Comfort improvement of landscape and housekeeping components on government green building using Building Information Modeling (BIM) integrated web-based information system

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Abstract. The aim of building maintenance is to preserve the function, structure, and aesthetics of the building in accordance with the initial conditions. An ineffective building maintenance management leads to increased cost, reduced building reliability, and failure to achieve the green building mission. One problem highlighted is that building management are still using call-center system with no database to store building damage data. Therefore landscape and housekeeping components are damaged below the allowable standard and become no longer functional. The purpose of this study is to improve the maintenance performance on landscape and housekeeping components of government green buildings. The case study was the Ministry of Public Works and People’s Housing Republic of Indonesia. The research methods used are literature reviews, surveys, case studies, and expert judgement for validating content and construct. This study uses a Work Breakdown Structure (WBS) in managing data dynamically using Building Information Modelling (BIM), integrated with web-based information systems. The result is that using BIM-based website leads to a more effective and efficient maintenance, thus improving the maintenance performance especially comfort on landscape and housekeeping components. The most significant variable according to the coefficients model are infiltration well, trash bin, groundcover, carpet floor, and visualisation.

1. Introduction
The purpose of landscaping is to manage the appereance and fully utilize the outdoor area components according to thier functions [1]. Additionaly, there is also housekeeping components,which main function is to create a safe environment and keeping a certain level of comfort, privacy, health and hygiene [2]. Building Maintenance System is used for building supervision and building information management. In addition, a study on risk management strategy found that this strategy can improve the maintenance performance of government building, particularly in the aspect of comfort and ease of construction [3]. According to the Regulation of Minister of Public Works Number: 29/PRT/M/2006 about Guidelines for Building Technical Requirements, there are 4 indicators to measure building reliability, which are safety, health, comfort, and convenience. From these four indicators, comfort is the closest one to the purpose of landscape and housekeeping. A couple analysis have shown that green buildings is superior non-green buildings in terms of temperature comfort [4] and air quality [5].
The research object for this research case study is the Government Building of the Ministry of Public Works and Public Housing, where the main problem is the low maintenance performance of the Green Building. Damages were reported using a manual and outdated call-center system, while there was no database to store building impairment data, resulting in undetected wear and tear and lengthy repair handling. These problems will immediately impact increasing cost, along with unrealised realizability and building mission targets. Judging from the problems that occur, it can be inferred that the root cause of these issues is ineffective building maintenance system due to scattered and not well integrated data point. Referring to the study conducted [6], implementing ICT equipment, will leads to major savings in cost and budgeting, time planning improvement and increase rate of receiving the correct data used for handling defect. In addition, the application of BIM can cut down the impact of repeated mistake in decision making on the specifications of the design used and the construction applied for structures and building facilities. Hence the writers concluded that the solution to this problem is the development of a BIM-based web-based information system for the maintenance of landscape and housekeeping green building components. BIM can support various aspects of green buildings during their life cycle.

Overall, the benefits of using BIM on a project's green life cycle process can be categorized into three aspects, which are: BIM data can be exchanged among multi-disciplinary users with differing methods in analysing sustainability; the BIM application can provide visual information related to the building performance and process, thus enables project participants, such as designers, contractors and owners, to make more friendly decisions; and finally BIM can develop the communication and collaboration between various stakeholders related to green design, construction and operations [7].

2. Methodology

The aims of this paper is to answer the research question “How is the development of BIM-based information systems impacting the maintenance performance for landscape and housekeeping components of the green building?” and “What is the relationship model between the green building maintenance system and the maintenance performance for landscape and housekeeping components of the green building?”. To answer these questions, writer must take several steps of research strategy Figure 1.

![Figure 1. Research method and process.](image)

3. Results and discussion

3.1. Validated design alternative

The writer asked for inputs from 5 respondents to validate the design alternatives, with backgrounds in the field of green building maintenance or landscape and housekeeping. Respondents have work
experience ranging from 9-28 years in those aforementioned fields and latest education of at least bachelor degree. The output of expert’s validation is the validated alternative design on which maintenance guideline is able to improve the maintenance performance. Experts found that, related to the construct validation, the alternative design given for the landscape and housekeeping component (Table 1) of the green building maintenance guideline is valid. Additional alternative design, however was proposed by the 5 experts towards the landscape and housekeeping components, which are the rooftop garden and vertical wall.

3.2. Development of BIM-based system information

In this research, the BIM component (which are produced using Autodesk Revit software) are being developed as an online application which can be accessed through website. By using db-BIM and dB-BIMext database structure, each BIM can be consolidated using the Open Database Connectivity (ODBC) feature in Revit. After completing the website page and integrating it with BIM that has been produced by the writer, a user level access management will be implemented which will give certain privileged or restriction depending on which user are accessing the www.sipenjau.com. Employees who are logging in to the website Figure 2 can create a damage or complaints report to certain components or items through the reporting feature.

![Figure 2. Interface of green building maintenance website.](image)
Moreover, user can also see detailed information through image via item capture using Revit. This feature was embedded in order to enable users to see the complete information of the item, without changing the original BIM document which would require the permission of Building Maintenance Division. On the Building Maintenance Division level, user can receive and reply incoming reports to the corresponding user. They can also download the BIM documents (Figure 3) and use the data to improve the maintenance performance of the building. After completing the maintenance process, Building Maintenance Division will then update the BIM data using photo, and register actions which have been completed on the items as a log to help the division in the upcoming maintenance tasks. The updated document will then be uploaded to the website. In creating a model using the Autodesk Revit 2020, writer put in data item (Figure 4) which are included into the landscape and housekeeping components such as image, model (brand or material). Finally, in order to improve the maintenance performance, completed maintenance tasks and damages on the item are also listed down, to facilitate the user on what action to take if any damage happen to the item in the future.

![Figure 3. Building information modelling for landscape and housekeeping components.](image-url)
3.3. Regression model

By using multiple linear regression method to analyse the data, writer obtained a model which explained the relationship between the work list and the green building maintenance performance. Through the model, it can be inferred that the most significant maintenance performance variable for landscape and housekeeping components is comfort, in which the model for this component yield an R-squared $R^2$ value of 0.559. This metric shows how well the linear model would fit in with the data. Additionally, the most significant variable according to the coefficients model are infiltration well, trash bin, groundcover, carpet floor, and visualisation (with confidence level of 90%) (1).

$$Y = 1,302 + 0,248 X.1.1.4 + 0,188 X.1.1.13 + 0,201 X.1.2.4 + 0,142 X.1.4.11 + 0,157X.2.1.3$$  \(1\)

This conforms to the literature regarding green buildings maintenance that can increase comfort. Infiltration well and groundcover can be interpreted as a buffer zone which is capable of harmonizing the balance of nature and the environment, between the amount of pollutants, the ability to evaporate water (evapotranspiration), absorb water into the ground (infiltration), and control the rate of runoff [8]. These variables therefore can improve the comfort of landscape and housekeeping components through thermal comfort. Meanwhile trash bin is needed to support the cleanliness of the pedestrian path or the environment so that pedestrians feel comfortable [9]. According to CRI Green Label Indoor Air Quality Test requirements, carpet flooring system have very low emissions of Volatile Organic Compounds (VOC), and by using carpet flooring can actually improve the comfort of a green building. Finally, the visualization of BIM can help facilitate the building maintenance process, in this case encouraging complex forms of maintainable design such as thermal comfort analysis and building comfort analysis [10].

4. Conclusion

A BIM based information system development which aim is to raise the maintenance performance of green building landscape and housekeeping component has been established. The information system is used by the building maintenance team and building employees to track and resolved damages and
problems on landscape and housekeeping items. Furthermore, a database to store building damages and maintenance report has been develop to help further maintenance duties. Through regression analysis, comfort is become the most significant maintenance performance variable for landscape and housekeeping components. There are strong relationship between maintenance system, especially the importance of infiltration well, trash bin, groundcover, carpet floor and maintenance performance. Regarding the information system, BIM arose as the most impactful variable inside the green building information system components, accompanied by visualisation as the most significant variable.

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