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To cite this article:

Pratama AA, Nuriqmar TH, Theodora M, Ariyanto B, Ramadhana R (2024). Competency Management and Green Economy Education in the Field of Civil Engineering: A Traffic Project-Based Approach. *Jurnal Pendidikan Teknik Sipil*, Vol 6 (2), Pp 96-106. doi: [10.21831/jpts.v6i2.78481](https://doi.org/10.21831/jpts.v6i2.78481)

To link to this article:

<http://doi.org/10.21831/jpts.v6i2.78481>





Research paper

Competency Management and Green Economy Education in the Field of Civil Engineering: A Traffic Project-Based Approach

Aldi Adi Pratama^{a*}, Tgk Harmen Nuriqmar^a, Maria Theodora^a, Bintoro Ariyanto^a, Rakha Ramadhana^b

^a STIE Bhakti Pembangunan, Master of Management Education Program, Postgraduate Program, Indonesia

^b National Taiwan University of Science and Technology, Taiwan

*Corresponding Author: aldiadipratama20839aldi@apps.ipb.ac.id

ARTICLE INFO

Article History:

Received: October 20, 2024

Accepted: November 29, 2024

Published: November 30, 2024

Keywords:

Economy, Carbon, Civil, Competency, Green

How To Cite:

Pratama AA, Nuriqmar TH, Theodora M, Ariyanto B, Ramadhana R (2024). Competency Management and Green Economy Education in the Field of Civil Engineering: A Traffic Project-Based Approach. *Jurnal Pendidikan Teknik Sipil*, Vol 6 (2), Pp 96-106. doi: [10.21831/jpts.v6i2.78481](https://doi.org/10.21831/jpts.v6i2.78481)

ABSTRACT

Background: The modern era is characterized by the acceleration of infrastructure development and the increasing need for efficient transportation. Civil engineering human resource planning plays an important role in ensuring the availability of a workforce that has the required skills and knowledge. This article aims to explore the relationship between these three elements and how their application can contribute to achieving more efficient, environmentally friendly, and sustainable traffic projects.

Methods: The research uses a quantitative approach with a sample determination method to ensure each individual has an equal chance of being selected as a respondent. Quantitative analysis was carried out to identify patterns and relationships between variables through statistical tests such as regression or correlation. Meanwhile, qualitative data comes from in-depth interviews or group discussions focus (FGD) with some respondents and is used to dig deeper into the context, motivation, or perception that cannot be explained through numbers.

Results: 40% of civil engineering companies have in-depth knowledge of environmental regulations that apply in Indonesia. Cities like Jakarta are still lagging behind in implementing smart traffic systems. Of the 100 major cities in the world, Jakarta ranks 85th in terms of adoption of smart traffic technology, with implementation still below 20%. 30% of civil engineering professionals in Indonesia report strong collaboration between civil engineers, environmental experts, and urban planners.

Conclusion: The government can promote more green technology projects, such as implementing Leadership in Energy and Environmental Design (LEED) standards or the Green Building Council Indonesia and encouraging cross-disciplinary projects by forming teams consisting of various experts, including environmental experts, transportation planners, and engineers, from the planning stage to implementation.

INTRODUCTION

In the modern era characterized by accelerated infrastructure development and the increasing need for efficient transportation, the civil engineering sector plays a crucial role in ensuring the sustainability and efficiency of the transportation system. One important aspect of this effort is traffic project planning that focuses not only on traffic flow efficiency but also on environmental impact. For this reason, a comprehensive approach is needed through the integration of competency management, green economy education, and the application of relevant technology. Sustainable traffic infrastructure projects must be supported by a workforce that is competent and understands the green economy. Green economy is based on previous research, namely all actions taken or efforts to minimize or even eliminate the impact of economic activities of economic actors on environmental damage. This concept refers to ecosystem responsibility, what humans do as a form of concern for climate change which is increasingly worrying (Ardianingsih & Meliana, 2022).

Previous research revealed that effective human resource (HR) management still pays attention to and improves the concept of competitiveness in the global market and provides a form of contribution to organizing competition within an organization (Septiana et al., 2023). The focus of this attention competency is so that all innovations that organize public interests continue to prioritize the balance of nature, as well as accommodate the needs of the public interest. The public interest in question is in the form of public service facilities such as bus stops, transportation, toll roads, and even the use of open space must be studied with healthy city design designs. The most important thing is that the availability and distribution of adequate toll road infrastructure can be useful for accelerating the flow of distribution of goods and services from upstream to downstream so that it can trigger the rate of economic growth in the region (Sena & Anondho, 2024). The focus in question can be the value of pollution produced, absorption facilities, and irrigation layout, as well as smoking-free areas. Competency management is the key to ensuring that human resources in the civil engineering field have skills that suit technological and environmental demands. Green economy education, on the other hand, helps create an understanding and application of environmentally friendly principles in the design and implementation of civil engineering projects (Elassy et al., 2024).

A traffic project-based approach is an effective strategy for combining education and training in civil engineering, with an emphasis on practical experience relevant to industry needs. These projects provide a real picture of how transportation planning can be carried out efficiently while taking into account sustainability principles. In this context, human resource planning also plays an important role in ensuring the availability of a workforce that has the required skills and knowledge. Thus, the synergy between competency management, green economy education, and a traffic project-based approach provides a strong foundation for achieving sustainability in the development of transportation infrastructure in the future. This article aims to explore the relationship between these three elements and how their application can contribute to achieving more efficient, environmentally friendly, and sustainable traffic projects (Sarjana, 2021).

METHODS

The research uses a quantitative approach with a sample determination method to ensure each individual has an equal chance of being selected as a respondent. Quantitative

analysis was carried out to identify patterns and relationships between variables through statistical tests such as regression or correlation. Meanwhile, qualitative data comes from in-depth interviews or Focus Group Discussions (FGD) with some respondents and is used to dig deeper into the context, motivation, or perception that cannot be explained through numbers. The qualitative method only prioritizes literature studies by collecting competency and green economy keywords from trusted journal literature. Meanwhile, the quantitative method used is an analysis and processing of project data and case studies of sustainable traffic projects, supported by questionnaire data. The method is then detailed in determining the problem formulation to discuss the results of data processing. The results of the problem formulation include how competency management can play a role in improving the skills of human resources in the field of civil engineering to face the challenges of sustainable traffic infrastructure projects. Followed by an exploration of how green economy education can be applied in planning and implementing traffic projects in the field of civil engineering to reduce environmental impacts. In addition, this research also examines how a traffic project-based approach can help integrate competency management and green economy education in the development of efficient and environmentally friendly transportation infrastructure. Then study the main challenges faced in implementing a sustainable traffic project-based approach in the development of transportation infrastructure using the following methods (Figure 1).

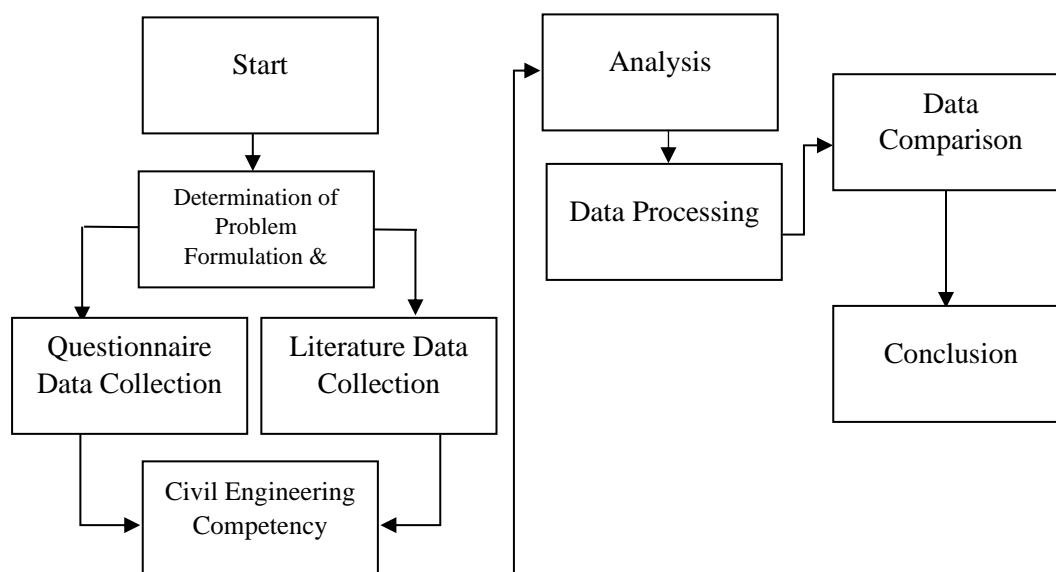


Figure 1. Observation Method

RESULTS AND DISCUSSION

Results

The questionnaire for carrying out this research uses a closed type of questionnaire. An open questionnaire is a questionnaire that provides freedom to fill in and answer without any restrictions on expressing opinions to the research object answer (Nurfaidah & Aliyyah, 2024) The collection of interview and questionnaire data was aimed at 71 respondents, from problems that arise in competency management and green economy education in the field of civil engineering, especially in a traffic project-based approach (Table 1).

Table 1.

Recapitulation of Respondent Identity Data

Respondent Profile	Frequency	Percentage (%)
Gender		
a. Woman	40	56
b. Man	31	44
Years Working		
c. 1-5 Years	60	85
d. 6-10 Years	11	15
e. 11- 15 Years	0	0
Age		
f. 17 - 23	50	70
g. 24 - 30	21	30
Level Education		
h. Bachelor	43	61
i. Masters	27	38

Source: Data Processed by the Author (2024).

The results of processing respondent data using SPSS, with the following references:

Q1: Green Economy Challenges

Q2: Civil Engineering Readiness

Q3: Government Policy Supports Environmentally Friendly Practices

Q4: Green Economy Curriculum Suggestions

Q5: Future Expectations

On a scale of 1 (not important) – 5 (very supportive) the data results are as follows:

Descriptive Statistics

Table 2.

Descriptive Statistics Results

Variable	Q1	Q2	Q3	Q4	Q5
Mean	3,15	3,08	2,76	2,79	2,90
Std Dev	1,32	1,50	1,39	1,33	1,43
Minimum	1,00	1,00	1,00	1,00	1,00
25th Pctl	2,00	2,00	1,00	1,50	2,00
Median	3,00	3,00	3,00	3,00	3,00
75th Pctl	4,00	4,50	4,00	4,00	4,00
Maximum	5,00	5,00	5,00	5,00	5,00

Source: Data Processed by the Author (2024).

The mean of all variables (Q1–Q5) ranges around the neutral value (3) on a scale of 1–5. The standard deviation shows moderate to high variation in answers, especially for Q2 (industry readiness) and Q5 (future expectations). The range of answers to all questions indicates that there is a wide range of views among respondents. There is no significant difference between the average respondents' answers for Q1–Q5 and the neutral value (3). This means that respondents tend to give answers that are not extreme, showing a neutral attitude or not leaning

too much toward one side. This may indicate uncertainty or a lack of a firm view of the green economy in traffic management.

- a. The biggest challenge (Q1), respondents are aware of the challenges in integrating the green economy but do not see it as something very difficult or easy.
- b. Industrial Readiness (Q2), respondents tend to be neutral, indicating the view that the civil engineering industry is not yet fully ready to adopt environmentally friendly technology.
- c. Policy Support (Q3), respondents showed a moderate view of the role of government policy.
- d. Curriculum and Competencies (Q4), respondents have a neutral view about the need to strengthen the curriculum to support the green economy
- e. Future Expectations (Q5), respondents have quite moderate expectations regarding the implementation of a green economy in the future.

Correlation Between Variables

Table 3.

Correlation Results Between Variables

Variable	Q1	Q2	Q3	Q4	Q5
Q1	1,000	0,152	-0,018	-0,071	0,297
Q2	0,152	1,000	0,017	0,045	0,044
Q3	-0,018	0,017	1,000	0,081	0,125
Q4	-0,071	0,045	0,081	1,000	0,087
Q5	0,297	0,044	0,125	0,087	1,000

Source: Data Processed by the Author (2024).

The positive correlation between Q1 (challenges) and Q5 (future expectations) ($r = 0,297$) indicates that perceptions of green economy challenges in traffic projects are related to their expectations for the future of their implementation. The relationship between other variables is weak, indicating that each aspect tends to be independent or does not really influence each other.

One Sample t Test Hypothesis

H0 (Hypothesis 0) : The average of the variable is equal to 3

H1 (Alternative Hypothesis) : The mean of a variable is different from 3

Table 4.

t Test Results

Variable	T - statistic	p- value	Decision ($\alpha = 0,05$)
Q1	0,99	0.324	Failed to Reject H0 (No significant difference)
Q2	0,47	0.636	Failed to Reject H0 (No significant difference))
Q3	-1,45	0,151	Failed to Reject H0 (No significant difference)
Q4	-1,34	0,185	Failed to Reject H0 (No significant difference)
Q5	-0,58	0,562	Failed to Reject H0 (No significant difference))

Source: Data Processed by the Author (2024).

All p-values are greater than 0.05, so there is no significant difference between the average of each variable (Q1–Q5) and the neutral value (3). This shows that the average respondent tends to be around the neutral value for all questions. Focus on improving aspects of Q1, because this variable most significantly influences Q5.

1. High Implementation Costs

Green technology and sustainable materials are often more expensive than conventional methods, so many infrastructure projects are reluctant to make the switch due to large initial costs. High funding creates problems in the form of green inflation, where organizations are required to carry out green updates but all supporting tools are said to have a high expenditure value (Djannah Rosadi & Rusiadi, 2024). This inability will result in the production impact of carbon emissions tending to increase.

2. Limited Resources and Green Technology

Not all traffic projects have access to environmentally friendly technology, sustainable materials, or construction methods that have minimal environmental impact, making it difficult to implement green economy principles optimally. This case was also found in other research that inadequate human resources (in terms of quantity and quality) can hinder the development process (Alau et al., 2024)

3. Unsupportive Regulations and Policies

Even though awareness about sustainability is increasing, regulations and policies that support the implementation of a green economy in traffic infrastructure development are often immature or unclear (Novian et al., 2024).

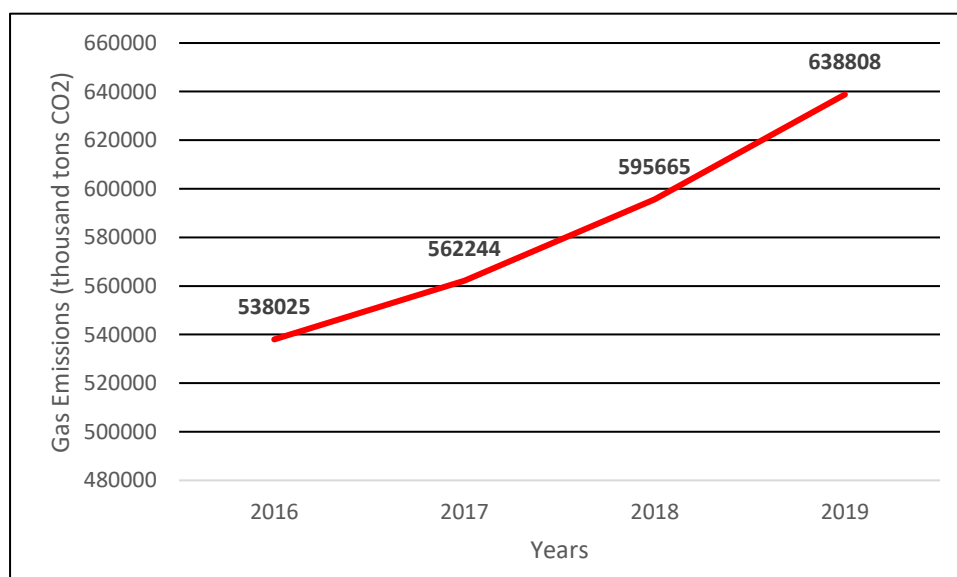


Figure 2. 2020 Greenhouse Gas and MPV Inventory, Ministry of Environment and Forestry of The Republic of Indonesia

4. Limitations of Workforce Competency

Many professionals in the field of civil engineering do not have sufficient competence in planning, implementing, and managing environmentally friendly infrastructure projects. This requires training and skill improvement. Respondent data reveals that the value of field implementation comes from permits from the Ministry of Environment and K3. However, the layout design regarding renewable energy has not been found in the results of the questionnaire data collection. Competency management is not only based on the curriculum at the education level but can be supported by the development of gamification-

based MOOCs in the learning process (Putra et al., 2023) .Analysis of forms of human resource quality management with a civil engineering background has been carried out in other research, showing that this is influenced by attitudes (10 competencies), knowledge (13 competencies), general skills (17 competencies), and specific skills (15 competencies), level of relevance of graduate competencies (Warnandes et al., 2022).

5. Lack of Collaborative Approach

Implementing a green economy in traffic projects requires collaboration between sectors, such as government, academia, industry, and society. Lack of communication and cooperation between parties can be an obstacle to realizing a sustainable project. Collaborative principles can take the form of cooperation in the integration of state business entities with private parties. This concept is to previous research, that the RMS principle (Reading, Mind, Mapping, and Sharing) can improve the quality of critical thinking regarding field problems, especially the green economy (Aminah et al., 2023).

6. Environmental Impact of Conventional Traffic Projects

Conventional traffic projects often result in significant environmental impacts, such as increased carbon emissions, noise pollution, and ecosystem damage, so there is an urgent need to shift approaches in a greener direction. Technologies such as the use of recycled materials and renewable energy technologies are not yet commonly applied in highway or public infrastructure projects.

Discussion

We referred to the previous results of data processing using SPSS based on previous research and factual data in the field, and obtained the following results:

Mastery of Environmentally Friendly Technology

According to the 2021 Global Infrastructure Hub report, only 23% of infrastructure projects in developing countries, including Indonesia, use environmentally friendly technology in the construction phase. This shows the low adoption of green technology in civil infrastructure. Technical competence in applying environmentally friendly materials and reducing carbon emissions from construction is still low. Previous research revealed that infrastructure development is considered to still have negative impacts, especially those related to hydrological development, green open spaces, and ecosystems (Aminah et al., 2023). The solution to this problem is that more intensive training on the use of green materials and renewable energy technology needs to be carried out. The government could promote more pilot projects involving the use of green technology. Based on a review of previous research, the development of environmentally friendly technology is the main key to overcoming and working on solid waste problems, with the potential to create new economic business opportunities (Astutik et al., 2024).

Sustainable Project Management

Only around 15% of infrastructure projects in Indonesia involve thorough environmental impact analysis, according to the Climate Transparency Report 2022. This lack of implementation of project management that considers sustainability impacts can cause environmental losses in the long term. Previous findings reveal that technology such as the Real Time Traffic Information System is the most appropriate solution to overcome the problem of

traffic congestion on the Jakarta Inner City Toll Road (Suyuti, 2022). However, this condition is only to overcome congestion and find the best route, not to reduce the vehicle's gas emission system. Many infrastructure projects still focus on quick results without considering construction waste management or efficient energy management. As a result, the project may contribute to increased carbon emissions and decreased environmental quality. Previous research studies suggest that infrastructure development must involve green systems in the future by focusing on direction, policy, organization, area, capacity and intervention from each party as a form of expanded combination strategy (Lumbanraja & Lumbanraja, 2023). The solution is in the form of increasing competency in sustainability-based project management through certification and training. An example is the application of Leadership in Energy and Environmental Design (LEED) or Green Building Council Indonesia standards.

Mastery of Environmental Regulations and Policies

According to a survey from the Green Building Council Indonesia in 2023, only 40% of civil engineering companies have in-depth knowledge of the environmental regulations that apply in Indonesia, such as Government Regulation no. 46 of 2017 concerning Greenhouse Gas Inventory. Lack of understanding of environmental regulations prevents companies from implementing green economy principles. This causes many infrastructure projects to not meet desired environmental standards, such as reducing greenhouse gas emissions or using more energy-efficient materials. The solution to this problem is to increase training for engineers and project managers in understanding and implementing environmental regulations, as well as encouraging civil engineering companies to develop internal policies that are in line with these regulations.

Use of Smart Traffic Technology

According to a report from McKinsey & Company in 2021, cities in Indonesia such as Jakarta are still lagging in implementing smart traffic systems. Of the 100 major cities in the world, Jakarta only ranks 85th in terms of adoption of smart traffic technology, with implementation still below 20%. One support for this observation is that it is discussed using the tier 1 method, namely calculating emissions and absorption using basic equations. The results of this research show that the amount of carbon emissions resulting from the work of 1 pile measuring 450x450 mm produces 11610.635 kg CO₂ (Arsyah et al., 2023). Smart traffic technology that utilizes sensors, big data, and artificial intelligence can reduce congestion by up to 25% and exhaust emissions by up to 15%. However, a lack of competence in using and applying this technology in civil engineering projects hinders this progress. Improve civil engineering professionals' skills in data analysis, use of AI, and smart technologies to manage traffic. The government could also accelerate investment in smart traffic technology in big cities.

Interdisciplinary Collaboration and Environmental Communication

Based on a 2022 World Economic Forum survey, only 30% of civil engineering professionals in Indonesia reported strong collaboration between civil engineering engineers, environmental experts, and city planners in sustainable infrastructure projects. Green infrastructure projects require better collaboration between disciplines. Civil engineers often focus on technical aspects without involving environmental experts or architects in the planning

stage. As a result, opportunities to create truly sustainable infrastructure are often missed. From this problem, the author was able to find a solution in the form of encouraging cross-disciplinary projects by forming a team consisting of various experts, including environmental experts, transportation planners, and engineers, from the planning stage to implementation. Environmental communication also creates the value of innovation and collaboration between groups and individuals in society (Nugroho & Dirgantara, 2023).

Green Finance

According to the Institute for Energy Economics and Financial Analysis (IEEFA) in 2023, investment in green projects in Indonesia will only reach USD 15 billion of the need of around USD 500 billion to achieve the national emission reduction target in 2030. The green route has been proven to have a positive impact on reducing and absorbing particle pollutants (Syahraeni et al., 2024). Awareness of green financing, including the use of green bonds or carbon trading, is still very low among civil engineering professionals. Most civil engineering projects are still funded through conventional financing which does not consider sustainability aspects. Green financing is aimed at encouraging civil engineers to carry out engineering activities to shift their business processes towards low-carbon and environmentally friendly business processes (Pratama & Firmansyah, 2024). From this, researchers can reveal solutions by increasing understanding of green financing through seminars, workshops, and training in the civil engineering sector, as well as encouraging easier access to green financing schemes from local and international financial institutions. One form of breakthrough in civil engineering is Geofom Expanded Polystyrene (EPS), which tends to save energy (Faishol et al., 2024). However, please note that it is susceptible to damage due to exposure to ultraviolet (UV) light. Another example of continued innovation is to reduce the need for additional materials such as aggregate or concrete, with geotextile innovation that can help reduce the exploitation of natural resources and carbon emissions from material transportation (Yona et al., 2023).

By increasing competence in these areas, Indonesia will be better prepared to face the challenges of creating environmentally friendly and sustainable infrastructure, in line with the government's targets for reducing carbon emissions and sustainable development (Alhusain, 2019). The following is an explanation of the competencies that need to be improved in competence management and education green economy in civil engineering, supported by data and facts:

CONCLUSION

The research results reveal the conclusion that 40% of civil engineering companies have in-depth knowledge of the environmental regulations that apply in Indonesia. Cities like Jakarta are still lagging in implementing smart traffic systems. Data collection from 100 major cities in the world, especially Jakarta, is only ranked 85th in terms of adoption of smart traffic technology, with implementation still below 20%. 30% of civil engineering professionals in Indonesia report strong collaboration between civil engineering engineers, environmental experts, and urban planners. The government can promote more green technology projects, such as the implementation of Leadership in Energy and Environmental Design (LEED) standards or the Green Building Council Indonesia, and encourage cross-disciplinary projects by forming teams consisting of various experts, including environmental experts, transportation planners, and

engineers, from the planning stage to implementation. Green projects in Indonesia have only reached USD 15 billion of the need of around USD 500 billion to achieve the national emission reduction target by 2030. 23% of infrastructure projects in Indonesia use environmentally friendly technology in their construction phase. This shows the low adoption of green technology in civil infrastructure. This urgent phase can be accommodated by increasing understanding of green financing through seminars, workshops, and training in the civil engineering sector, as well as encouraging easier access to green financing schemes from local and international financial institutions.

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