical information structure extracted for these eight areas has been formulated in six engineering disciplines: architecture, civil, mechanical, electrical, layout, and furniture. This information encompasses the technical services to locate these disciplines correctly, and represents an integrated and comprehensive information structure as a manual guide in six main contract documents. This information includes general conditions, special conditions, POQ with divisions, spatial and detailed drawings with ArcGIS+BIM software, and execution and monitoring information encompassing FM execution method information, FM periodical method information, FM preventive method information, and FM daily method information. The Maximo software protocol contains POQ (Bill of quantities) + DWG (Drawings), in addition to monitoring with BMS v 4.37.3/SCADA v 6.2.0. These contract documents take account of complete official obvious submittals, procedures, and forms for work scope, monitoring and follow-up, and finances for each scope aspect, enabling the determination of the proper number of laborers, responsibility distribution, the equipment test list, the necessary tools, the number of hours of work required to be provided to suit each service field scope, and implementation method. These contract documents ensure that the facility management authority will be able to monitor the efficient performance of the contract areas of financial control regulation, payment invoices, penalties in FM execution method information, FM periodical method information, and FM daily method information, in such a way that they are not subject to personal effort. Figure 9 shows an example of connecting the spatial database information and metadata using the ArcGIS10 software (Environmental Systems Research Institute (ESRI), Inc., Redlands, CA, USA) with as-built information transferred from the Revit program as BIM software for administration building (author's work). Figure 10 illustrates an example of connecting the spatial database information and metadata using the ArcGIS10 software with as-built information transferred from the Revit software (BIM software) for the chilled water network in the layout site (author's work). In addition, building information models are used in the architecture, engineering, and construction fields to design and manage buildings, infrastructure, and other construction works.

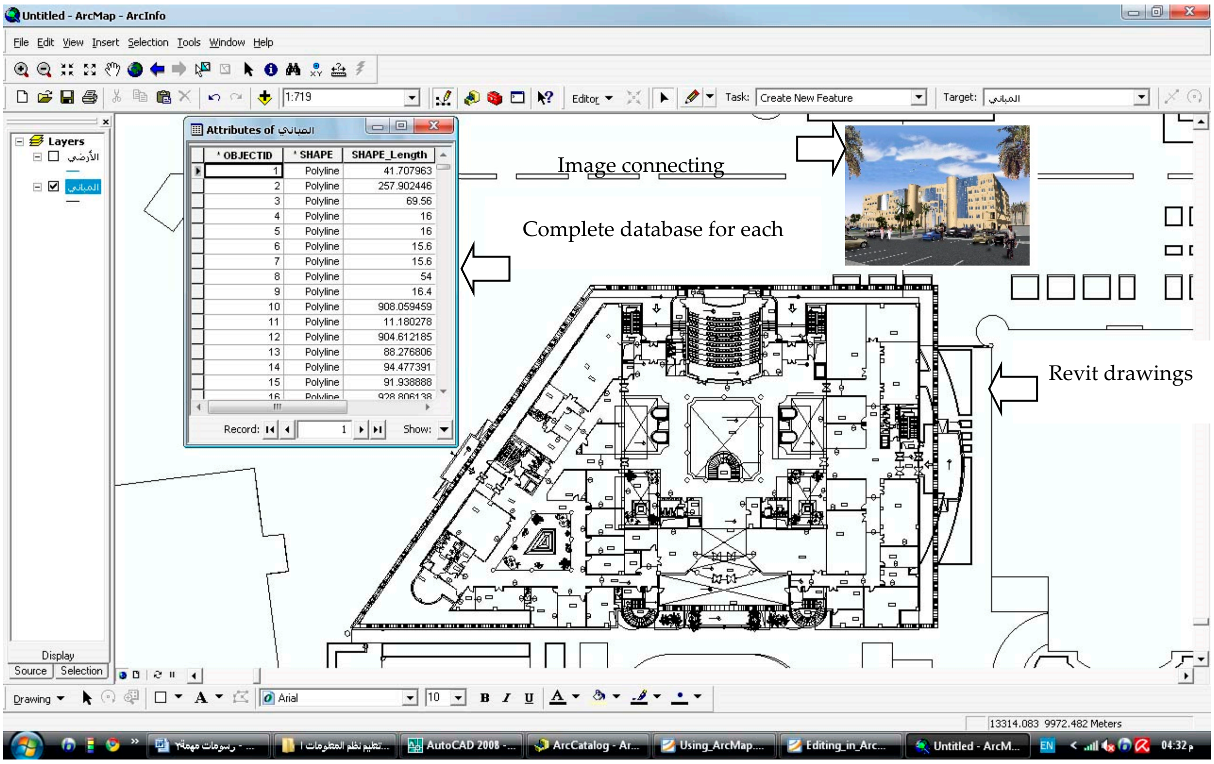

Figure 9. The as-built spatial database information and metadata using the ArcGIS10 software (ESRI) connecting with Revit program as BIM software for administration building (author's work).

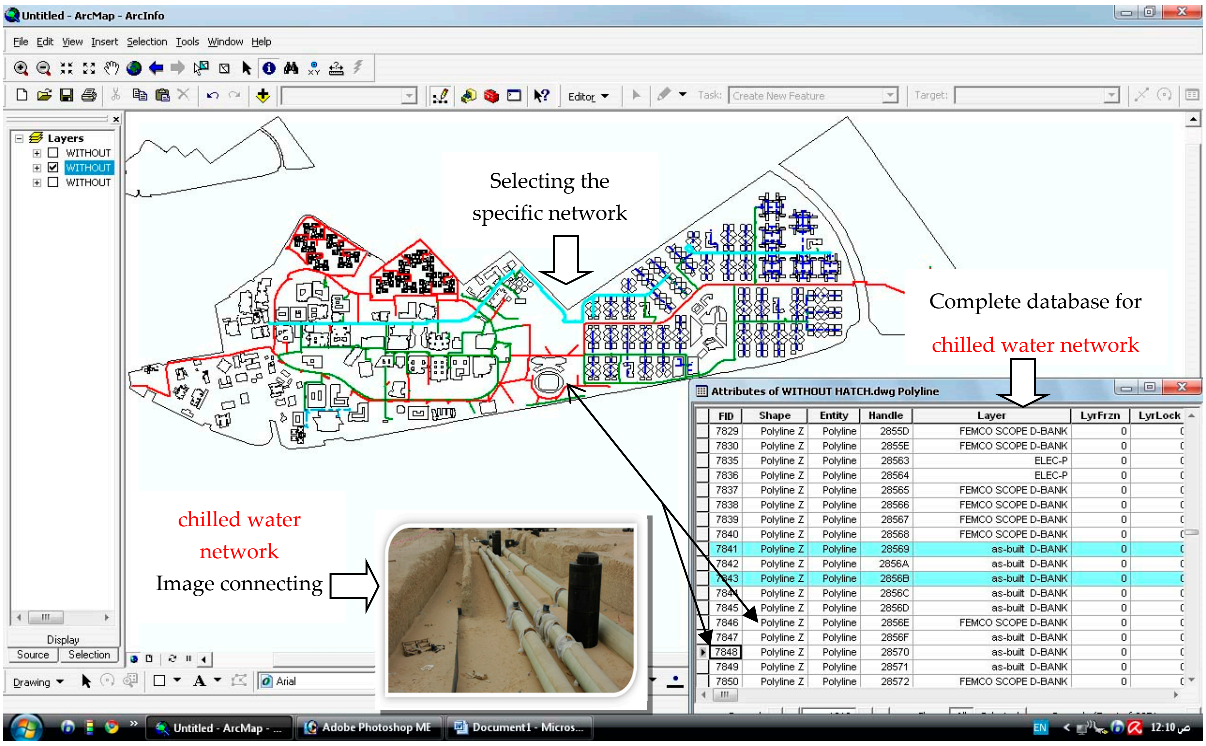

Figure 10. The as-built spatial database information and metadata using the ArcGIS10 software (ESRI) connecting with Revit program as BIM software for the chilled water network in the layout site (author's work).

Therefore, the study proposes enhancing the approach for the required information flow for facility management (FM) structure to rectify the contract items, as exemplified in Figure 11, which explains the flow of essential and needed information to build the Asset Information Model Management (AIMM) process and stages to obtain an applicable, robust, comprehensive, and practical facility management contract. This model is compatible with international standards in FM, using the available and latest software, e.g., the REVIT software, in the BIM method and ARGIS10.2 in the GIS method, and comprehensive analysis from client, experts, and stakeholder requirements, divided by project management processes. This AIMM model concept includes five steps, a scope for eight aspects, divisions for all project disciplines, and seven documents.

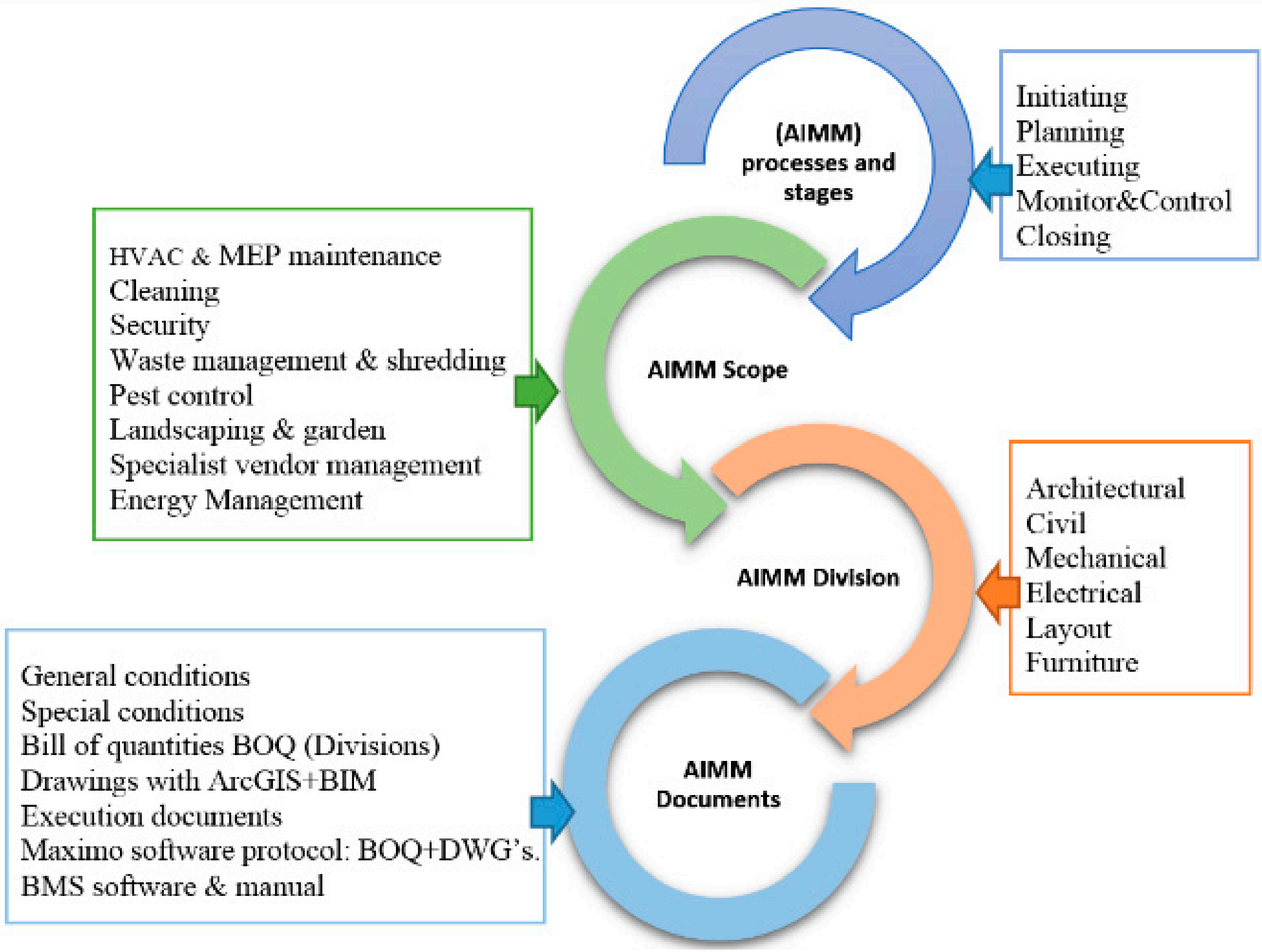

Figure 11. AIMM model concept.

The study follows best practices for project management [57] to obtain the necessary information to build the AIMM model with engagement for all stakeholders, suppliers, manufacturers, technical team, end-user recommendations, and client committee. Figure 12 illustrates details for the main five processes to build the AIMM model, as follows:

- Initiating process with six input items, three tools and techniques, and the output for general information in three articles.
- Planning process with eight input items, using hyperlinks between the leading five campus information documents, tools and techniques in five items, and the output for the primary information document in four things.
- Executing process with a primary full information document and five items as input items, using BIM/GIS integration as tools and techniques, and output for FM contract containing four main items, including FM agreement document, comprehensive in-

formation contract document, contract scope with final complete electronic as-built information documents, and schedule time.

- Monitoring and controlling process with two items as input items, two as tools and techniques, and FM monitoring and controlling forms as output in nine things.
- Closing process with two input items, two items as tools and techniques, and the output for general information in three things, including list of bidders and bidding invitation document, FM agreement document, and FM monitoring and controlling forms.

Process	Input	Tools and Technics	Output
Initiating	Definitions	Meetings with Stakeholders	General information:
	Principals	Expert Judgment	Organization Type
	Scope	Specialist company presentation	Regulations and Obligations
	Software		Operation Procedures & Information
	Metrics		
	Asset Management Contract type		
Planning	Campus Information documents	Hyperlink between Campus Information documents and catalogs	Primary Information document with several program extensions: excel, doc., pdf, dwg.
	Architectural spaces, Furniture,		Identify Organization Type
	Electro mechanicals equipment, Fixtures, and Utilities,	Guarantees	Geo campus map
	Civil structure.	Specifications.	Project Budget Estimation
	Layout, Hardscape, Softscape, and utilities,	BMS protocol	Project time duration
	Sustainability metrics and materials	PMI Knowledge area	
	Maintenance materials and procedures		
	Geo map for campus		
Executing	Primary Full Information document with several program extensions: excel, doc., pdf, dwg.	BIM/GIS integration and merging	FM Agreement document:
	Accurate geo utilities and entities locations Drawings	Exchange Cobie, IFC, XML	Comprehensive information contract document.
	Sustainability Specifications metrics &materials		Contract Scope with Final full electronic As built Information documents
	Maintenance materials and procedures manual		Schedule time
	Real Asset Quantities bill of Quantity.		
	Identify Organization Type		
Monitoring&Controlling	Comprehensive information contract document.	Extract with Stakeholders	FM Monitoring and controlling forms:
	Contract Scope with Final full electronic As built Information documents	Expert Judgment	QA/QC Procedures manual
			Field checklist
			Furniture Codes tracing
			BMS Protocol Inspection
			Technical Inspection list
			Invoices, VO
			Bidding Invitation
			Maintenance materials and procedures manual
			Execution time
Closing	FM Agreement document	Extract with Stakeholders	List of Bidder invitation Bidding document:
	FM Monitoring and controlling forms	Expert Judgment	FM Agreement document
			FM Monitoring and controlling forms

Figure 12. The five main processes to build the AIMM model.

There are more than 15 international standard services within hiring firms that any organization applies in its asset management study, using the previous stage to define the required services, collect all information needed, and classify them into HVAC and MEP maintenance, cleaning, security, waste management and shredding, pest control, landscaping and garden, specialist vendor management for critical key assets (UPS, air compressors, etc.), energy management (lighting fixtures, fire detecting, boards, etc.), the required information gathered from specific materials/system suppliers, specific manufacturers, and lessons learned from stakeholders involved in KFU asset management. The report includes the method and manual of O&M (operation and maintenance), vendor recommendations, required procedures, and technical team with the schedule for each process.

To facilitate the search for information for each entity, the correct information in the required submittal form should be specified, and the suitable procedure should be defined. Therefore, all information gathered from the previous stage, KFUFM scope, and all related information have been launched in related specific and adapted technical divisions as follows:

1. The architectural information document includes, as illustrated in the table, cleaning, landscaping and garden, and specialist vendor management.
2. The civil information document includes specialist vendor management.
3. The electrical information document includes UPS, air compressors, etc., energy management (lighting fixtures, fire detecting, boards, etc.), landscaping and garden, and BMS management.
4. The mechanical information document includes HVAC and MEP maintenance and BMS management for critical key assets.
5. The furniture information document includes cleaning and specialist vendor management.
6. The layout information document includes cleaning, security, waste management and shredding, pest control, specialist vendor management, and landscaping and garden. Figure 13 illustrates the AIMM-adapted matrix for scope, division, and document as well as their position through suitable AIMM division.

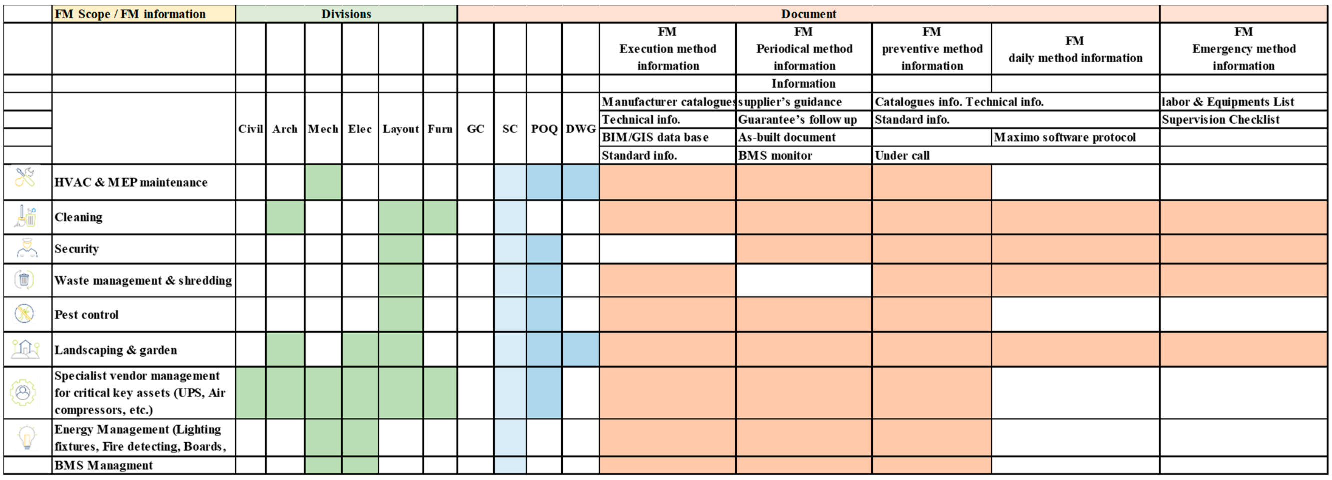

Figure 13. AIMM-adapted matrix for scope, division, and document.

At this stage, all the information is distributed in the document, using several software programs, for example, ArcGIS, Revit, BMS, SCADA, and Maximo, to explain the information about all the requirements for the client to execute and monitor each entity for each service registered in the AIMM scope. This stage had been arranged into the document encompassing general conditions, special conditions, POQ bill of quantities with divisions, and drawings with ArcGIS+BIM software. The execution and monitoring information includes FM execution method information, FM periodical method information, FM preventive method information, and FM daily method information. The Maximo software protocol contains POQ+DWG and monitoring BMS. The comprehensive information for all these documents contains mainly manufacturer catalogs, suppliers' recommendations and guidance (cleaning methods, replacing plan, operation process, malfunctions and damage procedures), technical information, guarantee follow-up, BIM/GIS database, international standard information, as-built document, Maximo software protocol v 7.6.0.9, BMS monitor devices, and call register. Figure 13 illustrates the AIMM information type as a bidding contract structure for KFU facility management and operation for its assets.

5. Discussion

The current study of asset information model management structure considered enhancing the approach for the organization's asset management construction projects, focusing on the quality of the contact information for facility management, which continually affects the quality of the performance and monitoring procedures within the project operation lifecycle. By going through the available literature, the study revealed that there exist some studies that have focused on the methods that enable organizations to merge descriptive narrative and precise spatial allocations for the all-information matrix in the official bidding context for facility management contracts based on the integration of two software programs, by focusing mainly on modeling the construction project information. The study conducted a comprehensive analysis to support the KFU client in the case study, using expert interviews for three primary information sources: information resources from comprehensive facility management contracts and organization types, information from international facility management firms' scope and services, and analysis of the existing KFUFM contract to establish integration asset information model management. The study illustrates a method to build a model for the organization that manages construction projects along with robust, comprehensive, and practical information scope for the facility management contract to be a bidding information document adopted with all international firms' content working in the facility management market. Therefore, the model concept encompasses built-in process stages, scope, and documents. The processes were explained in five management processes, and were analyzed using input, tools, techniques, and output for each process to achieve all the required information based on integration BIM/GIS, using ArcGIS software and Revit software for all documents. The model division was illustrated in six divisions, including all engineering disciplines inside the organization. The study selected eight tasks that cover all services needed for the organization in the construction project field. The study illustrated a distribution matrix between six model divisions and eight service tasks. Consequently, the study achieved the distribution of all information for the FM bidding contract in five main facility management contract documents, including the drawings, specifications, bill of quantities, general conditions, and special conditions format. Therefore, the study facilitates and enhances the case study organization to build its facility management contract document to cover all facility services. It also makes robust and precise technical and financial bidding documents to control and enhance its asset management through the project's lifecycle.

The study model, which includes stages in five steps, scope in eight aspects, six divisions for all project disciplines, and seven bidding contract documents, using software for the spatial allocation and descriptive data, i.e., GIS/BIM integration software, represents the best practice for flow information in asset management contract guidelines. It facilitates other organizations to adjust the model to manage their facility management. In addition, it opens the gate for further studies in enhancing the facility management in construction projects in monitoring procedures, development tools, controlling processes of procurements for facility management, and technical qualification identification of contractor and consultant teams working in facility management.

The study carried out an extensive analysis of over 400 studies on the scope of asset management information. The literature examined key issues related to dependability-driven facility management quality services and sustainability-oriented resource efficiency. It also focused on enhancing technical needs for effective service procurement and provision, lifecycle-oriented rapid dynamic responses, and strategic aspects of asset management.

This study established a novel classification scheme for multi-unit systems based on essential features such as diversity of assets and intervention options. It distinguished between cross-component and cross-asset interactions, and explained three types of potential multi-component dependencies (performance, stochastic, and resource) and how they apply to multi-asset systems.

Additionally, the study formalized an iterative approach to identify and characterize owner requirements, and developed a conceptual framework to relate digital and physical products to owner requirements and organizational constructs. It investigated correspondences between as-built models and O&M requirements, using procedures and semi-automated tools to facilitate quality management activities for FM-BIM.

The study illustrated asset management contracts and equilibrium prices using data to infer the constraints' tightness for computing a measure of effective arbitrage capital. It explained the benefits of using CAD for document information rather than developing a system information model (SIM). It also outlined the functions of an asset management information system, and deliberated the issues relating to its use, resourcing, and operation.

The study proposed an approach of combining smart legal contracts and blockchain smart contracts to handle legally binding contractual aspects of intellectual property rights (IPR). It also investigated network-level effects of important contractual parameters such as contract duration in public–private partnership (PPP) contracts.

The research study aimed to simplify asset management processes, in addition to reducing complexities by considering two possible solutions: 3D representation and visualization of asset management data as well as integrating different systems and data types used in the processes. It also explained that GIS/BIM integration is well-suited to the needs of urban management tasks and various processes in the construction lifecycle.

Overall, the study aimed to fill the gap in the context of asset management processes by building robust information guidelines for the asset management contract document. It used accurate and valid FM information sources based on BIM and GIS integration, and focused on the needs and satisfaction of clients and stakeholders to achieve successful asset management execution during the construction project lifecycle. The study recommends establishing a five-contract bidding document for asset management in line with its results for future clients, stakeholders, and project managers utilizing BIM/GIS platforms in asset management construction projects.

6. Conclusions

This paper introduces a framework for the Asset Information Management Model (AIMM) that outlines the necessary information required for construction projects to serve as an Asset Management Bidding Contract. The model is comprehensive and robust, and is based on the integration of specific software for asset and facility management, such as BIM, GIS, BMS, and SCADA, along with as-built documents. The study includes expert interviews and analysis of all available resources involved in the project, including the client committee, specialist firms, manufacturer/supplier manuals, end-user recommendations, GIS and BIM software specialists, and lessons learned from previous contracts. The result is a Facility Management Model for the case study organization. The Asset Information Model (AIM) used the concept of facility management contracts from different organization types and the scrope of international facility management firms. It analyzed the existing KFUFM contract as a comprehensive approach for experts to interview and gather information. AIM is built as an integrated approach that collects model information through specific methods, including five processes and stages, to select suitable FM information. The scope of FM information is defined by eight facility management operations, with six divisions illustrating the technical information structure of FM engineering disciplines. The processes, content, and divisions of FM information are merged as comprehensive information and classified in the leading five documents as a bidding contract structure for the KFU asset management case study. This structure contains complete official information of submittals, procedures, and forms for work scope, monitoring, and follow-up along with financial information for each item of the FM contract. The study, along with its model in the case study, helps the client follow the best practices in managing their assets. This guarantees that they receive distinguished service throughout the lifespan of their asset management. Additionally, it assists the service provider in delivering proper technical teams, labor, materials, and equipment in a precise manner in line with the approved schedule. This commitment ensures the successful completion of the facility management contract.

For future studies on asset management using BIM/GIS platforms, it is worth considering the following points:

- Enhancing facility management in construction projects by improving monitoring and control procedures, development tools, and procurement processes.
- Ensuring technical qualifications of contractor and consultant teams working in facility management.
- Taking into account the limitations of stakeholders who have access to the BIM/GIS asset management database.
- Incorporating mobile asset tracking methods into the BIM/GIS asset management system.
- Integrating BIM/GIS with environmental management and sustainable measures in the asset database.
- Using building automation systems for more efficient asset management.
- Integrating smart building systems with new technology for asset management.
- Improving facility management by enhancing monitoring procedures and development tools.
- Controlling facility management procurement processes.
- Identifying technical qualifications of contractor and consultant teams working in facility management.
- Enhancing FM cost budget and service quality through the O&M contract lifecycle.

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