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Implementation of green river retrofitting concept using Blockchain-BIM for cost performance

Eka Juni Arif*, Albert Eddy Husin
Department of Civil Engineering, Faculty of Engineering, Universitas Mercu Buana, Indonesia

Abstract
Considering the global climate change and anticipation of water needs, this can pose significant problems. Trees play a crucial role in mitigating climate change, with the ability to assimilate carbon dioxide (CO2) and certain air pollutants, purify rainfall, and act as a barrier against soil erosion. This research focuses on the Bekasi River, which has a length of 6 km and a cross-sectional width of 65 meters. The data used is directly extracted from project data utilized for cost estimation, and data collection is conducted through interviews and questionnaires. The research methodology integrates Structural Equation Modeling-Partial Least Squares (SEM-PLS) as a data processing tool for survey and factor identification, along with Blockchain-Building Information Modeling (BIM) to assess the cost performance improvement of environmentally friendly reinforcement. Based on the test results, the utilization of BIM combined with blockchain technology can result in cost savings of 3.69% for the Improved level, 3.72% for the Enhanced level, 4.39% for the Superior level, 4.92% for the Conserving level, and 5.17% for the Restorative level in terms of cost enhancement.

Keywords:
Blockchain-BIM;
Cost performance;
Green River;
Green Retrofitting;
SEM-PLS;

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Corresponding Author:
Eka Juni Arif
Department of Civil Engineering, Faculty of Engineering, Universitas Mercu Buana, Indonesia
Email: 4ndr07777@gmail.com

INTRODUCTION

Greenhouse gases (GHG) can cause global warming, directly impacting climate change [1]. When atmospheric carbon dioxide (CO^2) and other GHG concentrations rise, the quality of the climate deteriorates. Reducing the atmosphere [2] CO2 is crucial to lessen the associated environmental issues [3] as per the Paris Agreement [4]. Biodiversity suffers from high CO^2 levels. Urban vegetation [5] and urban forests are the primary solutions for reducing CO^2 levels in cities because they successfully support urban sustainability.

The concept of Green River Retrofitting, serving as the assessment framework in this research, utilizes ENVISION as its reference. ENVISION represents a step towards renewing infrastructure more sustainably. It involves replacing old components with environmentally friendly and sustainable solutions. This process includes applying cutting-edge strategies, techniques, and technologies to enhance performance standards in sustainability.

The implementation of green river conditions has undergone some changes, including establishing numerous criteria that discuss the characteristics of an environmentally friendly river [6]. We must adopt ecologically [7] and environmentally friendly river conditions to reduce the effects of geothermal heat due to climate change. Hence, there must be standards that can be used as guidelines for cost-effective, environmentally friendly green rivers [8]. A river is ecologically friendly without harming the environment or impeding its natural material cycle [9]. The impact of the environmental harm generated depends on the distinction between the Green River and conventional implementation methods [10]. Figure 1 explains the vegetative method, which emphasizes an eco-hydraulic strategy for addressing erosion and sedimentation issues on riverbanks.

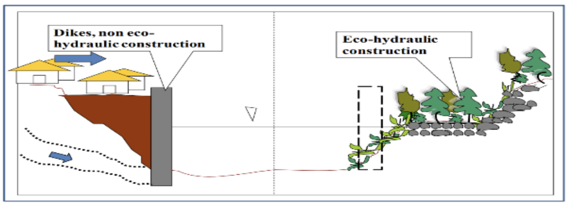

Figure 1 Concept comparison between levees (non eco-hydraulic) and eco-hydraulic

METHOD

This study involves acquiring primary data through an audit or verification procedure to assess the adherence of current buildings to green building standards. The primary data indicates the extent to which the Envision Guidelines are being followed. At this stage, data use begins with available Secondary data. In addition to that, secondary data can be obtained from project papers, such as planning drawings and Bills of Quantities [11]. Moreover, facility Operational data will be used as well, when developing the questionnaire, the author looked for the most influential indicators. Throughout the questionnaire's development [12], The author sought those indicators that had the most impact. The questionnaire was developed by referencing the materials identified and shared by previous researchers.

Applying Structural Equation Modeling (SEM) [13] to interdependent variables is justified because it does not consider excessive multicollinearity. This questionnaire will be disseminated to project stakeholders, including those directly and indirectly engaged. We will employ the Structural Equation Modeling (SEM) technique with the SMART PLS simulation program. 3.0 software to analyze the data. Furthermore, we shall carry out interviews to acquire a more profound comprehension. This involves identifying relevant factors and subfactors.

Next, data collection was conducted using research instruments. The processes mentioned above were accomplished before the ongoing discussion. This study thoroughly examines existing literature to collect many factors using this instrument. We aim to ascertain the primary elements and subordinate aspects that impact cost-effectiveness.

Our research aims to identify significant factors influencing the implementation of cost efficiency in retrofits. Environmentally friendly Green River is based on Blockchain-Building Information Modeling [14] (BIM), as shown in Figure 2, which shows the envision assessment process followed by the SEM-PLS process.

Experimental Design

The plan of the experiment Blockchain ensures a secure and managed collaborative environment for BIM projects [15]. This vision is a strong construct based on a computer design environment [16] that values user data. Due to the distributed database architecture of the blockchain, which guarantees fundamental neutrality to model modifications, neither side gains from the other. System participants can rely on blockchain as a reliable source when sharing information. Using blockchain, you can leave a record immune to changes made to BIM objects.[17]

This research aims to determine the key elements that impact implementing cost efficiency in strengthening environmentally friendly green rivers based on Blockchain-Building Information Modeling (BIM). The building has a sustainable concept of saving natural resources (energy, water, land, and nature [18]. Figure 2 illustrates the factors with the most significant effect. During the initial phase of this research, the process of identifying pertinent components and sub-factors was conducted.

Moreover, data collection was conducted using research equipment. The processes mentioned above were done before the ongoing conversation. This study entails doing a comprehensive evaluation of existing literature to gather significant factors associated with Green River (X1), Green Retrofitting (X2), Blockchain-BIM (X3), and Variable Cost (Y).

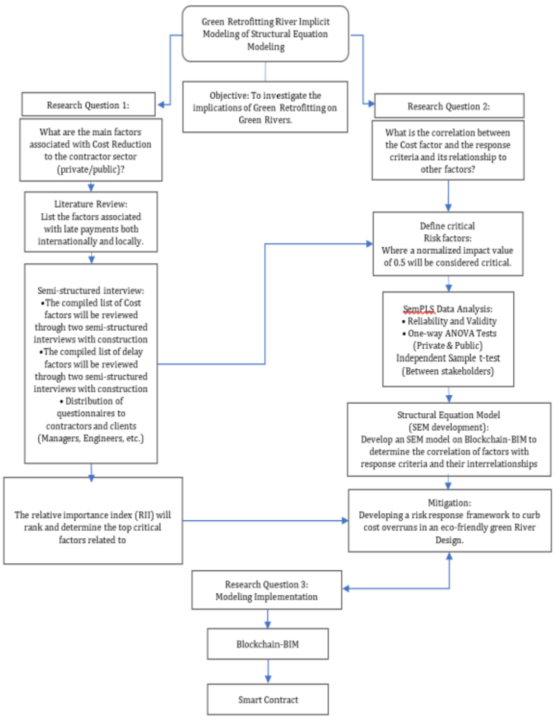

Figure 2. Research Framework

Secondly, during this initial phase, the evaluation must satisfy a minimum basic rating threshold of 74.25. The research methodology is outlined in Figure 3, detailing the Research Flow for the Envision Concept.

This study gathers primary data by conducting an audit or verification process to assess the alignment of current buildings with Green River criteria. The initial data indicates adherence to Harvard University's Envision Guidelines. Currently, the process involves presenting crucial evidence on the influence of validating the information model on creating a unified delivery environment. Data usage begins with secondary data already available within the organization, involving energy generation and usage data. Furthermore, supplementary details in project documentation, including planning drawings, Bills of Quantity [19], and facility operational data, will also be used.

The author identified factors that had the most significant impact on the questionnaire's development. When developing the questionnaire, we referred to the established methodologies used by previous researchers. Applying SEM to the interdependent variables is justified because it does not consider excessive multicollinearity. This survey will be disseminated to project stakeholders, including directly and indirectly involved individuals.

We will analyze the data using Structural Equation Modeling (SEM) with SMART PLS 3.0 software. Furthermore, we shall conduct interviews to acquire a more profound comprehension. By using this instrument, our objective is to discern the primary components and subordinate aspects that impact the cost-effectiveness of our study. SMART PLS is a widely renowned software used for scientific research data analysis.

Payments and Project Management

Late payments and related cash flow problems are common in the construction sector. Late payments increased by 27% in 2015, per the Euler Hermes Quarterly Overdue Payments Report. Construction firms and small and medium-sized businesses experienced average payment delays of up to 120 days, endangering the supply chain. The collapse of Carillion in January 2018 had a significant effect, endangering over 30,000 small businesses by potentially depriving them of payment. Despite efforts to address this issue, it underscored the ongoing necessity for improved measures [11] transparency and traceability of payments in the sector.

According to a piece written for Constructible, a website that shares construction knowledge, Blockchain technology can enhance efficiency and cost-effectiveness in this domain by implementing automated payments that rely on digitally verified work, contractual terms, and Smart Contracts. The ICE provides an example of a smart contract that records an employee's working hours and initiates automatic payments to illustrate this concept, as illustrated in Figure 4.

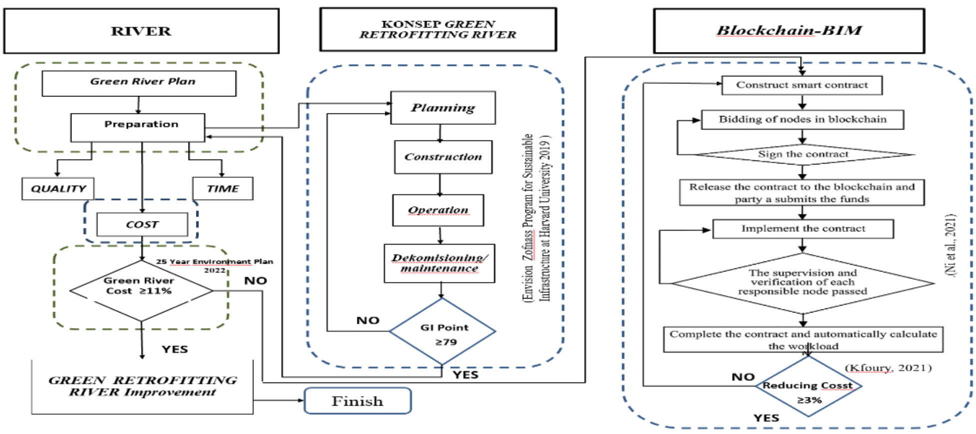

Figure 3. Research Implementation of Concept Green Retrofitting River

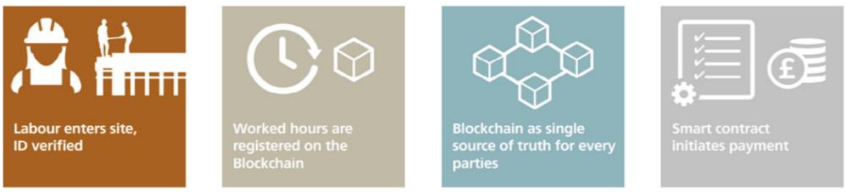

Figure 4. Smart Contract governed site working hours register and payment system

In the illustration mentioned above, the client, the consultant, and the contractor are all parties to a Blockchain [20], A logbook that documents the identities of individuals who entered and the duration of their on-site work. This obviates the necessity for additional administrative tasks. There should be no doubts or uncertainties when the Smart Contract initiates the payment according to the agreed-upon number of hours worked, as the blockchain provides a reliable and indisputable record of information. Blockchain enables real-time tracking of project expenditures and progress. A Smart Contract is fulfilled each time a goal or task is accomplished. Because payments [21] may be made in smaller sums, the cash flow is enhanced, and several administrative procedures and pieces of paper are eliminated. The model's ability to visibly display each Smart Contract's progress makes it possible to track development and expenditures more effectively.

RESULTS AND DISCUSSION

Case Study

The research was conducted at the Bekasi River flood control project in North Bekasi, Indonesia, as illustrated in Figure 5. The assessment yielded a score of 72 points, as per the planned assessment criteria in the planning stage. This indicates that multiple tasks in the building planning department still require completion and various enhancements to get a minimum score of 79 points.

The need to improve the condition of existing rivers due to dense population growth and poor river governance can be seen in the picture. The Envision Harvard concept is used based on Blockchain-BIM to improve the environmentally friendly and cost-effective Green River Retrofitting process.

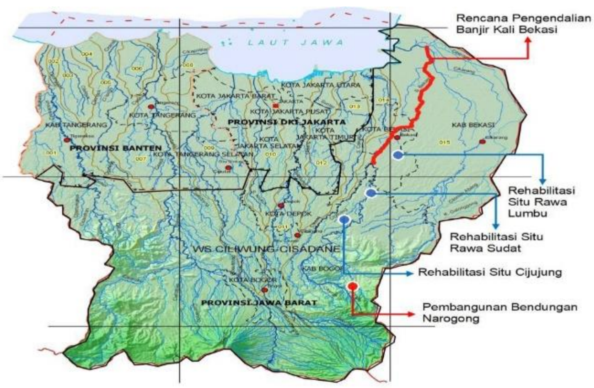

Figure 5. Geographic location of the study area in Bekasi Regency, Indonesia

In Figure 6, conditions Rivers are essential for creating awareness and community involvement in efforts to maintain environmentally friendly rivers to ensure the long-term sustainability of these water resources. This can also involve active participation from governments, environmental agencies, and non-governmental organizations in managing and protecting this river.

Questionnaire Analysis

One hundred nine individuals were surveyed using research questionnaires, surpassing the minimum threshold of 86 responders required for statistical analysis. The respondent data consists of the information collected from the participants.

According to the data, 89% of the respondents did not return 11%, as depicted in Figure 7. The respondents were categorized into different age groups: less than five years (37%), 5 to 10 years (35%), 10 to 15 years (20%), 15 to 20 years (4%), and below 20 years (4%), as depicted in Figure 5. Additionally, 38% of the participants have fewer than five years of experience, while the rest claimed to have 5 to 10 years of knowledge. 35% of the years fall within the range of 10 years. 20% of the years fall within the range of 10 to 15 years. 4% of the years fall within the range of 15 to 20 years. Another 4% of the years are under more than 20 years.

(a) (b)

Figure 6. (a) River Condition Existing & (b) Retrofit river condition

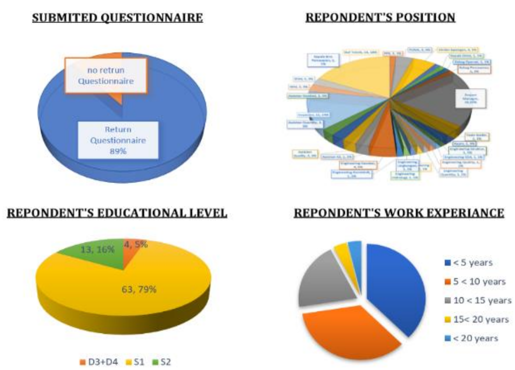

Figure 7. Respondent Data

Most respondents (79%) have a university degree, while the remaining individuals have a combination of CAPE, Master's, and Diploma qualifications as their highest level of education. Most of the sample is employed full-time and affiliated with a small to medium-sized organization of 4-13 employees. First, the technique involves running the SEM-PLS software for calculation. Convergent Validity analysis assesses how closely a measure is linked to other measures of the same construct [22]. The assessment utilizes Composite Reliability and Cronbach's Alpha as measurement techniques. Cronbach's alpha values are used to assess the internal consistency and reliability of the scales. All variables in the study's overall scale had reliability scores exceeding 0.6 [23].

A validity test is valid if the Average Variance Extracted (AVE) value exceeds 0.5. AVE values exceeding 0.5 suggest that the latent variable construct explains more than 50% of the variability in the indicators [24]. Reliability is assessed using two established criteria: Cronbach's Alpha > 0.7 and Composite Reliability > 0.7[25].

According to the data in Table 1, the AVE values for the latent and median variables are above 0.5, showing that the convergent variables are valid. Additionally, the Composite Reliability and Cronbach's alpha values are higher than 0.7, indicating that the instrument is reliable and meets the necessary criteria.

Evaluation of Measurement Models (Inner Loading – Bootstrapping)

The study was performed utilizing SEM SMART-PLS software version 3.0. The R-Square value, depicted in Figure 8, quantifies the combined impact on the Cost (Y) variable and is measured at 0.810. Furthermore, the value of the corrected R-Square is 0.810.

This indicates that the combined independent factors significantly impact 82.5% of the Cost (Y) variable. Given that the corrected R-square value exceeds the significance level of 50%, it can be inferred that all independent variables substantially impact the Cost (Y) variable.

We can identify the most influential components from the 150 sub-factors analyzed based on the questionnaire answers. Reviewing a structural model involves assessing collinearity among constructs and analyzing the model's prediction performance. Subsequently, additional metrics like the analysis utilize the coefficient of determination (R2), cross-validation redundancy (Q2), effect size (f2), and path coefficients. A positive value of Q2 suggests that the model has strong prediction capabilities. Relevance, Q2 < 0, indicates a lack of predictive relevance in the model.

The estimated route coefficients in the structural model are assessed for their robustness and statistical significance. A P-value less than 5% and a T-statistic greater than 1.96 are considered significant. A comprehensive examination is performed to analyze different elements' direct and indirect impacts utilizing the calibrated Structural Equation Modeling (SEM) model. [25]. The ten most influential criteria have been arranged in descending order, with the validation of Green River (Envision) being the most impacting factor, as depicted in Table 2.

Table 1. Results of construct reliability examination based on convergent validity

Main Factor	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
1. Cost (Y)	0.922	0.928	0.939	0.722
2. Blockchain-BIM (X3)	0.963	0.967	0.968	0.705
3. External (Y1.2)	0.883	0.884	0.945	0.895
4. Green River Retrofit (X2)	0.982	0.984	0.983	0.528
5. Internal (Y1.1)	0.882	0.888	0.920	0.742
6. Reliability In BIM (X3.1)	0.944	0.948	0.960	0.831
7. Technology Adjustment (X3.2)	0.958	0.972	0.967	0.791
8. Feasibility Study Stage (X2.1)	0.983	0.986	0.984	0.564
9. Decommissioning Stage (X2.2)	0.824	0.894	0.878	0.603
10.Implementation Stage (X1.3)	0.937	0.956	0.950	0.689
11. Auction Stage (X1.2)	0.821	0.850	0.879	0.649
12.Maintenance Stage (X1.4)	0.895	0.933	0.922	0.674
13. Planning Stage (X.2.1)	0.989	0.990	0.990	0.857
14.X.1 (River)	0.982	0.984	0.983	0.636

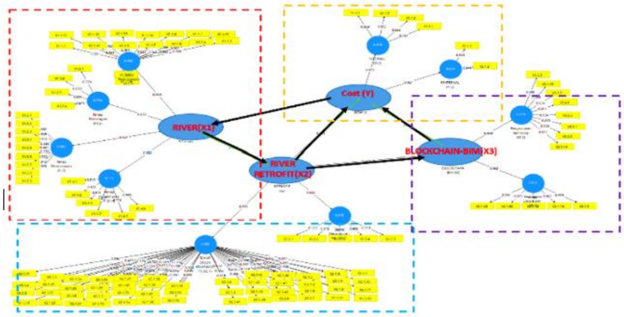

Figure 8. The diagram of p-values and partial coefficients

Table 2. The most influential sub-factor (significant)

No	Sub Factor		Original Sample Value	Mean	T.Statistic > 1.96 (p < 0.05)	R Square
1	Pollutant emission	X2.1.50	0.972	0.973	131.169	
2	Greenhouse gas emissions	X2.1.49	0.971	0.970	81.222	
3	Specification	X3.1.5	0.970	0.965	186.896	
4	Blockchain data sources	X3.2.4	0.965	0.965	70.077	
5	Project requirements	X3.1.1	0.964	0.966	157.585	
6	Term Of Reference (TOR)	X1.1.7	0.963	0.964	102.194	0.992
7	Professional role	X3.1.3	0.962	0.962	73.75	
8	Financing Planning (Budget)	X1.1.5	0.962	0.963	100.104	
9	Maintenance Operation Plan	X1.4.1	0.961	0.961	59.123	
10	Manage the heat island effect	X2.2.5	0.959	0.959	78.159	

Building envelope energy efficiency standards are designed to guide all parties involved in building design, development, maintenance, and operation to attain energy efficiency. Proper envelope design is one of the most critical factors in significantly reducing building energy use. In fact, heat loss via the building envelope accounts for more than half of the energy requirement for multipurpose buildings, a factor that is frequently disregarded.

Successful implementation of river conservation requires several essential elements, including planning the implementation of advanced and energy-efficient technologies, careful selection of machinery and infrastructure, and ensuring that the system operates efficiently. In reality, energy-saving projects usually consist of three main steps: planting trees around riverbanks, creating parks/landscapes, and building waste disposal facilities. Reduce greenhouse gas emissions.

Blockchain-BIM Dashboard Interface Design

Blockchain-BIM is essential in optimizing environmentally friendly green river buildings, reducing waste and pollution, and encouraging sustainable green rivers. User interface (UI) design is essential to Blockchain-BIM as it facilitates effective management by facility settings or administrators. To understand more about environmentally friendly green river design, this research conducted a benchmark study on fifteen selected papers [27, 28, 29, 30, 31, 32]

Researchers have tried to reproduce the application of blockchain-BIM by following the steps detailed on the previous page. They confirm the practicality of deploying the network on the backend, explicitly validating smart contracts integrated within the blockchain network throughout the simulation. We utilize Visual Studio Code as an integrated development environment (IDE) for blockchain-BIM simulation. It is a software application used for programming and developing software. Integrating functions such as editing, constructing, testing, and packaging software in a user-friendly application boosts productivity.

Figure 9 illustrates the outcome of enhancing the project's cost efficiency across all grades. For clarity, we have translated the whole budget for the plant project with Blockchain-BIM implementation into foreign currency units.

The evaluation results scored 72 points according to the planning stage of the assessment points. Several elements in the building planning section still need to be completed with different improvements to achieve a minimum rating of 79 points.

Table 3 shows the assessment stages of the case study, with four certification levels: Improved, Enhanced, Superior Conserving, and Restorative. Figure 10 shows the result of the BIM modeling process for Renewable Energy using Revit Software from Autodesk.

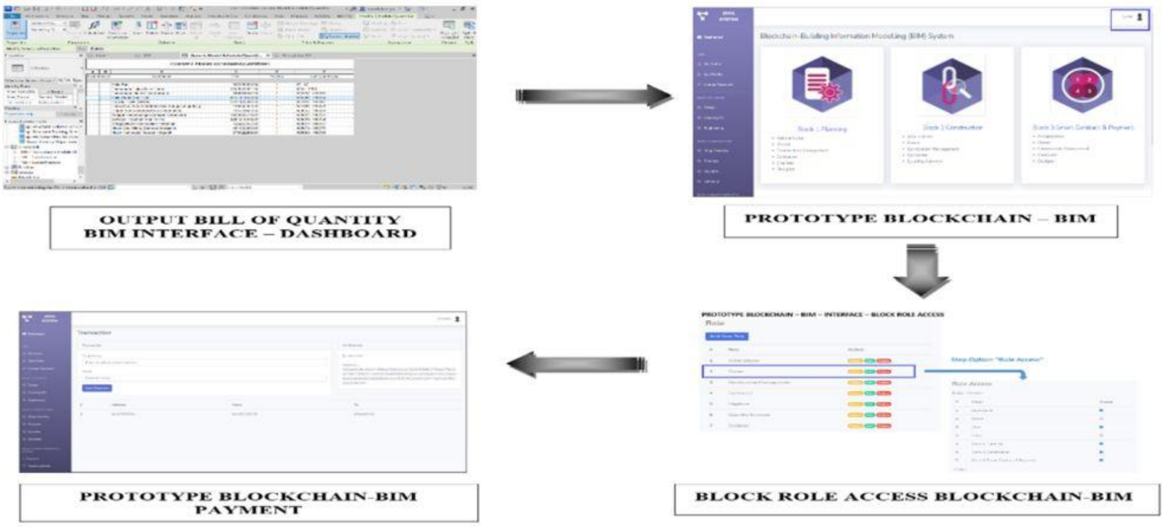

Figure 9. Prototype Blockchain–BIM Role Map

(a) Green River (b) Building Sewage Treatment Plant

Figure 10. Building Information Modeling (BIM) for Renewable Energy

Table 3. Work Improvement Cost Base on Green Retrofitting Assessment

No.	Work Item	Initial Cost Budget Plan (Non-River)	River Increasing Cost Budget Plan				
			Improved	Enhanced	Superior	Conserving	Restorative
1	SOP Management & Policy Document	62,931	106,163	106,163	106,163	106,163	106,163
2	Customization Planning Work	371,761	449,775	456,276	521,287	586,298	651,309
3	AreaMaintenance and Service Work	232,351	264,856	264,856	264,856	264,856	264,856
4	inspection of road works	1,194,578	1,194,578	1,194,578	1,194,578	1,194,578	1,194,578
5	Road and drainage works	960,607	960,607	960,607	960,607	960,607	960,607
6	River Protection Works	5,910,703	6,364,605	6,364,605	6,364,605	6,364,605	6,364,605
7	Landscaping Work	243,136	243,136	243,136	243,136	243,136	243,136
8	miscellaneous work						
	- Lighting	39,007	78,013	106,943	106,943	106,943	106,943
	- Temporary Garbage Shelter	780	1,950	3,949	1,609	1,609	1,609
	-Integrated garbage disposal site	-	-	-	7,151		8,296
	- Garbage Composter Building	-	-	12,092	18,593	18,593	18,593
	- Garbage Recycling Building	-	-	9,622	9,622	9,622	9,622
	- Garden Complementary Buildings	-	-			11,702	7,801
	TOTAL (USD)	**9,015,854**	**9,663,683**	**9,722,827**	**9,799,150**	**9,868,712**	**9,938,118**
	Deviation Cost Before Green Retrofitting – Become Green Retrofitting (USD)		**647,830**	**706,973.52**	**783,296.50**	**852,858.32**	**922,265**
	DEVIATION (%)		**6.70%**	**7.27%**	**7.99%**	**8.64%**	**9.28%**

Table 4. Improvement Cost Performance for Green Retrofitting Cost using Blockchain-BIM

No.	Work Item	Initial Cost Budget Plan (Non-River)	Blockchain BIM Cost Reduction				
			Improved	**Enhanced**	**Superior**	**Conserving**	**Restorative**
1	SOP Management & Policy Document Work	62,931	102,978	100,855	100,855	100,855	99,050
2	Customization Planning Work	371,761	436,281	433,462	495,222	556,983	607,671
3	AreaMaintenance and Service Work	232,351	256,911	251,614	251,614	251,614	247,111
4	Relocation and inspection of road works	1,194,578	1,158,741	1,134,849	1,134,849	1,134,849	1,114,541
5	Road and drainage works	960,607	931,789	912,577	912,577	912,577	896,246
6	River Protection Works	5,910,703	6,173,667	6,173,667	6,173,667	6,173,667	6,173,667
7	Landscaping Work	243,136	235,842	230,979	230,979	230,979	226,846
8	miscellaneous work		-	-			-
	- Lighting	39,007	65,011	101,596	101,596	101,596	99,778
	- Temporary Garbage Shelter	780		3,752	1,529	1,529	1,501
	- Integrated garbage disposal site	-	-	-		-	7,740
	- Garbage Composter Building	-	-	11,487	17,664	17,664	17,347
	- Garbage Recycling Building	-	-	9,141	9,141		8,977
	- Garden Complementary Buildings	-	-	-	-		7,279
	TOTAL (USD)	**9,015,854**	**9,361,219**	**9,363,978**	**9,429,691**	**9,482,311**	**9,507,755**
	Deviation Cost Before Green Retrofitting – Become Green Retrofitting (USD)		**345,366**	**348,124**	**413,837**	**466,457**	**491,901**
	Deviation (%)		**3.69%**	**3.72%**	**4.39%**	**4.92%**	**5.17%**

The cost component can be succinctly described as a compilation of many tasks, ranked in order of their contribution to the adoption of renewable energy, with the most significant tasks listed first. Alternatively, one might consider applying cost reduction measures, but assessing the efficiency in relation to the demand and the supplementary structures for garbage recycling and landscaping is crucial.

The literature study obtained for previous research [30, 31, 32, 33] shows that several green river studies have been conducted using ENVISION guidelines. However, blockchain-BIM has yet to be available to streamline green retrofitting costs worldwide. So, the novelty of this research is improving the cost performance of green retrofitting with ENVISION guidelines on blockchain-BIM-based rivers, which is the first research in the world, as listed in Table 4.

CONCLUSION

The authors declare no conflict of interest. In this study, referring to a concept from Harvard University's ENVISION guidelines, we examine the cost-benefit ratio of converting an existing river with undeveloped greenery into an eco-friendly river. As part of Harvard University's ENVISION, a review process is underway for green rivers providing commercial support buildings and support buildings related to green area planning and reproduction, such as Solar panel public lighting, waste storage area, sewage treatment plant, landfill building, waste recycling building, beautiful green garden. One of the problems encountered in implementing the green concept, such as carbon sequestration, lighting, Conservation, and reuse of rivers, caused an increase in green building costs (renovation costs), an increase of 9.27%. Based on the assessment results, all papers are rated 9.27% or more, so some opinions must be corrected. Renovation costs can be reduced by leveraging the Blockchain-BIM approach. After the introduction of the blockchain-BIM, every kind of innovation costs were reduced. For each rating, the Increase in green building costs from the current rating to the leading rating is 6.70% (down 3.69%) Increase, 7.27% (decrease of 3.72%) Increase, 7.99% (decrease 4, 72%), 39%) Continuation, 8.64% (down 4.92%) Conservation, 9.28% (down 5.17%) Recovery. The claims show that this process reduces the cost of implementing a Blockchain-BIM by more than 3%. Due to technological constraints, the researchers in this study found it difficult to start creating intelligent application contracts on the Blockchain network. Creating applications based on Blockchain-BIM has repeatedly disappointed researchers. So that this method can be immediately developed and used in the future, research must be carried out, and similar work must be carried out with Blockchain-BIM practitioners. It can help with assessments so that green rivers in Indonesia can more optimally help river governance in Indonesia in a cost-effective and environmentally friendly manner. Pushing the adoption of Blockchain-BIM would be digital software.

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