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Motor Vehicle Carbon Emission Reduction Strategy Using the PROMETHEE Approach: A Case Study in Higher Education

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ABSTRACT

This study aims to develop a model for a carbon emission reduction strategy at a university and implement it in practice. The research is structured around a three-dimensional framework for the strategy development process. These aspects include providing easy transportation facilities, maintaining a clean and beautiful campus environment, fostering active student involvement in environmental activities, and implementing an electric bicycle grant program. Furthermore, the developed alternatives include operating a campus bus to shuttle students living near campus, establishing a bicycle community at the university, limiting the number of motorized vehicles on campus, encouraging the use of environmentally friendly technologies and energy sources (such as biodiesel and electric vehicles), implementing a walk-friendly campus policy, promoting the use of public transportation, and creating a car-free day program on campus. This model utilizes multi-criteria decision-making. To solve the problem and identify alternative options, the PROMETHEE decision support system was employed. The results indicate that implementing a walk-friendly campus policy is considered crucial for achieving the university's long-term economic, social, and cultural development goals.

1. INTRODUCTION

Rapid industrial expansion worldwide and the heavy dependence on finite energy resources have intensified the release of greenhouse gases, which in turn accelerates global warming and amplifies diverse environmental deterioration [1]. From the pre-industrial period around 1850 up to the year 2022, the mean concentration of atmospheric carbon dioxide (CO_2) increased markedly, rising from about 285 ppm to roughly 419 ppm [2]. By 2050, global emissions of greenhouse gases are expected to rise by roughly 50%, driven predominantly by carbon dioxide released from the continued reliance on non-renewable energy sources [3, 4]. Without the implementation of effective strategies or technologies aimed at reducing or controlling CO_2 emissions, global atmospheric CO_2 levels—as well as both surface and ocean temperatures—will continue to rise. The resulting global warming driven by greenhouse gases has already produced substantial ecological and societal impacts, including accelerated species extinction, declining biodiversity, prolonged droughts, severe flooding, widespread forest fires, ocean acidification, melting ice sheets in polar regions, and continuous sea-level rise [5, 6].

Without the implementation of effective strategies or technologies aimed at reducing or controlling CO_2 emissions, global atmospheric CO_2 levels—as well as both surface and ocean temperatures—will continue to rise. The resulting global warming driven by greenhouse gases has already produced substantial ecological and societal impacts, including accelerated species extinction, declining biodiversity, prolonged droughts, severe flooding, widespread forest fires, ocean acidification, melting ice sheets in polar regions, and continuous sea-level rise [7].

Under the *Paris Agreement*, countries pledged to prevent global temperatures from increasing beyond 2℃, while also striving to constrain the rise to no more than 1.5℃ [4]. As of February 2021, 124 nations had formally declared their intention to achieve carbon neutrality and realize net-zero emissions by either 2050 or 2060 [2, 8]. Meeting the objectives outlined in the Paris Agreement and advancing sustainable development demands a two-pronged strategy: lowering CO_2 emissions and extracting CO_2 already present in the atmosphere. Achieving net-zero or even negative carbon levels requires an integrated set of social, economic, environmental, and technological interventions.

Carbon neutrality denotes the attainment of net-zero carbon emissions, in which all direct and indirect releases of carbon dioxide or other greenhouse gases associated with a nation, organization, product, activity, or individual over a defined period are fully counterbalanced through carbon-offsetting or carbon-removal measures [9]. To achieve carbon neutrality, the Intergovernmental Panel on Climate Change (IPCC), through its special report on limiting global warming to 1.5℃, highlighted the critical need to curtail and ultimately eliminate fossil-fuel use, expand the deployment of renewable energy, improve energy-efficiency measures, and apply these strategies within urban environments [10, 11]. Furthermore, realizing net-zero emissions and advancing sustainable development requires strengthening efforts to remove or sequester carbon within both terrestrial and marine ecosystems [12, 13]. A range of regions, nations, and urban areas have adopted diverse initiatives designed to strengthen carbon sequestration or removal as part of their efforts to achieve carbon-neutral targets [14-16]. Nevertheless, achieving net-zero carbon emissions remains a highly demanding objective, accompanied by numerous substantive obstacles [1].

A comprehensive evaluation of higher education's carbon emissions is urgently needed, necessitating the use of integrated methods such as Multi-Criteria Decision Making (MCDM). This method systematically addresses the framework related to carbon emissions and the factors that influence them, which form the basis for selecting optimal reduction alternatives. Recent study findings emphasize the importance of MCDM in formulating carbon emission reduction strategies for higher education institutions. The study conducted by Angelo et al. [17] shows that MCDM is an effective method for improving decision-making in planning by simultaneously evaluating multiple sustainability dimensions of the environmental impacts associated with various development alternatives. This integration allows for the selection of policies that reduce emissions while promoting social equity and economic viability, all crucial issues [17].

Campus sustainability and its effects on the environment are becoming more and more important in densely populated higher education institutions. Without incentives and with just measures, universities can cut carbon emissions by about 560 tons annually [18]. However, the university's yearly emission reductions are projected to rise to 800 to 1,045 tons when incentives and interventions are combined. The significant institutions, such as universities, utilize a huge quantity of energy daily [19]. In addition, one of the few examples in the literature documenting energy usage in university buildings in tropical climes is the Paricarana Campus of the Federal University of Roraima (UFRR), Brazil [20]. From 2015 to 2017, the research examined the energy usage of 30 national universities, 9 national universities of science and technology, 17 private universities, and 16 private universities of science and technology in Taiwan. The four categories of institutions released 1518, 1350, 760, and 557 kg-CO_2e/person/year of greenhouse gases per student [21]. Moreover, the research employed a stochastic impact model with population, wealth, and technology regression (STIRPAT) to create a carbon emission forecast model for university buildings in a hot and humid location, using Guilin as an example. There were three scenarios: baseline, low-carbon, and ultra-low-carbon. The results indicated that the latter two scenarios had substantial potential for reducing carbon emissions. Emissions are predicted to reach a peak of 17,227.97 tCO_2 in 2028 under the low-carbon scenario. According to the ultra-low-carbon scenario, emissions are expected to peak earlier in 2021 and then drop to 13,999.60 tCO_2 in 2035, a 16.1% decrease [22, 23].

In a key contribution, researchers [24] examined the significance of demand-side mitigation strategies in achieving climate goals. The paper underscores the importance of understanding non-financial barriers to behavior modification for the effectiveness of policy measures designed to reduce carbon footprints. This perspective aligns with the need for comprehensive evaluation approaches such as MCDM that consider diverse stakeholder perspectives. This research demonstrates that behavioral insights can be successfully integrated into MCDM frameworks to increase community engagement and acceptance of low-carbon programs. Furthermore, a recent study in the journal Sustainability examined the effectiveness of several urban carbon reduction initiatives using system dynamics methodology. Akbari et al. [25] argued that utilizing MCDM techniques can substantially improve the robustness of policy proposals by taking into account multiple factors and stakeholder preferences. This study underscores the importance of incorporating MCDM to formulate effective methods for sustainability. The authors present case studies demonstrating how cities have effectively implemented this approach, resulting in measurable reductions in carbon emissions. Furthermore, Colapinto et al. [26] examined how a region can utilize the MCDM framework to evaluate the trade-offs between economic development and environmental sustainability. The results showed that regions that applied this technique were able to manage complex decision-making environments more effectively while ensuring efficient and equitable solutions. This study highlighted that MCDM can enhance participatory decision-making processes, enabling stakeholders from various sectors to share their views on development initiatives.

MCDM is a concept commonly used in planning that allows decision-makers to evaluate the ranking of various solutions based on multiple, often conflicting criteria. Development programs designed to reduce carbon emissions always involve considerations between economic feasibility, social equity, environmental impact, and technical feasibility [27]. MCDM is the primary approach employed to assess the sustainability of a nation or region within the energy sector. Issues with numerous objectives can be addressed through the MCDM technique. Various solutions can be implemented for energy management and preparatory declarations based on the weighted average, outranking methods, critical concern scenarios, fuzzy logic, and integrations [28, 29]. MCDM has undergone substantial advancements since the early 1960s, encompassing cutting-edge methodologies and robust algorithms (computational tools) [30]. A study by Gazi et al. [31] was undertaken on synergistic techniques for sustainable hospital site selection in Saudi Arabia, utilizing the Spherical Fuzzy MCDM algorithm. The aim was to create a model for choosing a PhD supervisor from the available possibilities at the academic institution. A hybrid MCDM framework was employed to select supervisors according to the criteria favored by students in an interval-valued intuitive fuzzy (IVIF) context.

There are various MCDM models, including the Analytic Hierarchy Process (AHP), the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), and the Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE) [29, 32-34]. Each of these approaches has its own advantages that depend on the specific context and objectives of the decision-making process. Decision Criteria Making (DCM) encompasses all possible strategies undertaken by stakeholders within a framework to ensure that the chosen strategies align with societal goals.

This study uses the PROMETHEE methodology to combine qualitative and quantitative aspects of the existing carbon emission reduction strategy landscape. This article is further enhanced by using data to evaluate carbon emission reduction strategy scenarios in higher education. This study examines appropriate decision-making in carbon emission reduction in higher education institutions within the framework of sustainable development for university institutions.

2. METHOD

Addressing complex decision-making problems requires the evaluation of multiple criteria and available alternatives. A wide range of Multi-Criteria Decision Aid (MCDA) techniques can be utilized to support decision-makers across diverse fields. Over the past several decades, these approaches have grown into a major branch of operational research. MCDA frameworks apply to numerous sectors, including business, management, and engineering. Among the many methods that have been developed, the PROMETHEE family represents a prominent set of tools capable of handling both qualitative and quantitative criteria. Originally proposed by Brans in 1982 and later refined by Vincke and Brans in 1985, this methodology is built upon several fundamental components [35]:

a. Enhancing the preference structure by incorporating various preference functions and defining dominance relations among alternatives, while considering the contribution of each criterion.
b. Providing decision support based on either partial or fully established rankings of the alternatives.

PROMETHEE, much like the ELECTRE family, represents an outranking methodology that applies a series of iterative procedures to derive a ranking from a finite set of alternatives. Compared with many other MCDM techniques, its design and practical application are relatively straightforward, which has contributed to its growing adoption by decision-makers each year for addressing complex problems. Numerous scholars have explored the nuanced aspects of this approach in their research [36, 37]. This method utilizes a range of preference functions that are adjusted to the specific characteristics of each criterion, thereby reducing potential scale-related distortions. This feature represents one of the key strengths of the PROMETHEE methodology. Within the PROMETHEE procedure, both the preference functions and the associated threshold parameters must be selected in accordance with the judgments and perspectives of the decision-makers for the particular decision context [35].

The PROMETHEE framework includes several procedural variants. PROMETHEE I was originally formulated to generate partial rankings, whereas PROMETHEE II was designed to produce complete rankings of the alternatives [38]. Additional extensions of the method were later developed. PROMETHEE III enables the ranking of alternatives using interval-based evaluations. PROMETHEE IV is applied in situations where decision-makers must assess a continuous set of feasible solutions for either partial or complete rankings, while PROMETHEE V addresses problems that incorporate segmentation or constraint-related considerations [39]. Other variants of the method—namely PROMETHEE VI, Group Decision Support System (GDSS), and Geometrical Analysis for Interactive Aid (GAIA)—were developed to model human judgment, facilitate group decision-making, and provide graphical decision support, respectively. GAIA functions as an interactive visualization tool, particularly useful for addressing complex evaluation scenarios. More recent extensions, PROMETHEE TRI and PROMETHEE CLUSTER, have been introduced for sorting tasks and nominal classification. Collectively, these versions represent robust MCDM tools, attributed to their intuitive structure and sound mathematical foundations [36]. The following sections provide a detailed overview of the fields in which PROMETHEE methods are applied, together with their respective advantages and limitations. The final section offers a concise exposition of the operational steps and algorithms associated with the PROMETHEE I and II procedures [40].

The case study in this research is Pancasila University. Located in southern Jakarta, Pancasila University covers 111,255 m^2 of land and 38,076 m^2 of buildings, offering easy access to various forms of public transportation, including buses and trains. There is a train station, Pancasila University station, located in front of the campus.

This research seeks to identify the optimal technique for mitigating carbon emissions at universities through the application of the PROMETHEE method. Strategies to reduce carbon emissions are identified and executed to ascertain the optimal alternative depending on the results gained. Data is collected through a review of pertinent literature, interviews with diverse individuals, field observations, and expert surveys. The PROMETHEE method is used to assess alternative carbon emission reduction strategies through a paired comparison questionnaire. This questionnaire was distributed to experts, taking into account their depth of experience, time availability, and expertise in carbon emission engineering. The criteria and alternatives are established via an open questionnaire disseminated to academics, non-governmental groups, carbon emission analysts, and politicians, with the findings subsequently organized in tabular format.

The PROMETHEE method involves several calculation steps during its implementation. The calculation stages are shown in Figure 1.

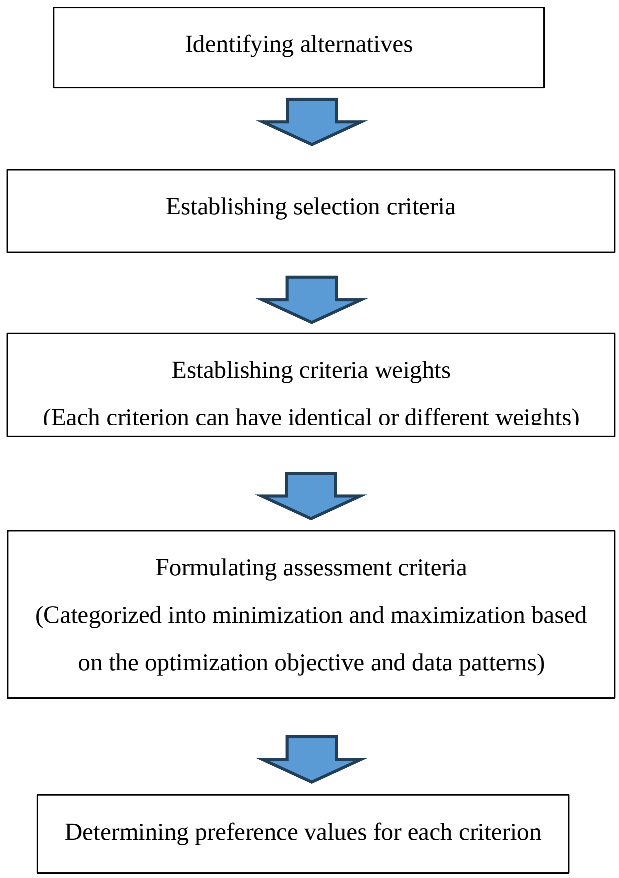

Figure 1. Flowchart of decision-making using the PROMETHEE method

In calculating the PROMETHEA method, there are several concepts, as follows:

a. Criterion dominance

Each alternative a ∈ K is evaluated based on the function f(a), which represents the assessment of a criterion. The value of f itself is the real value of a criterion f: K → R. When two alternatives a, b, ∈ K are compared, their preference ratio must be determined. The preference intensity (P) of alternative a over alternative b is expressed as follows:

- $P(a,b) = 0$: there is no indifference between a and b, or there is no preference for a over b.
- $P(a,b) \sim 0$: weak preference for a over b.
- $P(a,b) \sim 1$: strong preference for a over b.
- $P(a,b) = 1$: absolute preference for a over b.

Preference functions often produce different function values between two evaluations, so that:

$$P(a,b) = P(f(a) - f(b)) \tag{1}$$

b. Criteria preference function

In the PROMETHEE method, there are six forms of criterion preference functions, including:

- Usual criteria

$$H(d) = \begin{Bmatrix} 0 \; if \; d \leq 0 \\ 1 \; if \; d > 0 \end{Bmatrix} \tag{2}$$

where,

$H(d)$ = function of the difference in criteria between alternatives

d = difference in criteria values $\{d = f(a) - f(b)\}$

- Quasi criteria

$$H(d) = \begin{Bmatrix} 0 \text{ if } d \leq q \\ 1 \text{ if } d > q \end{Bmatrix} \tag{3}$$

where,

$H(d)$ = function of the difference in criteria between alternatives

d = difference in criteria values $\{d = f(a) - f(b)\}$

q = fixed value

- Linear preference criteria

$$H(d) = \begin{Bmatrix} 0 \text{ if } d \leq 0 \\ \dfrac{d}{p} \text{ if } o \leq d \leq p \\ 1 \text{ if } d > p \end{Bmatrix} \tag{4}$$

where,

$H(d)$ = function of the difference in criteria between alternatives

d = difference in criteria values $\{d = f(a) - f(b)\}$

p = upper tendency value

- Level criteria

$$H(d) = \begin{Bmatrix} 0 \text{ if } d \leq q \\ 0.5 \text{ if } q \leq d \leq p \\ 1 \text{ if } d > p \end{Bmatrix} \tag{5}$$

where,

$H(d)$ = criterion difference function between alternatives

d = criterion value difference $\{d = f(a) - f(b)\}$

p = upper tendency value

q = fixed value

- Linear preference criteria and non-differential areas

$$H(d) = \begin{Bmatrix} 0 \text{ if } d \leq q \\ \dfrac{d-q}{p-q} \text{ if } q \leq d \leq p \\ 1 \text{ if } d > p \end{Bmatrix} \tag{6}$$

where,

$H(d)$ = criterion difference function between alternatives

d = criterion value difference $\{d = f(a) - f(b)\}$

p = upper tendency value

q = fixed value

- Gaussian criterion

$$H(d) = \begin{Bmatrix} 0 \text{ if } d \leq 0 \\ 1 - e - \dfrac{d^2}{2a^2} \text{ if } d > 0 \end{Bmatrix} \tag{7}$$

where,

$H(d)$ = criterion difference function between alternatives

d = criterion value difference $\{d = f(a) - f(b)\}$

p = upper tendency value

q = fixed value

c. Multicriteria preference index

$$\varphi(a,b) = \sum_{i=1}^{n} \pi_i P_i(a,b) \colon \forall a,b \in A \tag{8}$$

$\varphi(a,b)$ is the intensity of the decision maker's preference, stating that alternative *a* is better than alternative *b* with simultaneous consideration of all criteria. This can be presented with *a* value between 0 and 1, with the following conditions:

- $\varphi(a,b) = 0$, indicating a weak preference for alternative a > b based on all criteria.
- $\varphi(a,b) = 1$, indicating a strong preference for alternative *a* > *b* based on all criteria.

d. PROMETHEE *ranking*

- *Leaving Flow*

$$\varphi^{+}(a) = \tfrac{1}{n-1} \textstyle\sum_{x \in A} \varphi(a,x) \tag{9}$$

- *Entering Flow*

$$\varphi^{-}(a) = \tfrac{1}{n-1} \textstyle\sum_{x \in A} \varphi(a,x) \tag{10}$$

- *Net Flow*

$$\varphi(a) = \varphi^{+}(a) - \varphi^{-}(a) \tag{11}$$

where,

$\varphi(a,x)$ = indicates the preference that alternative *a* is better than alternative *x*.

$\varphi(x,a)$ = indicates the preference that alternative *x* is better than alternative *x*.

$\varphi^{+}(a)$ = Leaving Flow, used to determine the priority order in the PROMETHEE I process that uses partial ordering.

$\varphi^{-}(a)$ = Entering Flow, used to determine the priority order in the PROMETHEE I process that uses partial ordering.

$\varphi(a)$ = Net Flow, used to produce the final decision on the order in solving the problem, resulting in a complete order.

3. RESULT

Based on the results of the questionnaire that was distributed to five respondents, the alternatives were obtained, which are presented in Table 1.

Table 1. Criteria for carbon emission reduction strategies at universities

No.	Criteria	Code
1	Public transportation can be utilized by the academic community in the strategic location of the Faculty of Engineering, Pancasila University, as an implementation of the green campus program. (Ease of transportation facilities)	C1
2	A clean and beautiful campus environment can be a supporting factor in the formation of a cycling community and the implementation of an environmentally friendly lifestyle. (Environment-friendly lifestyle)	C2
3	Active student involvement in environmental activities can be directed towards designing climate mitigation solutions and reducing motor vehicle carbon emissions. (Students are active in environmental activities)	C3
4	Electric bicycle grants can be used as a first step in supporting academic communities to use electric vehicles, which are now widely available. (Electric bicycle grant)	C4
5	Leveraging financing programs to develop environmentally friendly facilities. (Financing program)	C5

Table 2. Alternatives in carbon emission reduction strategies

No.	Alternative	Code
1	Operating campus buses to pick up and drop off academics residing around Jakarta	A1
2	Forming a bicycle user community at the university	A2
3	Restrictions on the number of motorized vehicles coming to campus	A3
4	Encourage the use of environmentally friendly technology and energy (Biodiesel, Electric Vehicles)	A4
5	Implementing a policy for academics to be able to walk within the campus area	A5
6	Using public transportation	A6
7	Create a one-day, car-free program on campus	A7

Table 3. Respondents' assessments of the alternatives

Respondents	Alternative						
	1	2	3	4	5	6	7
1	5	5	4	5	5	5	5
2	3	2	2	3	4	4	3
3	5	4	5	3	5	5	5
4	4	3	4	5	5	5	5
5	3	3	5	5	5	5	4

Moreover, from the results of distributing the questionnaire, alternatives were also obtained, which are presented in Table 2.

After the distribution of the PROMETHEE questionnaire was carried out, the results of the respondents' assessment of the alternatives that had been determined were obtained. After the respondents' assessments were obtained, the first step that would be taken was to calculate the alternative preference value.

After the alternatives were determined, a questionnaire was distributed to five respondents. The results of the assessments against the criteria and alternatives are in Table 3.

In this stage, the preference value will be calculated by comparing one alternative with another. This calculation will be done by subtracting the value of the first alternative from the second alternative, then continuing by calculating the preference value based on the preference type that will be used, based on Formula (3), namely the usual criteria. The calculation results can be seen in the following Table 4.

As stated in the preference value tables above, the calculation is performed using the example of subtracting A1 and A2 from No. 1, where 5 – 5 = 0. From the calculation results, a value of 0 indicates that $d \leq 0$. If $d \leq 0$, then $H(d) = 0$. If $d > 0$, then $H(d) = 1$. Therefore, it can be concluded that the results of A1 and A2 obtained $H(d) = 0$, meaning there is no preference between A1 and A2 for that criterion. This value indicates that A1 is not better than A2, or both are considered equivalent. Then, the subsequent data calculations are carried out in the same manner.

After calculating the alternative preference values, the multicriteria preference index is calculated. Table 5 shows the overall multicriteria preference index obtained from the calculation using Eq. (8). For example, the calculation for A1 and A2 is as follows:

$$\varphi(a,b) = \frac{1}{5} \times (0 + 1 + 1 + 1 + 0) = 0.6$$

In calculating Leaving Flow, it will be done based on the multicriteria preference index of each alternative by calculating horizontally, where the calculation results are as follows:

(A1) = 17 – 1 × (0.6 + 0.4 + 0.2 + 0 + 0 + 0) = 0.2
(A2) = 17 – 1 × (0 + 0.2 + 0.2 + 0 + 0 + 0) = 0.066
(A3) = 17 – 1 × (0.2 + 0.6 + 0.2 + 0 + 0 + 0.2) = 0.2
(A4) = 17 – 1 × (0.4 + 0.6 + 0.6 + 0 + 0 + 0.2) = 0.3
(A5) = 17 – 1 × (0.6 + 0.8 + 0 + 0.4 + 0 + 0.4) = 0.36
(A6) = 17 – 1 × (0.6 + 0.8 + 0 + 0.4 + 0 + 0) = 0.3
(A7) = 17 - 1 × (0.4 + 0.8 + 0.6 + 0.2 + 0 + 0) = 0.33

Based on these calculations, the Leaving Flow calculation for Alternative 1 yields a value of 0.2. Alternative 2 yields a value of 0.066. Alternative 3 yields a value of 0.2. Alternative 4 yields a value of 0.3. Alternative 5 yields a value of 0.36. Alternative 6 yields a value of 0.3. And Alternative 7 yields a value of 0.33.

After obtaining the Leaving Flow values for the seven alternatives, the Entering Flow calculation will be performed.

In calculating Entering Flow, it will be done based on the Multicriteria Preference Index of each alternative by adding it up vertically, where the calculation results are as follows:

(A1) = 17 – 1 × (0 + 0.2 + 0.4 + 0.6 + 0.6 + 0.4) = 0.36
(A2) = 17 – 1 × (0.6 + 0.6 + 0.6 + 0.8 + 0.8 + 0.8) = 0.7
(A3) = 17 – 1 × (0.4 + 0.2 + 0.6 + 0 + 0 + 0.6) = 0.3
(A4) = 17 – 1 × (0.2 + 0.2 + 0.2 + 0.4 + 0.4 + 0.2) = 0.26
(A5) = 17 – 1 × (0 + 0 + 0 + 0 + 0 + 0) = 0
(A6) = 17 – 1 × (0 + 0 + 0 + 0 + 0 + 0) = 0
(A7) = 17 – 1 × (0 + 0 + 0.2 + 0.2 + 0.4 + 0) = 0.13

Based on these calculations, the Entering Flow value for Alternative 1 is 0.36. Alternative 2 is 0.7. Alternative 3 is 0.3. Alternative 4 is 0.26. Alternative 5 is 0. Alternative 6 is 0. And Alternative 7 is 0.13.

After the Entering Flow values for the seven alternatives are obtained, the Net Flow calculation will be performed to determine the ranking of the selected alternatives.

After calculating the Leaving Flow and Entering Flow, the next step is to calculate the Net Flow value obtained from the subtraction of the Leaving Flow and Entering Flow values, as follows:

(A1) = 0.2 – 0.36 = -0.1667
(A2) = 0.06 – 0.7 = -0.6333
(A3) = 0.2 – 0.3 = -0.1000
(A4) = 0.3 – 0.26 = 0.0333
(A5) = 0.36 – 0 = 0.3667
(A6) = 0.3 – 0 = 0.3000
(A7) = 0.33 – 0.13 = 0.2000

Based on the calculation results, it is known that the Net Flow calculation results for Alternative 1 obtained a value of -0.1667. Alternative 2 obtained a value of -0.6333. Alternative 3 obtained a value of -0.1000. Alternative 4 obtained a value of 0.0333. Alternative 5 obtained a value of 0.3667. Alternative 6 obtained a value of 0.3000. Alternative 7 obtained a value of 0.2000.

Based on the results of the Net Flow calculation, the ranking order of the seven alternatives can then be determined to determine the selected alternative, namely as follows in Table 6.

Table 4. Alternative preference values

Alternative Preference Value 1						
No.	**(A1.A2)**	**(A1.A3)**	**(A1.A4)**	**(A1.A5)**	**(A1.A6)**	**(A1.A7)**
1	0	1	0	0	0	0
2	1	1	0	0	0	0
3	1	0	1	0	0	0
4	1	0	0	0	0	0
5	0	0	0	0	0	0
Alternative Preference Value 2						
No	**(A2.A1)**	**(A2.A3)**	**(A2.A4)**	**(A2.A5)**	**(A2.A6)**	**(A2.A7)**
1	0	1	0	0	0	0
2	0	0	0	0	0	0
3	0	0	1	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
Alternative Preference Value 3						
No	**(A3.A1)**	**(A3.A2)**	**(A3.A4)**	**(A3.A5)**	**(A3.A6)**	**(A3.A7)**
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	1	1	0	0	0
4	0	1	0	0	0	0
5	1	1	0	0	0	1
Alternative Preference Value 4						
No	**(A4.A1)**	**(A4.A2)**	**(A4.A3)**	**(A4.A5)**	**(A4.A6)**	**(A4.A7)**
1	0	0	1	0	0	0
2	0	1	1	0	0	0
3	0	0	0	0	0	0
4	1	1	1	0	0	0
5	1	1	0	0	0	1
Alternative Preference Value 5						
No	**(A5.A1)**	**(A5.A2)**	**(A5.A3)**	**(A5.A4)**	**(A5.A6)**	**(A5.A7)**
1	0	0	0	0	0	0
2	1	1	0	1	0	1
3	0	1	0	1	0	0
4	1	1	0	0	0	0
5	1	1	0	0	0	1
Alternative Preference Value 6						
No	**(A6.A1)**	**(A6.A2)**	**(A6.A3)**	**(A6.A4)**	**(A6.A5)**	**(A6.A7)**
1	0	0	0	0	0	0
2	1	1	0	1	0	0
3	0	1	0	1	0	0
4	1	1	0	0	0	0
5	1	1	0	0	0	0
Alternative Preference Value 7						
No	**(A7.A1)**	**(A7.A2)**	**(A7.A3)**	**(A7.A4)**	**(A7.A5)**	**(A7.A6)**
1	0	0	1	0	0	0
2	0	1	1	0	0	0
3	0	1	0	1	0	0
4	1	1	1	0	0	0
5	1	1	0	0	0	0

Table 5. Multicriteria preference index

	A1	A2	A3	A4	A5	A6	A7
A1		0.6	0.4	0.2	0	0	0
A2	0		0.2	0.2	0	0	0
A3	0.2	0.6		0.2	0	0	0.2
A4	0.4	0.6	0.6		0	0	0.2
A5	0.6	0.8	0	0.4		0	0.4
A6	0.6	0.8	0	0.4	0		0
A7	0.4	0.8	0.6	0.2	0	0	

Table 6. Alternative ranking order

Alternative	Weight	Ranking
5	**0.367**	**1**
6	0.300	2
7	0.200	3
4	0.033	4
3	-0.100	5
1	-0.167	6
2	-0.633	7

Of the seven alternatives that have been determined, there are three highest alternatives, namely Alternatives 5, 6, and 7. Where Alternative 5 is implementing a policy for students to be able to walk within the campus area, Alternative 6 is using public transportation, and Alternative 7 is creating a one-day program without motorized vehicles on campus. The main alternative that will be proposed as the best strategy for climate mitigation from carbon emissions produced by motorized vehicles is Alternative 5 which is ranked first, where the alternative proposes to implement a policy for students to be able to walk during activities within the campus area, both short and long distances, so that by implementing the policy, the movement of motorized vehicles will rarely occur or even not occur at all in the campus area, except when the vehicle has just arrived or left the campus area. With this policy, it is hoped that it can reduce carbon emissions produced by motorized vehicles at the university.

This alternative implies that Pancasila University is expected to provide space for pedestrians by creating a pedestrian walkway. This proposal, in addition to reducing motorized vehicle use, can also prevent accidents caused by vehicle traffic. By providing a dedicated space for pedestrians, it will provide comfort to the academic community, enabling them to implement this alternative to achieve the research objective of climate mitigation from motorized vehicle carbon emissions.

Based on the results of this study, one alternative policy that could be implemented is to encourage students to walk around campus. This policy is expected to reduce reliance on private motorized vehicles, especially for short-distance mobility. In addition to directly helping reduce carbon emissions, this policy can also strengthen a culture of sustainable transportation on campus. Implementation can be done by providing safe, comfortable, and shaded pedestrian paths and limiting motorized vehicle access to certain areas. The second and third alternatives can also be implemented, namely, using public transportation and establishing a one-day car-free program on campus. If implemented consistently by the entire academic community, this policy has the potential not only to reduce carbon emissions but also to maintain and even improve previously achieved environmental sustainability scores.

4. CONCLUSION

The escalation of global industrialization and the excessive utilization of non-renewable energy sources have led to substantial greenhouse gas emissions, exacerbating global temperature rises and several environmental degradation challenges. Moreover, attaining net-zero carbon emissions and sustainable growth requires the advancement of carbon removal or sequestration in terrestrial and marine ecosystems. The quest for net-zero carbon emissions poses considerable hurdles. An urgent, thorough assessment of carbon emissions in higher education is required, necessitating the application of integrated methodologies such as PROMETHEE. This methodically examines the framework concerning carbon emissions and the elements that affect them, which underpins the selection of optimal reduction solutions. The findings suggest that enacting a policy permitting students to traverse the campus is deemed essential for attaining the university's long-term objectives of economic, social, and cultural development.

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