



Infrastructure Model Development to Enhance Resilience Against Future Changes Using InfraWorks and GIS

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Abstract. The Smart City idea is becoming more popular because cities are getting too crowded. This study looks at how BIM and Geographical Information Systems (GIS) work together. The study focused on infrastructure and figuring out how long a building would last, as early stages of infrastructure development would help the public organization to better plan and design. The GIS mapping shows which areas are more likely to become cities or towns. The AEC industry stakeholders can benefit from mapping to achieve Sustainable Development Goals (SDGs). The AEC industry has also been constantly moving towards Building Information Modelling (BIM). In this study, the city of London was considered, and Land Cover predictions from 2000 to 2025 were made. The predicted Map of 2025 would help developers and planning authorities on decision making on housing development. Based on the current study, more research could be extended on how BIM and GIS could work together for urban development.

Keywords: Smart city · GIS · BIM · Infrastructure management

1 Introduction

The study focuses on a developed area of London in the United Kingdom to see how development changed over time of the Geographic Information System (GIS). Also, Building Information Modelling (BIM) tools are used to develop, model, and build a more sustainable solution based on GIS analyses. The tremendous increase of urban areas is a contemporary global trend, and migration and population growth are the real drivers of this growth. Urban growth affects how cities are organized and the economy and society function, but these effects cut across territorial boundaries and have a significant impact. Urbanization results from the current globalization, with social and economic

development due to which people migrate to the cities [14]. It is argued that this process is the center of progress that provide people with various possibilities. Emphasis on the urbanization process increases strain on the environment, its ecosystems, and its resources [1].

Designers employ infrastructure modelling at the urban community level to comprehend development and create and administer sustainable design plans [20]. Urban planners can then analyze city development that can boost effective mobility in urban areas by reviewing the prices and duration of the currently built environment. Unfortunately, collecting and keeping up-to-date building data from a neighborhood with many structures is challenging. Urban design development may suffer due to several uncertainties and mistakes. Since most current urban modelling systems use lower-level or abstract building data, planners may have to infer unknown building data to account for future uncertainty.

The abovementioned issues highlight the need for new strategies and tools that use current infrastructure design data to strengthen future development. Another issue is the distinction between design processes at urban level and infrastructure scale. The many design processes are interconnected and should not be considered separate from one another. This research examines the urban design development viability of employing ontologies to create semantic integration between GIS and InfraWork data. GIS, InfraWork, and urban design are the three fields this research covers. This study incorporates GIS and InfraWorks to analyze urban expansion and infrastructural model development utilizing Revit and Infracworks, both of which are a component of BIM [20]. BIM and GIS have the capability to facilitate applications in broader contexts, such as urban planning, by interconnecting and analyzing buildings, road networks, and underground utilities for detailed analysis and informed decision-making.

The current study would support creating a decision support system for policymakers to facilitate the efficient planning and design of urban development projects through cutting-edge information and technology. Utilizing a variety of software packages would lower the probability of mistakes for sustainable development in metropolitan areas. A more comprehensive strategy was attempted for efficient planning and development. Research objectives outlined in the current study included: (1) analyzing how future urban infrastructure can improve with time; (2) analysis of City's Expansion; and (3) 3D Modelled Infrastructure for achieving Sustainability using BIM.

2 Literature Review

A GIS is a system that can represent and analyze the items and connections in the actual world [8]. The traditional GIS can represent geographical data on scales ranging from the globe to the building level. Research findings also demonstrated that GIS was an effective tool for managing and analyzing diverse spatial data throughout the decision-making process [8]. Geo database, Shapefile, and TIGER are some examples of prominent data formats. Each of these data formats was built for a distinct GIS platform, resulting in a great deal of complexity and difficulty regarding data interchange [2].

InfraWorks is a highly popular software used for planning and designing infrastructure projects within a BIM environment [4]. Model-based planning and design of civil

infrastructure in the context of the actual environment is made possible by the BIM platform named InfraWorks [3]. InfraWorks enhances interoperability, enabling effective communication among project teams and providing designers with a more authentic context to work in [6]. While there is limited research on the combined usage of Revit and InfraWorks, both being integral components of BIM, they can contribute to enhancing the efficiency and effectiveness of construction processes [7].

The integration of GIS-BIM represents a cutting-edge data mining application that supports decision support systems. In recent times, the utilization of BIM and GIS in the building industry has progressed from research to practical implementation [16]. However, the adoption of BIM-GIS integration has been limited due to the differences in data formats and modeling approaches used in these fields [19]. Nevertheless, the concept of Geo-BIM, which involves the integration of GIS and BIM data, is believed to hold the potential for resolving the interdisciplinary challenges of the built environment [11]. Municipal administration must employ smart cities to address the problems brought on by the growing urbanization. Systems for intelligent and environmentally friendly mobility are a component of ICT, the backbone of the smart city. For planning and observing traffic, geospatial technologies might be helpful [9]. The integration of BIM and GIS analytics during the design and preconstruction stages will considerably help the planning process [12]. Therefore, in this era of smart cities, when aspirations for a better future are strong, this combination of BIM and Geospatial technologies could no longer be ignored [15].

Building safer and more intelligent transportation systems and structures is made possible by integrating geospatial services into infrastructure design and construction [18]. Technologies rely exclusively on reliable data and software systems and their integration [17]. More issues arise because engineers, designers, and planners must sometimes manually retrieve such data [5]. In designing an urban infrastructure system, it is desirable to integrate data from many sources and LODs [13]. Designers may access information from macro and micro level-built environment data to integrate GIS and InfraWork. It also makes it possible to use the advantages of these two technologies [16]. While Infracore focuses on the micro-level of infrastructure components, GIS focuses on the macro level, providing descriptions and precise geographic coordinates of an item, such as cities, land, and building landscape. Since both BIM and GIS are based on the graphic depiction of specific objects connected to a database, they may be used for various purposes [10]. To obtain a more integrated approach, current research on integrated BIM/GIS systems aims to leverage a variety of formats, such as Industrial Foundation Class (IFC) and City Geography Markup Language [21].

This study evaluates the methodology used in Autodesk Revit and InfraWorks [16]. The major goal was to use the program to build a BIM-GIS for the city of London, starting with the features already included in the package. The idea presented in this study outlines the key benefits of working with InfraWorks and the accessible cartographic data. However, the method described in this research needed additional software tools to overcome various issues discovered during data processing.

3 Methodology

This study suggested a method for urban mining that is based on the process of classifying data from different dimensions. A case study building was constructed using Autodesk Revit 2019 as the BIM authoring tool to establish the model shown in Fig. 1.



Fig. 1. Developed model on revit with exterior finishing

The researchers recognized the integration of BIM and GIS to improve planning and implement sustainable strategies in London, as partly shown in Fig. 2. The model was imported into InfraWorks to enhance visibility and assess its structural viability on the ground. InfraWorks enables the incorporation of GIS data or files within its platform. The urban area of London was considered as the scene, encompassing various selected areas. The processing order involved spectral analysis followed by spatialization, which was conducted using the Google Earth Engine (GEE) cloud computing environment. Cloud-based processing and deployment allowed for efficient scaling of computing efforts across large geographic regions. The process consisted of the following steps: (1) pre-processing and selection of Landsat scenes for the desired geographic area and time period; (2) computation of index normalized difference spectral vectors (NDSVs), which served as effective inputs for classifying urban areas; (3) spatial post-processing; (4) accuracy assessment; and (5) prediction of land cover.

Autodesk InfraWorks is a straightforward drawing tool that landscape architects and infrastructure designers may use. With Autodesk InfraWorks, high-level visual models could be made without the need for any other visualization tools than what is included in the package. A highly accurate model may be constructed by efficiently gaining access to data from various sources and combining that data. It is possible to confidently envision a project's full potential and establish a competitive distinction by utilizing cloud technology and vertical position capabilities, in conjunction with a computer-controlled and robust capability for the creation of 3D models. When InfraWorks was used for the first time, a model of the existing conditions was created by combining data from CAD, GIS, raster, and BIM files. This model represents the current state of the infrastructure. In this research, an InfraWorks 360 model was constructed, and an InfraWorks

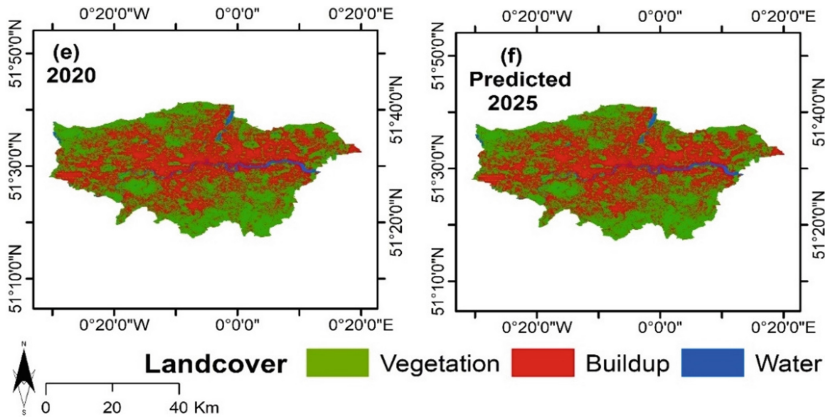


Fig. 2. Partly screenshot map of the London city and its position with vegetation, buildings, and water.

environment with ESRI data sources was used to acquire a 200 km² region in London. InfraWorks was connected to a 3D GIS making it possible for customers to obtain real-time mapping directly from InfraWorks. ArcGIS allowed users to manage imagery and other remotely sensed data and obtain information from such datasets. InfraWorks made it possible to include a wide variety of data sources into the model so that it could be analyzed. Following the construction and acquisition of the model, the Revit Architectural model was customized with the help of data sources. The defined Co-ordinate system was chosen, and the model was then positioned in a free-form environment as shown in Fig. 3. The structure's location on the designated terrain was located using the coordinates 51.5072° N and 0.1276°. Following the model's placement, the designated region was analyzed in a real-time 3D environment to provide urban planners with useful information. The coordinates could be seen on Google Street Maps. With the help of the InfraWorks conceptual design software, professionals in architecture, technology, and construction could model, evaluate, and visualize connectivity design concepts in the context of the built and natural environment. This helps them make better decisions and speed up project approval. Furthermore, the Conceptual Design Model provides users with the capability to create diverse projects, encompassing highways and roads, site designs and layouts, railway routes, water systems, bridge designs, and more.

4 Results and Discussion

In this study, BIM and GIS were employed to aid in the planning stage of building projects and manage urbanization. GIS was utilized to predict land cover and land use, and a series of six images were generated at intervals of five years. A comprehensive architectural model was generated via Autodesk Revit. InfraWorks 360 was adopted to analyze this building once it was constructed. Real-time visualization was made easier with InfraWork, which in turn enabled planners to organize projects more effectively.

When it comes to the process of building design, the primary advantages of using BIM are parametric modelling and interoperability, specifically by compiling data from

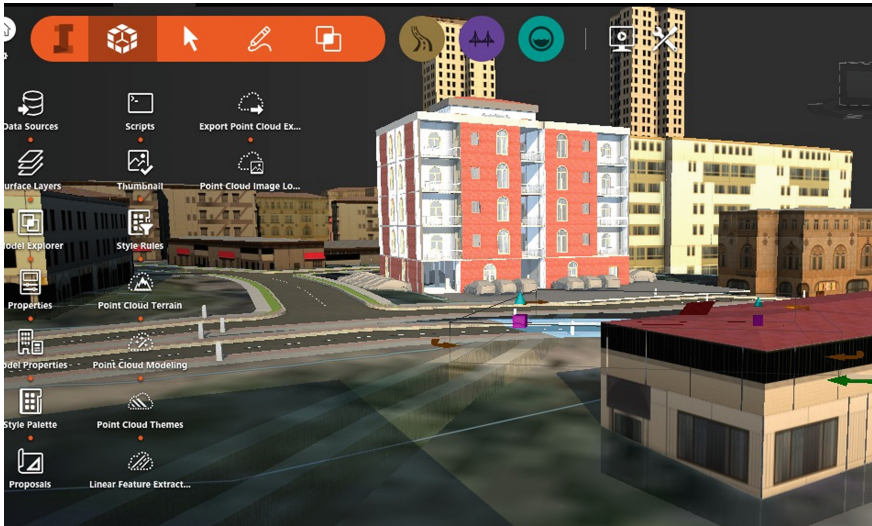


Fig. 3. Three-dimensional revit model inclusion in infrawork environment

a wide variety of fields into a single file and providing designers with a model that responds to certain geometry-related criteria. In its most basic form, BIM is a digital representation of the structural and functional properties of a structure. BIM allows the creation of smart cities that are both more environmentally friendly and more stringent in their requirements. In addition to this, it has the potential to correct the planning error in any development project. The case study model created in Revit 2019 was imported and adjusted in InfraWorks using the provided coordinates. When multiple building structures in an area are designed using BIM and GIS, it becomes easier for the council to obtain census data and promote sustainability in that specific region. BIM can be integrated into urban development and design processes during the pre-construction phase, facilitating effective planning and decision-making. When combined with GIS, BIM could provide a graphical database that could improve the visual tracking and collection of information about landscapes, grids, buildings, and cities. Because BIM and GIS are able to provide 3D models of buildings and sites, an early assessment of the construction site could be carried out applying this technology. The combination of BIM and GIS offers significant potential for improving various aspects of the planning and design phases, particularly in site selection, site planning and safety considerations, climate change adaptation, pre-construction stage operations, and the planning and design of the deconstruction process.

This research also adopted GIS in order to improve urban planning and management by more sophisticated design methodologies within BIM and GIS. Both Revit and InfraWorks were part of BIM platform, and each contributed to the lifespan study of a building structure, which in turn contributed to sustainability. The vast majority of design companies have been using Revit because to the sophisticated capabilities it offers for architectural, structural, MEP, multi-discipline collaboration, design and documentation, and conflict analysis. In contrast, InfraWorks allows professionals in the fields of

architecture, engineering, and construction to model, analyze, and visualize proposals for infrastructure design within the context of both the built and natural environments. The combination of BIM and GIS is helpful in the following areas:

- A centralized data repository and an ongoing, fluid exchange of information between the two systems, with no data being lost in the process
- A perspective on the project, the urban setting, and the environment that is far more specific and all-encompassing
- Offering users the ability to make strategic choices throughout the design, construction, and operating phases of the life cycle of a construction project.

5 Conclusion

The Smart City idea has become more popular because cities are getting more crowded. There has been growing needs of smart urbanization for citizens' wellbeing and sustainable community. The study focused on how BIM and (Geographical Information Systems) GIS work together in addressing urbanization. The study has been mostly about infrastructure and figuring out how long a building could last. All possible uses for the recommended case study model at all stages of smart cities were laid out. The early stages of infrastructure development would help the public organization to better plan and design. All project stakeholders could visualize it, obtain geographic and environmental data, and make their recommendations about infrastructure development. The GIS mapping showed which areas were more likely to become cities or towns. The AEC industry stakeholders could benefit from mapping to achieve Sustainable Development Goals (SDGs). The city of London was considered as case study and Land Cover predictions from 2000 to 2025 were made. The methodology of integrating GIS and BIM could be applied to other urban areas worldwide. The predicted Map of 2025 would help stakeholders find suitable areas for urbanization. Overall, the developed methods in this research could help the government and the planning department on decision making. These digital technologies, including GIS and BIM, could be utilized to develop intelligent, safer, well-planned cities. With more availability of digital tools to stakeholders such as planning and construction professionals, more practices of integrating GIS and BIM can be implemented in the future. The current study has not considered cost implications. More cost-related issues can be studied in the future, such as how to optimize the ratio of investment to outputs.

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