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Feasibility Assessment of Construction 4.0 Technology Investment: Drones, Building Information Modeling (BIM) and Virtual Reality (VR)

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ABSTRACT

Construction 4.0 technology is an anticipation of the challenges of quality improvement in the construction industry. However, its implementation has not been simultaneous with an evaluation of the benefits and value of investment. For this reason, this research evaluates the benefits and investment feasibility of construction 4.0 technology on 36 projects of the Indonesian construction state-owned enterprise (SOE), PT. XYZ Persero Tbk. during 2020-2022 for Drones, Building Information Modeling (BIM) and Virtual Reality (VR) as individually and integrated. Based on evaluation data on the use of technology and financial data from technology investments obtained, this research quantitatively calculates the value of the benefits of increasing productivity and then calculates the financial evaluation using the Return on Investment (ROI), Net Present Value (NPV), Internal Rate of Return (IRR) and Benefit-Cost Ratio (BCR) methods and implies those results qualitatively. As a result, individually, BIM is the technology that contributes the most in terms of benefits, VR contributes well in terms of investment value, while drones still have development potential. Integration between technologies is still challenging where the use of technology simultaneously does not guarantee significant integration between the three technologies reviewed in this research.

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1. Introduction

The development of construction technology in the industrial era 4.0 is anticipated to overcome various problems in the construction process [1]. The use of technology has been recognized in the construction sector since the Construction 2.0 era when technological developments in the construction and industrial sectors developed simultaneously. In that era, heavy machinery such as excavators and bulldozers assisted the construction process. Furthermore, in the era of Construction 3.0, computer technology began to be widely used as software to support construction projects, until the latest development, Construction 4.0 [2], [3]. Construction 4.0 combines digitalization and automation of construction projects [4], [5]. Some examples of technology that have been deployed include Drones, Virtual Reality (VR), Building Information Modeling (BIM), Artificial Intelligence (AI), etcetera [6]–[8].

Table 1. Types of Construction 4.0 Technology [9]

Group	Technology	Description
Reality Computing Technology	Unmanned Aerial Systems (Drones)	Deployed to take pictures/video from a certain distance
	Laser Scanners	The technology used to obtain real data and conditions in the field, both in terms of quantity and quality.
	Rovers	Machines equipped with high-resolution cameras and recording sensors can navigate construction sites
	360-degree Technologies	A tool for taking pictures using a 360-degree camera
Visualization Technologies	Virtual Reality (VR)	Technology that uses computers to create an environment that can give users a real sensation because they can see and walk around building models
	Augmented Reality (AR)	Technology that can move digital information to the project location in real-time
	Mixed Reality (MR)	Technology that combines virtual with real environments
	Digital Twins (DT) – Building Information Modeling (BIM)	Approaches that use digital models to plan, design, and manage construction projects and concepts that create digital copies of physical buildings or infrastructure
Automation Technologies	Robotic System	Machines that are designed to act automatically.
	Additive Manufacturing (AM) / 3D Printing	A technology that works like a "printer", to convert digital information (3D models) into the physical form of a building.
	Prefabrication and Modularization	A factory-made component or material that can be installed or assembled at the project location.
	Autonomous Equipment	Vehicles or equipment that are programmed so that they can operate automatically without human assistance.
Intelligent System	Internet of Things (IoT)	A system where the internet will be connected to the real world through sensors spread across various locations.
	Artificial Intelligence (AI)	A system created to be able to capture and analyze large amounts of data and determine patterns and trends that occur
	Cloud Computing	A system that uses the internet as a place to store data and applications, thereby reducing the use of physical storage media, and can guarantee data security
	Big Data	A medium for storing large amounts of data, and can also function to make assessments and provide appropriate decisions based on the data held.
	Generative Design	The design exploration process uses computational analysis to produce different design possibilities according to given constraints such as material type, shape, etc.
	Radio Frequency Identification Device (RFID)	A wireless system to detect the location and report the condition of a physical asset or labour.
	Wearable Sensors	Technology combined with a device that can be worn on the human body to monitor the user's health condition.

A notable case of the application of construction 4.0 technology integration can be seen in the "Wuhan Leishenshan Hospital" project. First, the drone is applied to gather data and information and operate as a project site inspector. The information is automatically saved in the Cloud and processed to support project implementation using Tekla (BIM software) [10]. An example of the application of Construction 4.0 technology in Indonesia is the construction of the Jakarta-Bandung high-speed railway infrastructure, which uses BIM and drone technology to monitor construction projects and prefabricate railway components such as columns, concrete beams and bridges [11], [12]. Overall, implementing those technologies will provide more advancement in the construction sector and boost efficiency and productivity, especially in integrating a series of technologies [9], [13]. The types of construction 4.0 technology applied to the construction sector can be seen in Table 1.

Until now, the main challenges and success of construction projects have depended heavily on the planning and control of costs, quality, and time by construction management [9], [14]. In Indonesia, around 30% of construction projects experience delays in completion, with an average delay of 4-6 months [15]. During the construction process, various types of problems are often encountered which have an impact on reducing productivity because of factors related to the workforce, such as training, experience, educational background, talents and interests, analytical abilities, technical skills, health, energy and physical characteristics of workers [16]. Apart from that, the availability and capability of tools during the construction process determine the quality of the construction itself by assessing its effectiveness and productivity [17]. Indonesia's construction productivity also tends to decline because construction projects in Indonesia still tend to use conventional construction methods [18], which cause about 10% of materials to be wasted, 40% of projects to be over budget, 30% of projects to be reworked, and almost 90% of projects to be delayed [19]. Therefore, to overcome these challenges in the Indonesian construction sector, the implementation of Construction 4.0 technology is necessary.

Construction technology in Indonesia has begun to be implemented, especially in Indonesian construction state-owned companies (SOEs) [18]. However, the benefits of increasing productivity through construction technology need to be assessed, and investments need to be evaluated. Theoretically, the implementation of technology has quite a significant impact even though it requires considerable expensive investment costs. Successful investment in the use of construction technology requires analysis by comparing the benefits and costs of the initial investment [20]. Meanwhile, it is recognized that the internal evaluation carried out by construction companies needs to be more comprehensive, and it is suspected that its implementation is forced due to regulatory demands or the demand from the project owner.

This research evaluates the benefits of using construction technology on productivity and assesses technology investment in Indonesian SOE, PT. XYZ Persero Tbk. including Drones, BIM, and VR. Evaluation of benefits and investment feasibility is proposed from two points of view, namely per-technology and technology integration analysis. To the best of the researcher's knowledge, this is the first research in Indonesia related to the analysis of benefits evaluation on productivity and investment evaluation of construction technology 4.0. Thus, this research is expected to provide up-to-date information and encourage stakeholders in the construction industry in Indonesia to implement the right construction process.

2. Method

This research is a mixed methods study between quantitative and qualitative research approaches in one study [21], [22]. An overview of the concept of thinking that emerged from this research is shown in Fig. 1.

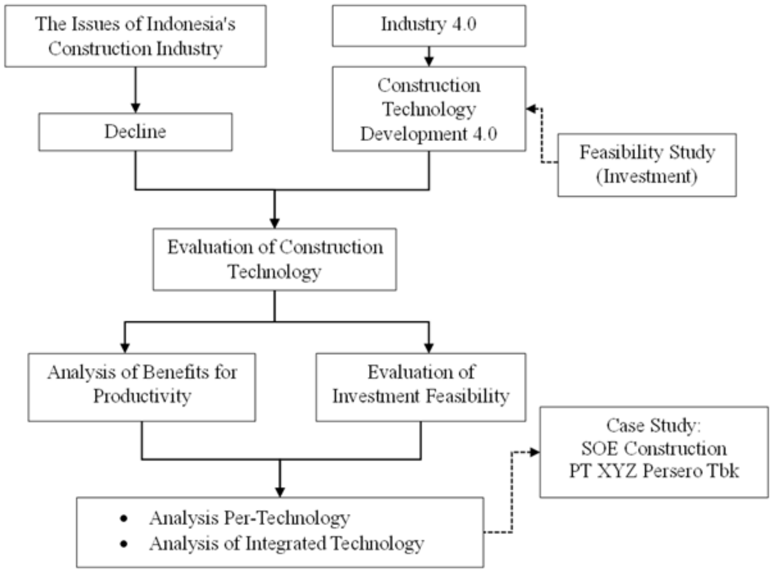

Fig. 1. Research Framework

As shown in Fig. 1, this research began with a preliminary study of the issues occurring in the Indonesian construction industry. In addition, the researcher attempted to explore the potential use of technology in addressing these construction issues based on a literature review. This research was conducted on 36 active building construction projects of PT. XYZ Persero Tbk. in the 2020-2022 period. PT. XYZ Persero Tbk. has required construction technology implementation in all its projects, especially on projects with a contract value of more than Rp. 200 billion. Each project has used construction 4.0 technology, among others, Drones (18 Projects), BIM (36 Projects), and VR (9 Projects). The feasibility analysis of those three technologies (Drones-BIM-VR) was carried out in two parts, partially per technology and integrated among that technology. The technology integration reviews were carried out on nine projects that had implemented those three technologies together.

2.1. Analysis of Benefits to Productivity

The productivity analysis reviewed and summarized from the report on the construction 4.0 technology application in the Cloud database platform of PT. XYZ Persero Tbk., would be used to determine the construction activities that were affected by the implementation of construction technologies (Drones, BIM, and VR). Then, data recapitulation was carried out in two parts, namely, recapitulation of technology use separately and integration of technology—for example, BIM implementation in the project of building X, which accelerated ten construction activities. For instance, the process of structural quantity recalculation, which manually took seven days, was accelerated to 3 days with the BIM. Such data was recorded as 57.14% of the value of benefits. Thus, detailed calculations were carried out on the value of the benefits of each technology used in each review project and summarized in Tables 2, 4, 6 and 8.

2.2. Analysis of Investment Feasibility

Evaluation of technology investment using PT XYZ Persero Tbk. investment data combined with a literature study to identify the comparison of cost and benefit components of the construction project. Feasibility evaluation was conducted through the financial analysis of investments using construction 4.0 technology as primary data. A few notable assumptions based on the Indonesia Central Bank regarding the interest rate are Indonesia's average inflation rate in 2020-2022 (2.60%) and the Central Bank's (BI) average interest rate in 2020 (3.75%) as the basis for analysis. The evaluation methods used include Return On Investment (ROI), Internal Rate of Return (IRR), Benefit Cost Ratio (BCR) and Net Present Value (NPV). The Cash Flow Diagram (CFD) for each analysis was composed to facilitate the calculation and analysis of the construction 4.0 technology investment feasibility (Fig. 2 - Fig. 5).

2.2.1. Return On Investment (ROI)

ROI is a ratio used to evaluate the efficiency or profitability of an investment. The higher the ROI value, the more profitable the investment. The ROI calculation in this research uses an inflation interest rate assumption of 2.60%. The ROI can be obtained using the formula [23]:

$$ROI = \frac{Net\ Benefit}{Initial\ Cost} \tag{1}$$

2.2.2. Net Present Value (NPV)

NPV is a method for measuring the present value of the expected net cash flow from an investment. Positive NPV shows that the investment generates profits. The NPV calculation in this research uses an inflation interest rate assumption of 2.60%. With i as the discount rate and t as the time of the cash flow, the equation used to calculate NPV is as follows [24]:

$$NPV = \sum_{t=1}^{n} \frac{Benefit - Cost}{(1+i)^t} \tag{2}$$

2.2.3. Internal Rate of Return (IRR)

IRR is the rate of return or interest rate that makes the present value of an investment's net cash flow equal to zero. The IRR calculation in this research uses the assumption of a comparative interest rate, namely the BI interest rate of 3.75%. If the IRR is higher than the rate of return or interest rate, then the project is considered feasible.

2.2.4. Benefit Cost Ratio (BCR)

BCR is a ratio that compares the net benefits at the cost of a project or investment. If BCR is more than 1, it indicates that the benefits of the project exceed its costs. The BCR calculation in this study uses an inflation interest rate assumption of 2.60%. The BCR formula is as follows [25]:

$$BCR = \frac{Total\ Benefit}{Total\ Cost} \tag{3}$$

3. Results and Discussion

3.1 Assessment of Drones

3.1.1 Benefits of drone on productivity

Table 2. Summary of drone benefits in PT. XYZ Persero Tbk.

No	Activity	Average value of benefit	Position during the construction phase		
			Planning	Implementation	Evaluation and supervision
1	Work progress documentation	4%	√	√	
2	Project inspection and monitoring costs	41%		√	√

Table 2 presents the recapitulation of drone performance from 18 projects. This result could be more optimal because drones only provide two benefits, namely, as a documentation tool for updating work progress and project inspection and monitoring. Drones can also be used for the mapping process in the project planning phase for their ability to produce images with high resolution [26], [27]. High image quality produces obvious location details, making it easier to collect data that supports detailed construction planning and efficiency. Therefore, increasing the benefits of drones is highly recommended following the results of previous research [28], which states that the potential for drone use in Indonesia can still be improved further, especially in the aspect of integration with other technologies, especially BIM.

3.1.2 Feasibility of drone investment

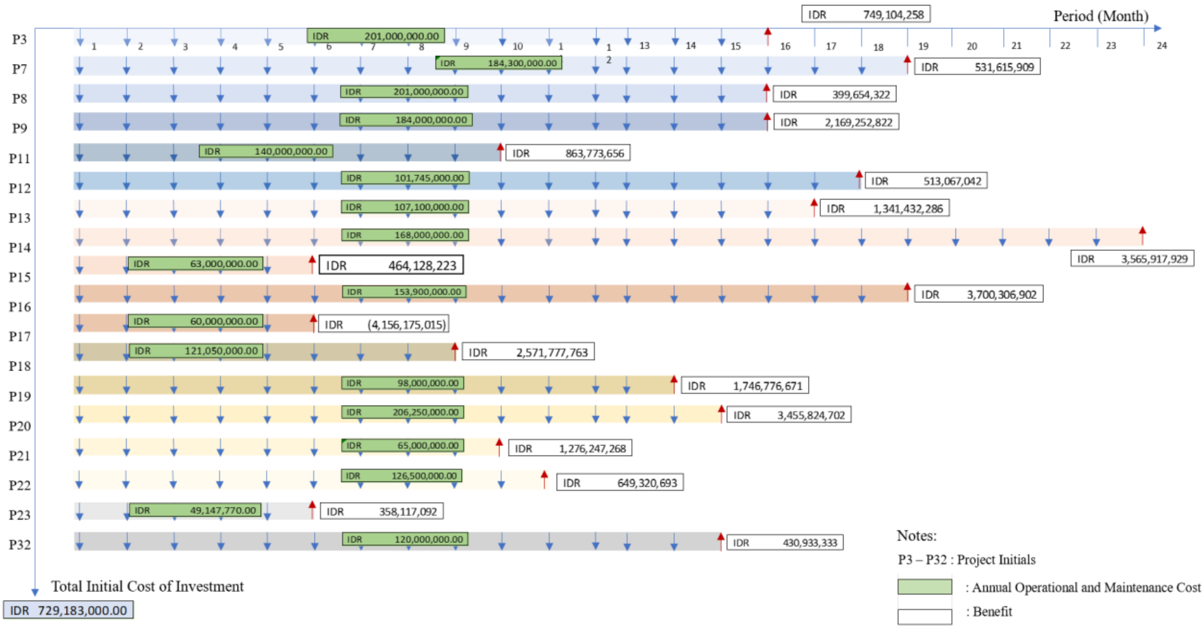

Fig. 2. Cash flow diagram of drone investment in PT. XYZ Persero Tbk.

The cash flow diagram as shown in Fig. 2, shows the cash flow in drone construction investments in PT. XYZ Persero Tbk. with a construction period from 2020 to 2022, reaching 18 of 36 review projects. The project's duration ranges from 6 to 24 months. Total investment costs for the 18 construction projects amounted to IDR 729,183,000, assuming the benefits of technology investment recorded at the end of each project's period. Fig. 2 presents more details of investment, operational and maintenance costs and benefits.

Table 3. Feasibility of drone investment

Indicators	Value	Description
ROI	5.18%	The rate of return on investment is greater than the predetermined inflation rate assumption.
NPV	IDR 3,781,238,205	A positive NPV value indicates that this investment generates profits at that investment time.
IRR	0.5%	The IRR value is inadequate to exceed the set interest rate.
BCR	1.33	The benefits are greater than the investment costs.

Based on Table 3, the ROI calculation results show a positive figure of 5.18%, indicating that investment in drones is feasible because it produces higher profits than inflation interest rates. The results of the NPV calculation also support this conclusion, with a total profit of IDR 3,781,238,205 which shows that this investment generates profits after considering the initial investment costs and expected future cash flows. However, it is worth noting that the IRR only stands at 0.5%, which needs to be higher to match or exceed interest rates. However, the BCR reached 1.33, indicating that the benefits generated exceed the investment costs. Thus, investment in drones individually requires more consideration, for example, by first increasing the benefits aspect of their productivity to increase their investment feasibility.

3.2 Assessment of Building Information Modeling (BIM)

BIM has been used in all projects in PT. XYZ Persero Tbk. BIM itself is used in all construction phases namely planning, implementation, and inspection and maintenance.

3.2.1 Benefits of BIM on productivity

Table 4. Summary of BIM benefits in PT. XYZ Persero Tbk.

No	Activity	Average value of benefit	Position during construction phase		
			Planning	Implementation	Evaluation and supervision
1	Acceleration of quantity recalculations by contractor	41.5%	√		√
2	Acceleration of approval material by supervisor	38.99%	√	√	
3	Material savings	8.17%	√	√	
4	Work safety	49.3%		√	
5	Request for information process	36.4%		√	√
6	Clash detection coordination	53.85%	√	√	√

Based on Table 4, As a result of recapitulation of the use of BIM, there are six benefits obtained, including the process of volume recalculating by the contractor at the beginning of the construction phase is almost two times faster. Acceleration of contractor material approval by consultants by 38.99%, contribution to material savings to reduce waste by 8.17%, contribution to reducing the risk of accidents at work by 49.3%, acceleration of the Request for Information (RFI) process between stakeholders by 36.4%, and increased ease of coordination in the event of a conflict by 53.85%. The use of BIM increases the project efficiency. BIM also contributes at every stage of PLC in the construction stage. The lowest BIM contribution is waste reduction or material savings by only 8.17%. However, based on this analysis, BIM is considered to contribute to the construction project implementation process.

3.2.2 Feasibility of BIM Investment

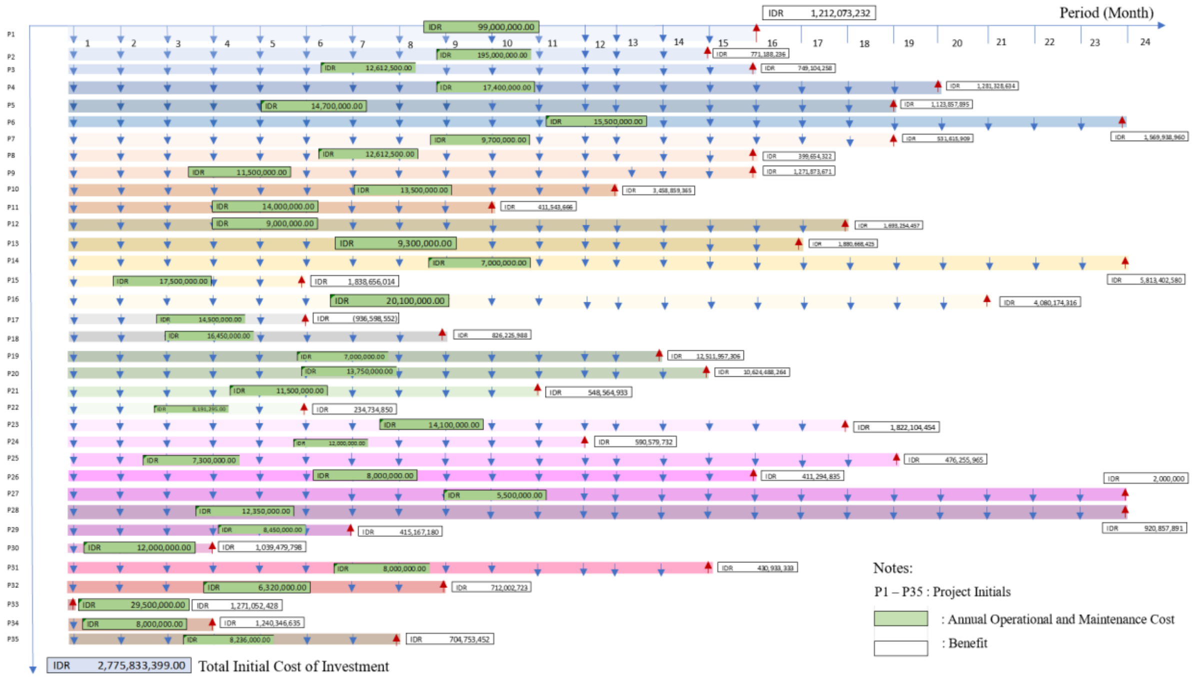

Fig. 3. Cash flow diagram of BIM investment

Fig. 3 shows the cash flow pattern in BIM technology investment in the PT. XYZ Persero Tbk. from 2020 to 2022, reaching 36 projects. The duration of the construction project ranges from 4 to 24 months. The total BIM investment cost for the 36 construction projects is IDR 2,775,833,000, assuming the value of the benefits of technology investment is calculated at the end of each project's implementation period. Details of investment, operational and maintenance costs and benefits are presented in Fig. 3.

Table 5 Feasibility of BIM investment

Indicators	Value	Description
ROI	12.59%	The rate of return on investment is greater than the assumed level of inflation rates that have been set.
NPV	IDR 34.937.096.940	A positive NPV value indicates that this investment is profitable based on the initial investment costs and expected future cash flows
IRR	0.91%	The IRR value is insufficient to match or exceed the applied interest rate.
BCR	7.13	The resulting benefits are greater than the investment costs

Based on Table 5, the ROI calculation results show a positive number of 12.59% signaling that investment in BIM technology is considered feasible because it produces higher profits than inflation interest rates. The NPV calculation results also support this conclusion, with a total profit of IDR 34,937,096,940 which indicates that this investment is profitable based on the comparison of the initial investment costs and expected future cash flows. However, it is worth noting that the IRR only stands at 0.91%, which is insufficient to match or exceed interest rates. Despite this, the BCR reached 7.13 showing that the benefits generated are greater than the investment costs. The results of this analysis show the major contribution of BIM at the construction stage. The key to the proposed development lies in the challenge of integrating BIM with other technologies to increase the level of digitalization and advanced integration.

3.3 Assessment of Virtual Reality (VR)

3.3.1 Benefit of VR on productivity

Table 6. Summary of VR benefits in PT. XYZ Persero Tbk.

No	Activity	Average value of benefits	Position during construction phase		
			Planning	Implementation	Evaluation and supervision
1	Reduction of defect design	29.47%	√	√	√
2	Accelerated of approval material	45.86%	√	√	
3	Reducing the risk of work accidents	42.5%		√	

Table 6 is a summary of the benefits of VR. Firstly, contractors can detect design errors from virtual project visualizations via VR, this can minimize design defects amounting to 29.47%. Secondly, digital project visualization via VR allows stakeholders to easily identify and determine the type of material used in the project, speeding up the material approval process by 45.86%. Thirdly, contractors can simulate the project environment before the project is undertaken, allowing them to identify areas that have the potential to cause workplace accidents, thereby anticipating and minimising the risk of workplace accidents by up to 42.4%. However, VR requires a digital design of the project or building first to be able to visualize the project's environmental conditions, therefore the use of VR relies heavily on a digital model from BIM to maximize its potential.

3.3.2 Feasibility of VR Investment

The cash flow diagram as shown in Fig. 4 shows the investment pattern of VR technology at the PT XYZ Persero Tbk. with a construction period from 2020 to 2022, reaching 9 of the totals of 36 projects. The project's duration ranges from 6 to 24 months. The total VR investment cost for the 9 construction projects is IDR 264,855,000 assuming the value of the benefits of technology investment is calculated at the end of each project's implementation period. Details of investment, operational and maintenance costs as well as profits can be seen in Fig. 4.

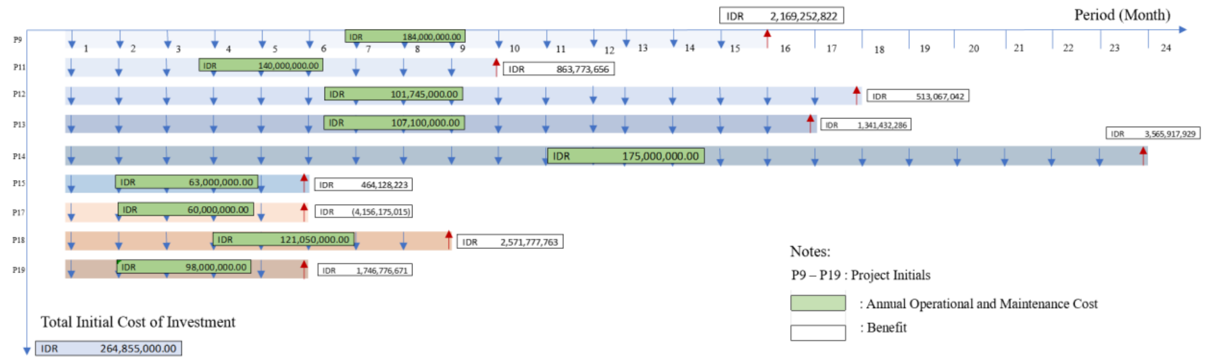

Fig. 4. Cash flow diagram of VR investment

Based on Table 7, the ROI calculation results show a positive figure of 8.02%. This indicates that investment in VR technology is considered feasible because it produces profits that are higher than inflation interest rates. The NPV calculation results also support this conclusion, with a total profit of IDR 2,124,795,737 which indicates that this investment is profitable after taking into account the initial investment costs and expected future cash flows. The IRR only reached 0.59%, which is lower than interest rates. The BCR value reached 1.36, indicating that the benefits generated are greater than the investment costs.

Table 7. Feasibility of VR investment

Indicators	Value	Description
ROI	8.02%	The rate of return on investment in using VR technology is greater than the assumed level of inflation interest rates that have been set.
NPV	IDR 2,124,795,737	A positive NPV value indicates that this investment is profitable based on the initial investment costs and expected future cash flows.
IRR	0.59%	If the IRR value is lower than the interest rate, the investment is feasible and can produce good returns.
BCR	1.36	The resulting benefits are greater than the investment costs

In general, VR performs well in terms of benefit calculation and investment evaluation. However, it is necessary to understand the relationship between VR and digital technologies such as BIM to maximise its potential.

3.4 Assessment of Integrated Technology (Drones-BIM-VR)

Nine projects successfully implemented three construction technologies, namely Drone, BIM, and VR during the construction phase. The following is an analysis of the impact of combining these three technologies on each review project, as well as a discussion of the investment evaluation.

3.4.1 Benefits of integrated technology on productivity

According to Table 8, out of the 16 construction projects that have implemented three of the Construction 4.0 technologies, the combined use of Building Information Modelling (BIM) and Virtual Reality (VR) has had the most significant impact during construction. BIM and VR were found to be simultaneously involved in six of the eight benefit factors, including volume calculation, accelerated material approval, material savings, occupational safety, coordination of clash detection and reduction of design defect. However, all three technologies, namely BIM, VR, and drones, were involved in various stages of the construction individually. Among these technologies, BIM had the most significant contribution, with five factors carried out, particularly on risk reduction of clash detection, amounting to 54.4%. In contrast, drones only had an impact on two factors, mostly on project inspection and monitoring, which can save costs by 50%.

Table 8. Summary of Drone-BIM-VR benefits in PT. XYZ Persero Tbk.

No	Activity	Average Value of Benefit	Technology			Position during construction phase		
			BIM	VR	Drone	Planning	Implementation	Inspection and maintenance
1	Acceleration of Volume Recalculations	18.3%	√			√		
2	Accelerated Approval Materials	47.5%	√	√		√		
3	Material Savings	24.03%	√			√	√	
4	Work Safety	47.42%	√	√			√	
5	Coordination Clash detection	54.4%	√			√	√	√
6	Reduction Design Defect	28.75%		√		√	√	√
7	Documentation Services	10%			√		√	
8	Inspection and Monitoring Costs	50%			√		√	

Table 8 also reveals that even when a project employs all three technologies, there are no activities that can involve all the technologies at the same time except for BIM and VR. These two technologies were found to be used in two factors, namely accelerated material approval and reducing the risk of work accidents. The combined use of BIM and VR was able to speed up the approval process by 47.5%, whereas in reducing the risk of work accidents, BIM and VR were able to reduce the risk by 47.42%.

3.4.2 Feasibility of integrated technology investments

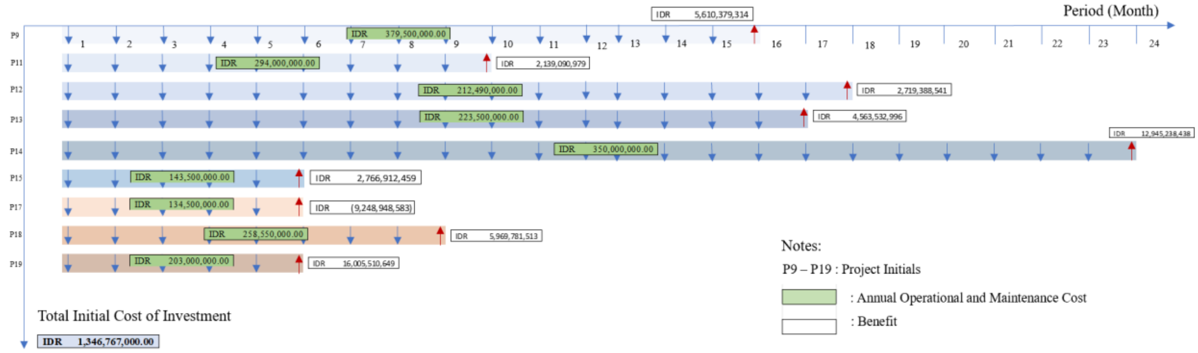

Fig. 5. Cash flow diagram of integrated technology investment

The Cash Flow Diagram in Fig. 5 shows the number of projects that implemented Drone, BIM, and VR on each of those nine projects during 2020-2022. Each project duration ranges from 6 to 24 months. The total technology investment of the nine construction projects is IDR 1,346,767,000 assuming that the benefit is calculated at the end of each project's period. The details of investment, operational and maintenance costs, and profits are presented in Fig. 5.

Table 9. Feasibility of integrated technology investment

Indicators	Value	Description
ROI	15.60%	The rate of return on investment in the use of technology integration between technologies is greater than the assumed level of inflation interest rates that have been set
NPV	IDR 21,007,665,563	A positive NPV value indicates that this investment is profitable after considering the initial investment costs and expected future cash flows
IRR	0.88%	The IRR value is not high enough to match or exceed the applied interest rate.
BCR	2.71	The resulting benefits are greater than the investment costs

Based on Table 9, the ROI calculation results show a positive figure of 15.6%, indicating that the investment in the three technologies reviewed is feasible because it produces higher profits than the inflation interest rate. The NPV calculation results also support this conclusion, with a total profit of IDR 21,007,665,563 showing that this investment generates profits after considering the initial investment costs and expected future cash flows. However, the IRR only reached 0.88%, lower than the benchmark interest rate. The BCR value reached 2.71, indicating that the investment generates higher benefits than the costs. Overall, investment in these three technologies shows excellent potential, with the consideration of the IRR value. However, the integration of these three technologies is still not optimal, as the direct relationship between the technologies only exists between BIM and VR. Therefore, it is highly recommended to develop the integration of drones with two other technologies and improve the sophistication of the integration between technologies to increase the benefits [29], [30], especially for the future trends of construction technology integration [31], [32].

4. Conclusion

This research regarding the benefits of increasing productivity and investment evaluation of three Construction 4.0 technologies (Drones, BIM, VR) in an Indonesian construction SOE (PT. XYZ Persero Tbk.) concludes some critical points:

Individually, BIM is the technology that provides the most beneficial contribution to the construction implementation process with six benefits, including accelerating work volume calculations, work and material approval, material savings, reducing the risk of work accidents, accelerating the RFI process, and coordinating clash detection. This condition is in line with the results of the BIM investment evaluation, which is considered profitable, but only with the caveat that the IRR value needs to be considered. VR contributes to three benefits: detection of design errors, acceleration of the material approval process, and simulation of the project environment to reduce the risk of accidents. The investment evaluation is also good. However, due to its nature as a visualization technology, VR cannot operate alone without input from digital technology such as BIM, so direct and indirect integration is necessary. Of the three technologies reviewed in this research, drones are the technology that still keeps its most significant potential for development. The benefits of using drones can still be developed, especially if they are integrated with BIM to increase the investment value simultaneously.

Based on an analysis of 9 projects that have used the three technologies together, the evaluation results are generally considered quite good. The three technologies impact accelerating volume calculations, accelerating material approval and material savings, increasing work safety, accelerating clash detection coordination, reducing the risk of design defects, and reducing documentation inspection and monitoring costs. The evaluation of the investment value is also quite good, except for the IRR value. However, in closer detail, the actual integration only occurs between BIM and VR, specifically in accelerating material approval and reducing the risk of work accidents. These two technologies are also dominant, contributing six of the eight benefits of using three technologies together. This result shows that the use of construction technology simultaneously does not guarantee good integration, so this needs to be paid attention to for further development, especially by construction practitioners and academics in Indonesia.

Recommendation

This research has successfully demonstrated how to assess the feasibility of investing in and deploying Construction 4.0 technology in Indonesia, specifically at the state-owned construction company PT. XYZ Persero Tbk. The evaluation results based on the profit variables, ROI, NPV, IRR and BCR show good results. However, in some parts, improvements need to be made to maximize the potential benefits of each technology. Regarding the integration between the reviewed technologies (Drone-BIM-VR), there is still a need to improve the relationship between technologies, especially for Drones. This result should give optimism to researchers and practitioners in the Indonesian construction sector to further increase the use of Construction 4.0 technology to increase productivity and progress in the construction sector. However, this research was only limited to PT. XYZ Persero Tbk. and only reviews three types of related technologies (Drones, BIM and VR). The data used is also secondary data collected from the reviewed companies. For this reason, there is still considerable scope for further research on other companies or projects, examining different types of technology as shown in Table 1 and using observational data in the field to obtain more detailed and concrete results. Researchers also consider it necessary to develop research related to comparisons between assessing the feasibility of using and investing in Construction 4.0 technology in Indonesia and abroad, to obtain benchmarks for technology implementation in Indonesia. In addition, several important issues that accompany technological developments, such as labour and sustainability, are also critical to further understanding and maturing the use of Construction 4.0 technology in Indonesia.

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