Strategic Assessment of Low-Carbon Initiatives in Malaysian Geoparks Using Importance-Performance Analysis

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ABSTRACT

The growing urgency to mitigate climate change has prompted the integration of low-carbon initiatives within environmentally sensitive areas such as geoparks. This study assesses the implementation and perceived importance of various low-carbon initiatives in Malaysian geopark sites using the Importance–Performance Analysis (IPA) framework. A quantitative research design was employed, utilizing a structured questionnaire distributed to 70 respondents from the management teams of recognized Malaysian geoparks. The variables examined include renewable energy use, waste management, eco-transportation, green technology adoption, and policy enforcement mechanisms. Descriptive statistics and IPA were applied to evaluate the performance of each initiative and to identify strategic improvement priorities. Findings reveal that initiatives such as renewable energy installation, 3R (Reduce, Reuse, Recycle) programs, and tree planting campaigns are performing well and should be maintained. Conversely, regulatory standardization, dedicated funding for low-carbon projects, and improved infrastructure for sustainable mobility were found to require more focused attention. The study highlights significant gaps in institutional capacity, awareness, and policy enforcement that hinder optimal implementation. Policy implications emphasize the need for stronger institutional frameworks, financial incentives, and community engagement mechanisms to strengthen sustainable practices in geoparks. The results contribute to enhancing Malaysia's transition towards a low-carbon future and provide valuable insights for policymakers, local authorities, and sustainability practitioners in developing effective low-carbon strategies for protected environmental sites.

Keywords: Geopark, Importance- Performance Analysis (IPA), Low Carbon Initiative

INTRODUCTION

Geoparks are officially designated protected areas that highlight significant geological features and their interconnections with ecological, archaeological, and cultural heritage. Beyond conserving geological assets, geoparks serve as living laboratories for sustainable development, education, and environmental stewardship, while also providing meaningful participation from local communities [3], [16]. On a global scale, geoparks integrate geodiversity, biodiversity, and cultural diversity to promote a balanced and resilient relationship between people and nature.

In Malaysia, the establishment of geoparks has progressed considerably under the UNESCO Global Geopark Network. Notable examples include the Langkawi UNESCO Global Geopark, Kinabalu Geopark, and Lembah Kinta Geopark, alongside several others still undergoing national recognition and development [7], [18]. These geoparks not only contribute to preserving natural and cultural heritage but also play a pivotal role in driving sustainable economic growth and environmental protection within their surrounding communities.

Low-carbon initiatives have become a crucial pillar of climate change mitigation strategies worldwide. They aim to reduce greenhouse gas emissions, particularly carbon dioxide (CO_2), through the use of cleaner energy sources, efficient resource management, and sustainable technological innovations [14]. In Malaysia, these efforts align with the *National Low Carbon Cities Masterplan*, which promotes a national transition toward renewable energy use, efficient urban systems, and more responsible consumption patterns. However,

implementation at the local level remains inconsistent, as many low-carbon initiatives are still voluntary rather than mandatory [37]. This situation often results in uneven progress across regions. Moreover, local authorities and geopark management units face recurring challenges, including limited manpower, insufficient funding, and a lack of technical expertise to support and sustain low-carbon practices [17], [33].

Despite growing national awareness of sustainability, translating low-carbon policies into tangible actions within geopark settings remains a major challenge. Most existing research on low-carbon initiatives in Malaysia has focused on urban development, industrial operations, or higher education institutions [19], [24]. Compared to other initiatives, relatively little is known about how these initiatives are understood, prioritized, and implemented in protected natural areas, such as geoparks. Furthermore, few studies have examined which specific low-carbon actions deliver the greatest environmental and operational impact from the perspective of geopark managers and stakeholders.

The gap can be found out by the present study employs the Importance–Performance Analysis (IPA) framework [31] to evaluate the implementation of low-carbon initiatives across Malaysian geopark sites. The IPA approach enables the identification of initiatives that are performing effectively, those requiring improvement, and those where resources may need to be reallocated for greater impact. By combining quantitative data analysis with strategic interpretation, this study provides a practical decision-making tool for policymakers, local authorities, and geopark managers seeking to enhance sustainability performance.

The study pursues two main objectives, which are to assess the level of implementation and perceived importance of various low-carbon initiatives within Malaysian geoparks and to identify strategic priority areas for improvement using the IPA matrix.

In conclusion, the study aims to bridge the gap between sustainability policy and practical implementation, contributing evidence-based insights to advance Malaysia's transition toward a low-carbon future through its geopark system.

LITERATURE REVIEW

Low Carbon Implementation in Malaysian Geopark Sites

Implementing low-carbon initiatives in Malaysian geopark sites offers a significant opportunity to promote sustainable development, protect ecosystems, and strengthen local communities' resilience against climate change. Geoparks with their unique geological, ecological, and cultural assets, can serve as living examples of how environmental stewardship and sustainable practices can coexist with economic growth and tourism development.

One of the most critical steps in reducing carbon emissions is transitioning to renewable sources of energy. Solar, wind, and hydropower systems can drastically cut reliance on fossil fuels, which are major contributors to greenhouse gas emissions. Beyond reducing environmental impacts, renewable energy enhances energy security, reduces energy costs, and can empower local communities. By providing reliable and affordable energy, once energy-poor communities can become energy-rich, unlocking new economic opportunities and improving quality of life [36]. In geopark contexts, renewable energy can also support infrastructure for tourism, research, and conservation without compromising environmental integrity.

Next, adopting energy-efficient technologies is another effective low-carbon strategy. This includes upgrading lighting, heating, and cooling systems, implementing smart building designs, and using energy-efficient appliances. Leh et al. [25] emphasize that emission reduction measures not only lower greenhouse gas emissions but also reduce operational costs in the long term. This approach aligns with the strategies outlined in the *Pelan Pelaksanaan Geopark Negara* by the Jabatan Mineral dan Geosains Negara, which prioritizes the development of green technologies. By integrating these solutions, geoparks can minimize their environmental footprint while promoting innovation and sustainable infrastructure.

Apart from that, proper waste management is essential for maintaining the ecological balance of geoparks.

Practices such as waste minimization, recycling, and composting reduce the environmental impact of tourism and park operations. Sustainable waste management also supports biodiversity by preventing pollution of soil, water, and habitats. Engaging visitors in waste reduction initiatives, such as "carry-in, carry-out" policies or recycling programs, can foster environmental awareness and create a culture of responsibility among tourists, employees, and local communities.

Other than that, carbon offsetting has emerged as a proactive approach to mitigating climate change. Tree-planting campaigns, reforestation, and restoration of degraded lands not only absorb carbon dioxide but also enhance biodiversity and protect water resources. Involving multiple stakeholders, including employees, local residents, and tourists, strengthens community engagement and creates a shared sense of environmental responsibility [25]. Such programs also provide educational opportunities and help geoparks meet conservation targets while actively contributing to global climate goals.

Moreover, transportation is a significant source of carbon emissions, and geoparks can adopt various strategies to reduce this impact. Green transportation options include expanding public transport networks, encouraging the use of electric vehicles (EVs), developing bike lanes, promoting walking trails, and designing urban layouts that minimize travel distances [49]. By improving accessibility and offering eco-friendly alternatives, geoparks can reduce their carbon footprint, ease traffic congestion, and enhance visitor experiences. Efficient mobility solutions also encourage sustainable tourism and demonstrate the practical benefits of low-carbon living.

Furthermore, low-carbon tourism emphasizes minimizing energy consumption, pollution, and emissions throughout the tourism lifecycle. This approach integrates environmental, social, and economic benefits, creating a holistic model for sustainable tourism [51]. Low-carbon tourism strategies can include promoting eco-lodges, energy-efficient accommodations, sustainable food sourcing, and eco-friendly recreational activities. Research has shown that evaluating energy efficiency, low-carbon behaviors, and strategic planning in tourism regions helps guide decision-making, prioritize sustainable investments, and create replicable models for other destinations [27].

To ensure long-term impact, geoparks can implement annual low-carbon programs that systemically reduce greenhouse gas emissions across all sectors. These programs can include public awareness campaigns, workshops, and educational initiatives to encourage sustainable practices among visitors, local communities, and employees. Regular monitoring, reporting, and evaluation are essential to track progress, identify challenges, and refine strategies over time [33]. Continuous engagement ensures that low-carbon initiatives are not one-time efforts but part of an enduring commitment to environmental stewardship.

In conclusion, implementing low-carbon initiatives in Malaysian geopark sites can transform these areas into models of sustainable development and environmental conservation. By adopting renewable energy, integrating energy-efficient technologies, managing waste responsibly, promoting carbon offsetting, providing sustainable transportation, and supporting low-carbon tourism, geoparks can substantially reduce their carbon footprint. Coupled with annual programs, public education, and systematic evaluation, these efforts create a long-term, holistic framework for sustainability. Therefore, these initiatives not only protect Malaysia's natural and cultural heritage but also enhance the resilience and well-being of local communities while contributing meaningfully to global climate mitigation efforts.

METHODOLOGY

This research uses a quantitative approach to explore the implementation and perceived importance of low-carbon initiatives in Malaysian geopark sites. Data were collected through structured questionnaires distributed via Google Forms to the management teams of these geoparks, with 70 respondents participating in this preliminary study. Descriptive statistics were first used to calculate mean scores for each low-carbon initiative, providing an overview of current practices. To further identify areas needing improvement, an Importance-Performance Analysis (IPA) was conducted.

The Importance-Performance Analysis (IPA) is a powerful tool for evaluating and enhancing low-carbon initiatives. It helps to highlight which practices are effective and which require additional attention, offering

clear guidance for strategic decision-making [34], [11]. Through IPA, the study captures the perceptions of geopark management teams regarding the significance and performance of various low-carbon initiatives. The framework used in this study is based on the IPA model originally developed by Martilla and James [31], which measures both the importance assigned to an initiative and how well it is currently being implemented.

IPA has gained recognition across many fields as a strategic and practical decision-making tool [12]. Its simple, visual format provides clear insights without the interpretive complexity of more sophisticated analytical techniques, making it particularly useful for conservation, tourism management, and service-oriented sectors [11], [34], [41]. By using the I-P matrix model, this study organizes the data into a four-quadrant framework, where each initiative is plotted based on its perceived importance and performance. This approach makes it easier to prioritize actions and allocate resources effectively.

The IPA matrix is divided into four quadrants, each with practical implications:

I. Quadrant A – "Keep up the good work": Initiatives in this quadrant are performing well and are considered important by management.

II. Quadrant B – "Concentrate here": Initiatives in this quadrant are highly important but currently underperforming, indicating areas that need urgent improvement.

III. Quadrant C – "Low priority": These indicators are low in both importance and performance. While they do not require immediate attention, they can be monitored for potential future development.

IV. Quadrant D – "Possible overkill": Initiatives here are performing well but may receive more resources than necessary.

By applying the IPA framework, Malaysian geopark management teams can make evidence-based decisions that optimize both resources and outcomes. The approach not only identifies strengths and weaknesses in current low-carbon initiatives but also provides actionable recommendations to enhance environmental sustainability. For instance, Quadrant B initiatives highlight areas where focused investment and strategic planning can yield substantial improvements, while Quadrant D initiatives suggest opportunities to reallocate resources for maximum impact.

As a result, the IPA framework bridges the gap between perception and performance, allowing geopark managers to prioritize initiatives that matter most, reinforce successful programs, and systematically address areas needing improvement. In this way, IPA serves as a practical tool to guide the implementation of low-carbon strategies, ensuring Malaysian geoparks can contribute effectively to climate mitigation while fostering sustainable tourism, biodiversity conservation, and community engagement.

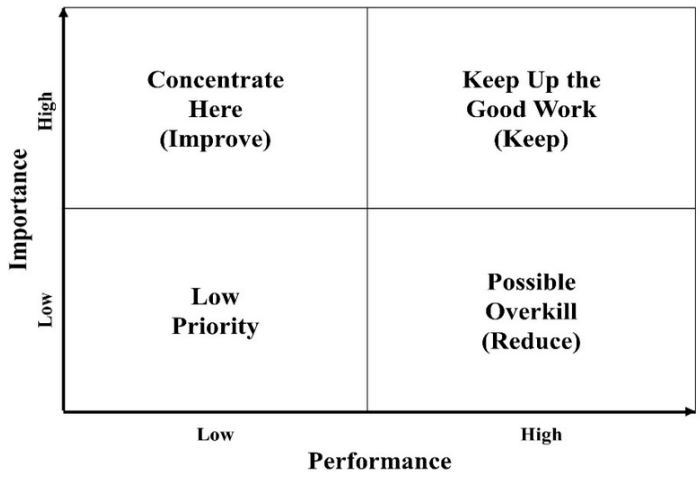

Fig. 1 Systematic Literature Review (SLR) information flow using PRISMA

FINDING AND DISCUSSION

This study aims to examine both the level of implementation and the perceived importance of low-carbon initiatives in officially listed Malaysian geopark sites, using a quantitative research approach. A total of 70 participants completed the survey questionnaire. The responses, collected using a dual Likert scale, were analyzed and ranked through an Importance-Performance Analysis (IPA). This approach provides valuable insights into how participants perceive the effectiveness and significance of current low-carbon initiatives in Malaysian geopark sites.

Samples Demography

To ensure the study reflects a practical, utilization-based perspective, only participants who were part of the management teams of Malaysian geopark sites at the time of the survey were included. This sample was considered essential for accurately representing the implementation of low-carbon initiatives within these sites. Participant information was summarized visually, including their familiarity with the concept of low-carbon initiatives (Fig. 2). Out of the 70 respondents, 61 participants (87%) indicated that they were familiar with the term. In contrast, 9 participants (13%) reported that they were not. This suggests that a small portion of the management team may not fully understand the concept of low-carbon initiatives and, consequently, may not actively implement them within their organizations.

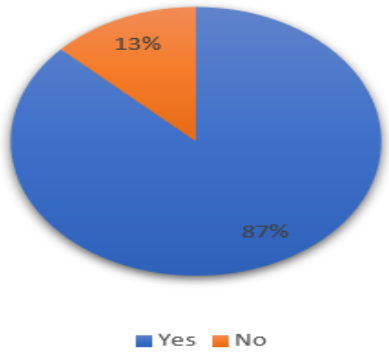

Fig. 2: Respondents' Understanding of Low-Carbon Initiatives Terms.

The demographic information of the respondents was categorized into four areas: gender, age, level of education, and work experience. The results showed that 57.1% of the participants were male, while 42.9% were female. Regarding age, 35.8% of participants were between 21 and 30 years old, 46.7% were between 31 and 40 years old, and 17.5% were over 40 years old. In terms of education, 15.7% of participants had completed SPM, 25.7% held a diploma, and 58.6% had a degree. Finally, participants' work experience varied, with 32.9% having less than five years, 47.1% between six and ten years, 7.1% between 11 and 15 years, and 12.9% with more than 15 years of experience in the industry.

Table 1: Demographics of participants

Gender	Frequency	Percentage (%)
Male	40	57.1
Female	30	42.9
Age		
21-30 years old	25	35.8
31-40 years old	33	46.7
More than 40 years old	12	17.5

Education Level		
SPM	11	15.7
Diploma	18	25.7
Degree	41	58.6
Master	-	
PhD	-	
Experience		
Less than 5 years	23	32.9
6-10 years	33	47.1
11-15 years	5	7.1
More than 15 years	9	12.9

Importance- Performance Analysis (IPA)

As shown in Table 2, the intersection point on the IPA grid is based on a mean performance score of 2.91 and a mean importance score of 3.69. By plotting initiatives according to their importance and performance, the IPA grid allows the management teams of Malaysian geopark sites to quickly identify which low-carbon initiatives require more attention and resources, helping to plan effectively and achieve the greatest impact. The IPA grid is divided into four main quadrants: Quadrant I – Concentrate Here, Quadrant II – Keep Up the Good Work, Quadrant III – Low Priority, and Quadrant IV – Possible Overkill. Figure 3 illustrates the placement of each low-carbon initiative within these quadrants, providing a clear overview of their current status and areas for improvement.

Table 2: The mean values of implementation and importance of low-carbon initiatives in Malaysian Geopark

Code	Low Carbon Initiatives	Level of Implementation		Level of Importance	
		Mean	Rank	Mean	Rank
L1	Use of renewable energy, such as solar energy.	3.35	7	3.96	10
L2	Installation of energy-efficient technology, such as LED lights.	4.08	1	3.73	13
L3	The implementation of the 3R waste separation (Reduce, Reuse, Recycle).	3.65	4	4.81	1
L4	Implementation of tree planting and forest conservation activities.	3.88	3	4.81	1
L5	Expanding access to public transport and infrastructure.	3.54	5	3.85	11
L6	Replacing the use of paper with an e-ticket system.	3.96	2	3.38	16
L7	Reduction in the use of plastic bags.	2.96	10	3.5	15
L8	Encourage the use of electric vehicles such as electric scooters.	3.27	8	4.31	6
L9	Detailed design for hiking and biking trails.	2.85	13	4.27	7

L10	Implementation of laws and regulations to standardize and institutionalize low-carbon.	2.46	15	4.77	3
L11	Standard setting of low-carbon initiatives and action plans.	2.73	14	4.65	4
L12	Provision of special funds to encourage the development of low-carbon projects and technologies.	2.88	11	4.65	4
L13	Provision of electric vehicle charging stations to reduce dependence on fossil fuel-powered transport.	3.12	9	3.85	11
L14	Implementation of waste reduction strategies, such as organic waste composting.	3.46	6	4.19	8
L15	The provision of "low emission vehicle" transport services, such as an EV shuttle bus	3.35	7	4.08	9
L16	Retrofit or re-install green and low-carbon technology facilities, such as the use of low-VOC paint.	2.88	11	3.58	14
	Average/Total	2.91	16	3.69	16

As shown in Table 2, the intersection point of the IPA grid is determined using a mean performance score of 2.91 and a mean importance score of 3.69. By mapping initiatives according to these two dimensions, the IPA grid enables the management teams of Malaysian geopark sites to quickly identify which low-carbon initiatives should receive more attention and resources, ensuring strategic planning and maximizing overall impact. The IPA grid is divided into four quadrants: Quadrant I – Concentrate Here, Quadrant II – Keep Up the Good Work, Quadrant III – Low Priority, and Quadrant IV – Possible Overkill. Figure 3 presents the placement of each low-carbon initiative within these quadrants, offering a clear overview of performance and priority areas.

Figure 3 illustrates the IPA grid applied to evaluate low-carbon initiatives in Malaysian geopark sites. Each quadrant represents a different strategic focus based on the importance and performance of various initiatives. Quadrant II - Keep Up the Good Work, shows initiatives in this quadrant are both important and performing well, indicating that current efforts should be maintained and reinforced. Examples include the use of renewable energy (e.g., solar power), installation of energy-efficient technologies like LED lighting, implementation of 3R waste management (Reduce, Reuse, Recycle), tree planting and forest conservation activities, expanding public transportation access, encouraging electric vehicle (EV) use such as scooters, providing EV charging stations, composting organic waste, and offering low-emission transport services such as EV shuttle buses. These strategies are recognized as effective by the community and represent best practices that should continue to receive support.

Quadrant I - Concentrate Here, shows initiatives in this quadrant are considered important but are currently underperforming, highlighting areas that require additional focus and resources. Key examples include the implementation of laws and regulations to standardize low-carbon practices, the development of action plans and standards for low-carbon initiatives, allocation of special funds to support low-carbon projects and technologies, and the detailed design of hiking and biking trails. Improving these initiatives could significantly enhance the overall effectiveness of low-carbon strategies in the geoparks.

Quadrant III - Low Priority, shows initiatives in this quadrant are both less important and underperforming relative to other strategies, suggesting that they do not require immediate attention or additional resource allocation. Examples include retrofitting or upgrading building facilities with green and low-carbon technologies, such as using low-VOC paints, and reducing the use of plastic bags. While still beneficial, these measures are currently not seen as urgent or high-impact.

Quadrant IV - Possible Overkill, shows initiatives in this quadrant are performing well but are perceived as less important by the community, indicating potential over-investment. For instance, replacing paper tickets with an

e-ticket system is effective but may not be as critical as other high-priority initiatives. Resources invested here could potentially be redirected to areas that the community considers more significant.

In conclusion, the IPA framework provides a practical way to visualize and prioritize low-carbon initiatives, helping management teams make informed decisions about where to focus resources, maintain successful practices, and improve underperforming areas.

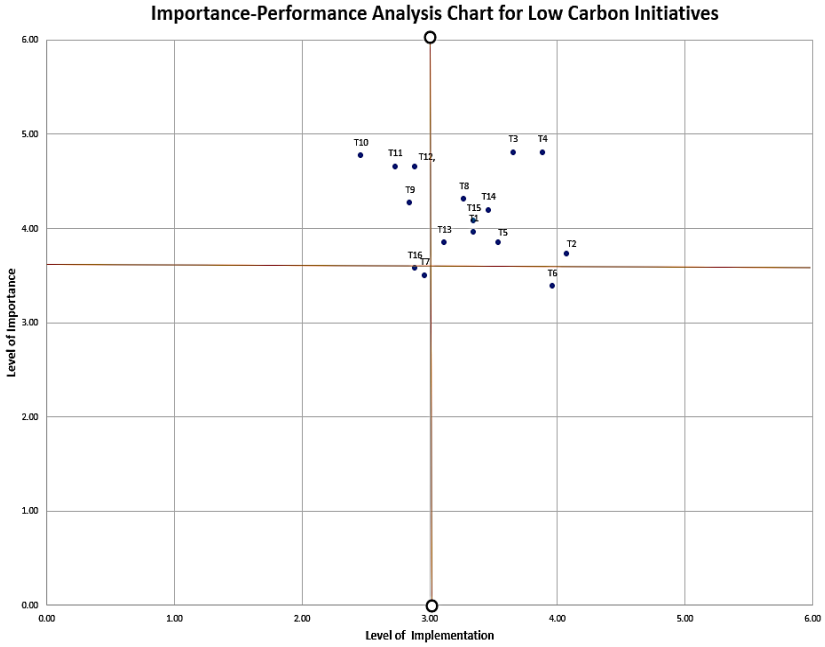

Fig. 3: IPA Chart for Low Carbon Initiatives

CONCLUSION

In conclusion, this study shines a light on the journey of implementing low-carbon initiatives in Malaysian geopark sites, revealing both the successes achieved and the challenges that remain. While many initiatives have already been introduced across the geopark's operations, there is still room for improvement to ensure these efforts are more effective, sustainable, and aligned with the long-term vision of environmental stewardship. By examining both the level of implementation and the perceived importance of these initiatives, this research provides a comprehensive snapshot of how Malaysian geoparks are progressing toward a low-carbon future.

The Importance-Performance Analysis (IPA) offers a practical roadmap for action. It highlights which initiatives deserve immediate attention, which ones can be refined, which are less critical, and which are already performing well and should be maintained. This approach allows geopark management teams to focus resources strategically, enhancing initiatives that make the greatest impact while avoiding unnecessary effort on lower-priority activities.

Therefore, this research emphasizes that promoting low-carbon practices is an ongoing journey, one that requires careful planning, continuous evaluation, and a commitment to improvement. It not only celebrates the progress Malaysian geoparks have made but also guides future researchers and practitioners looking to advance sustainability. By identifying key factors for successful implementation, this study contributes to a roadmap for greener, more resilient geoparks, where environmental conservation and sustainable development go hand in hand.

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