

Building Sustainable Futures: The Role of Green Intellectual Capital and Environmental Knowledge in Public Institutions

Nur'ain Achima,^a Nurul Liyana Mohd Kamilb,^{b*} and Nur Hairani Abd Rahman^c

Abstract: Pursuing sustainable development has become a critical concern for organisations worldwide. This concern also affects the public institutions, where balancing diverse stakeholder expectations, navigating resource constraints, and ensuring public accountability pose significant challenges to achieving comprehensive sustainability goals. Recognising the importance of intangible resources in achieving such goals, this study investigates the influence of green intellectual capital on sustainable performance and the mediating effect of environmental knowledge on this relationship in the Malaysian public institutions. A cross-sectional survey was conducted using a purposive sampling technique among leaders of government agencies in Malaysia. The data was analysed using partial least squares structural equation modelling (PLS-SEM). The results show that green intellectual capital acts as a positive predictor of sustainable performance. In this relationship, environmental knowledge acts as a mediating role, implying that organisations need to have a consistent practice in developing environmental knowledge among the employees. Instead, environmental awareness helps firms better leverage the value of green intangible assets.

Keywords: Green intellectual capital; environmental knowledge; sustainable performance; public institutions; resource-based view

JEL Classification: Q01, H83, C38

^a Department of International Business and Management Studies, Faculty of Business and Management, Universiti Teknologi MARA, 42300 Selangor, Malaysia. Email: ainachim@uitm.edu.my. <https://orcid.org/0000-0002-9331-1654>

^b Corresponding author. Department of Public Administration, Faculty of Business and Economics, Universiti Malaya, 50603 Kuala Lumpur, Malaysia. Email: nurulliyana@um.edu.my. <https://orcid.org/0000-0002-2965-5073>

^c Department of Public Administration, Faculty of Business and Economics, Universiti Malaya, 50603 Kuala Lumpur, Malaysia. Email: nurhairani@um.edu.my. <https://orcid.org/0000-0002-0046-3588>

1. Introduction

As environmental degradation escalates globally, the urgency to embed sustainable development across all levels of governance has never been greater. Malaysia, located in a warm tropical climate and rich natural landscapes, is home to incredible biodiversity, holds a unique responsibility in safeguarding the planet for future generations. However, the country has become increasingly vulnerable to climate-related disruptions such as biodiversity loss, extreme weather events, and ecosystem decline. In response, the Malaysian government has launched key frameworks to embed sustainability within its national development agenda. The National Green Technology Policy (NGTP) aims to promote economic growth through the adoption of green technologies, while the public institutions Conducive Ecosystem or also known as *Ekosistem Kondusif Sektor Awam (EKSA)*, complements the NGTP by fostering a supportive culture of environmental responsibility within the public institutions by promoting green procurement, innovation, and operational efficiency. Together, these initiatives reflect Malaysia's commitment to Sustainable Development Goal 12 (SDG 12), which emphasises sustainable consumption and production through strategic policy integration (Kamaruddin & Shamsudin, 2021; Zan & Ngah, 2012).

Despite these efforts, translating national sustainability commitments into consistent, measurable improvements within public institutions remains a persistent challenge. Limited resources, fragmented implementation structures, and competing priorities hinder the effective institutionalisation of environmental practices. As sustainability expectations increase, these constraints not only risk the failure of policy goals but also weaken the public institutions' capacity to contribute meaningfully to national and global environmental targets. Addressing this implementation gap requires more than procedural reform and demands a strategic shift towards leveraging internal, knowledge-based capabilities that foster innovation and green behaviour from within the organisation.

In this context, green intellectual capital (GIC) offers a promising but underexplored solution. GIC refers to the green-oriented human competencies, structural systems, and relational networks that comprise an institution's intangible assets (Chen, 2008). These valuable, inimitable, and rare assets are the basis of a competitive advantage and better sustainable performance (López-Gamero et al., 2011; Wang et al., 2014).

Through distinctive knowledge, experiences, and external linkages, GIC enables public organisations to stimulate green innovation and embed environmental principles in everyday practice. However, existing research has largely focused on GIC within corporate settings, leaving a notable gap in understanding its strategic role within public institutions, especially in emerging economies like Malaysia.

To address this gap, the present study positions environmental knowledge as a critical mediating mechanism that links GIC to sustainable performance. Rather than being a component of GIC, environmental knowledge reflects employees' capacity to interpret, internalise, and apply ecological principles in organisational contexts. As Ahmad et al., (2021) argue, fostering green behaviour in the workplace and effectively activating GIC depend on the depth of environmental understanding shared across institutional actors. This mediating role enables organisations to transform green intellectual assets into tangible sustainability outcomes. By examining this dynamic within Malaysian public institutions, the study offers novel insights into how internal green capabilities, when activated through environmental knowledge, can overcome structural barriers and accelerate institutional progress toward national sustainability objectives. In doing so, it addresses a critical theoretical and practical gap, contributing to the advancement of GIC literature and strengthening the strategic foundation of Malaysia's public-sector environmental leadership.

1.1 Resource-based view

This study is grounded in the Resource-Based View (RBV), which states that an organisation's specific resources and abilities are the main basis for competitive advantage. RBV suggests that firms can derive and preserve a competitive advantage when they develop and utilise valuable, rare, inimitable and non-substitutable resources (VRIN) (Barney, 1991; Barney, 2001). In this context, green intellectual capital (GIC) is conceptualised as a strategic and intangible resource capable of supporting sustainability transformation in public institutions. GIC encompasses environmentally oriented human competencies, organisational structures, and stakeholder relationships (Chen, 2008). These elements, when developed and integrated, constitute valuable assets that are difficult to replicate, often embedded in specific institutional routines and networks. For example, localised

environmental expertise or specialised knowledge in green building design is both rare and inimitable, offering public institutions the opportunity to tailor sustainability strategies to their context (Rahayu et al., 2023).

Additionally, within this framework, environmental knowledge is positioned not as a resource itself, but as a mediating capability, which is a mechanism that enables institutions to activate and apply GIC effectively. Employees' understanding, interpretation, and practical use of environmental principles are essential to translate green resources into measurable sustainability outcomes. Also, the cultivation of green behaviour in the workplace depends on a deep internalisation of ecological knowledge and its integration into everyday decision-making (Ahmad et al., 2021). Thus, the relationship between GIC and environmental knowledge serves as a key theoretical bridge, offering insight into how intangible assets generate strategic impact in public-sector sustainability efforts.

While RBV offers a valuable framework for understanding the strategic role of GIC in public institutions, its limitations deserve to be explored. RBV's static emphasis on resource possession and exploitation may fall short in addressing the complex and rapidly evolving demands of sustainability transitions (Fahy, 2000). Moreover, the intangible nature of GIC presents challenges for empirical validation, as its measurement is often ambiguous and context-dependent. RBV also prioritises internally controlled resources, particularly those that are rare and inimitable. This condition could potentially neglect critical external influences such as regulatory mandates, stakeholder pressures, and cross-sector collaborations that shape sustainability outcomes (Chahal et al., 2020).

Given these constraints, competing theoretical perspectives offer alternative lenses that could potentially frame this study. For instance, the Knowledge-Based View (KBV) focuses on knowledge as the most strategic resource within institutions, underscoring the importance of learning, innovation, and knowledge integration (Grant, 1996). However, KBV treats knowledge as a core asset, whereas this study conceptualises environmental knowledge as a mediating capability that activates the strategic potential of GIC, that align more closely with RBV's emphasis on intangible capital. Likewise, Institutional Theory highlights how external forces such as laws, norms, and societal expectations influence organisational behaviour, offering valuable insight into compliance dynamics (Scott, 2004). Yet, it does not adequately capture how internal assets like GIC drive voluntary and strategic

sustainability performance beyond external mandates.

Considering these alternatives, RBV remains the most suitable underpinning theory for this study. Its focus on valuable, rare, and inimitable resources provides a rigorous lens to examine how public institutions can cultivate and leverage GIC for long-term environmental performance. By introducing environmental knowledge as a mediating capability, this study also addresses RBV's limitations and enhances its relevance to the dynamic context of public-sector sustainability.

2. Literature Review and Hypothesis Development

2.1 Sustainable performance

Sustainable performance in public institutions reflects the evolving complexity of governance, equity, and environmental responsibility. Unlike private-sector organisations, which primarily pursue profitability, public institutions must navigate the intricate balance between economic efficiency, social impact, and ecological stewardship. Sustainable performance is an approach fundamentally aligned with the Triple Bottom Line (TBL) theory. Introduced by Elkington (1998), TBL emphasises that true organisational success hinges on three dimensions, that is, economic, social, and environmental outcomes. This framework has become an influential benchmark for sustainability assessment across sectors.

Strategic tools such as the Sustainable Balanced Scorecard and the Global Reporting Initiative build upon TBL principles, integrating them into performance measurement and sustainability reporting practices (Budiarso & Mir, 2012; Samuel et al., 2013; Trevlopoulos et al., 2021). However, in public institutions, implementing sustainable performance remains challenging. These organisations face pressure from diverse stakeholders, political shifts, and the inherent tension between short-term service delivery and long-term sustainability goals. Reporting and operationalising sustainability becomes particularly complex under these dynamic conditions.

Further complicating matters, public institutions operate within bureaucratic constraints and limited resource environments, which often inhibit the adoption of innovative sustainability practices (Amran et al., 2021; Joseph, 2013). Public institutions also must be open and responsive in their environmental and socially responsible activities, as the nature of

working for the public requires accountability to many diverse stakeholders (Huy & Phuc, 2020). Yet, their societal role positions them uniquely to drive systemic change, both as policy-makers and infrastructure developers. Their ability to embed sustainability into core operations directly influences ecosystems, communities, and broader national targets (Rahim et al., 2023).

In this literature review, green intellectual capital serves as a vital process in achieving sustainable performance within public institutions. By mobilising the environmentally intangible assets, institutions can strengthen their capacity to address sustainability imperatives grounded in TBL principles and respond more effectively to their multifaceted mandates.

2.2 *Green Intellectual Capital*

In alignment with the Resource-Based View (RBV), which posits that intangible assets serve as key drivers of sustained organisational performance (Barney, 1991), intellectual capital has long been recognised for its strategic role in achieving competitive advantage. Intellectual capital offers numerous performance benefits, including enhanced innovation, improved work systems, and strengthened organisational value (Xu & Liu, 2019; Shahzad et al., 2019; Dwianika & Gunawan, 2020; Yong et al., 2019).

Building on this foundation, Green Intellectual Capital (GIC) combines intellectual capital with environmental consciousness to advance sustainability within organisations (Chen, 2008). GIC encompasses intangible assets at both the individual and organisational level that allow for environmentally friendly behaviour. GIC comprises three key elements, namely, green human capital, green structural capital, and green relational capital.

Green human capital refers to employees' environmental knowledge, skills, creativity, and commitment to ecological values (Chen, 2008). In public institutions, a workforce equipped with such competencies can drive innovations in service delivery, enhance resource efficiency, and collaborate effectively on sustainability initiatives. Next, green structural capital represents the formalised systems, codified knowledge, and technological infrastructure that support environmental goals, including green technologies, environmental management systems, and sustainability-focused organisational culture (Chen, 2008; Jardon & Martos, 2012). These can be manifested in public-sector settings through green building standards,

sustainable procurement policies, and environmental performance monitoring systems.

Meanwhile, green relational capital focuses on the relationships between institutions and their external stakeholders, such as NGOs, community groups, private sector partners, and other government agencies (Chen, 2008). Through these networks, public institutions can leverage diverse expertise, exchange best practices, and expand their environmental impact (Chang & Chen, 2012).

Integrating GIC into organisational strategy offers multiple benefits for public institutions, including enhanced environmental management, improved regulatory compliance, increased attractiveness to talent, and a stronger sustainability-oriented culture (Huang & Kung, 2011; Xu & Liu, 2019). Notably, GIC plays a crucial role in advancing sustainable performance. It fosters innovation in public service delivery by facilitating cleaner technologies, reducing waste, and improving resource utilisation. Institutions with robust GIC are also better equipped to address social equity concerns tied to environmental policy, encouraging inclusive decision-making and advancing environmental justice (Anwar et al., 2020).

Moreover, GIC empowers public organisations to implement effective environmental management practices, leading to improved ecosystem preservation, pollution control, and climate resilience. By leveraging institutional knowledge and ecological expertise, public institutions can minimise their environmental footprint, protect biodiversity, and contribute meaningfully to long-term sustainability goals (Rahayu et al., 2023).

2.3 Environmental knowledge

Knowledge is one of the key assets both individuals and organisations possess, prior to their responses addressing environmental sustainability challenges (Munawar et al., 2022). Environmental knowledge is critical, especially for public-sector organisations that serve the public good. It allows these institutions to take data-led decisions, formulate balanced policies and adopt interventions which further economic development but also promote welfare and protect the environment.

Public institutions' environmental knowledge is much more than knowing about environmental problems. It requires detailed awareness of the complex interdependencies between human behaviour and ecological

systems, including an understanding of mitigation strategies to minimise adverse effects (Zsóka et al., 2013). It encompasses knowledge of environmental regulations, scientific concepts, sustainable practices, as well as the socio-economic aspects that impact environmental results. A public institution's workforce tasked with designing and implementing sound environmental policy is better equipped to do so with a strong knowledge base of environmental concerns. Understanding the science behind environmental problems and the possible social and economic effects of policy choices is important for drawing up effective and fair solutions. In addition, informed public servants help better communicate environmental challenges to the public, facilitate collaboration on solutions, and empower communities to embrace more sustainable behaviours.

Many studies demonstrate a strong relationship between knowledge about the environment and pro-environmental behaviour (Chan et al., 2014; Mostafa, 2007). People who understand environmental problems are more likely to practice green behaviour in their private lives and work. Indeed, low knowledge about the environment can be a barrier to the practice of green behaviours (Issock et al., 2019). For public institutions, cultivating environmental knowledge within their workforce is not merely a matter of corporate social responsibility. It is essential to fulfilling their mission to serve the public interest. With knowledge in the environment being as important as it is, thus it is necessary for organisations to adapt and innovate through upskilling the employees to tackle the current environmental storm facing us.

2.4 Relationship between Green Intellectual Capital and sustainable performance

Green intellectual capital is increasingly recognised as a strategic asset for advancing sustainability within public institutions, particularly as they face growing pressure to balance economic efficiency with environmental and social responsibility. Within GIC, green human capital plays a foundational role. It comprises employees' environmental knowledge, skills, creativity, and commitment to ecological values (Chen, 2008), equipping the workforce to innovate service delivery, promote resource efficiency, and foster a culture of sustainability. Studies have shown that institutions with green-competent employees are better positioned to meet environmental standards and

embed sustainable practices in organisational decision-making (Mansoor et al., 2021; Massaro et al., 2018; Yong et al., 2019). These competencies contribute not only to environmental protection but also to broader social outcomes, such as climate resilience and public well-being.

Beyond human resources, green structural capital, which represents the formal systems, processes, and knowledge infrastructure that support environmental goals is equally essential. It includes elements such as green technology adoption, environmental management systems, and sustainability-oriented organisational culture (Chen, 2008; Jardon & Martos, 2012). In public-sector settings, this might be reflected through green building standards, sustainable procurement practices, and data systems for monitoring environmental performance. Mohd-Yusoff et al. (2020) highlighted the critical role of green cultural values and innovation capabilities in driving sustainability, while Iranmanesh et al. (2019) demonstrated how design and process improvements aligned with lean management principles positively influence sustainable outcomes.

The third dimension, green relational capital, refers to the strength and quality of an institution's external partnerships and collaborative networks that support sustainability. These relationships, namely with suppliers, NGOs, industry partners, and community organisations, facilitate knowledge sharing, resource alignment, and joint environmental initiatives (Chen, 2008). Mohd-Yusoff et al. (2020) found that environmentally conscious suppliers and customers contribute to a deeper understanding of stakeholder perspectives on sustainability, enabling organisations to refine their strategies accordingly. In public institutions, engaging with environmentally responsible stakeholders enhances the effectiveness of green procurement and policy implementation, while also amplifying local relevance and public trust. For instance, (Tonial et al., 2018) found that stakeholder engagement fosters deeper insights into community needs, leading to more inclusive and context-sensitive sustainability programs.

Based on the above discourse, this research proposed that GIC significantly influences sustainable performance. Thus, the following hypothesis is established:

H₁ Green Intellectual Capital has a positive effect on sustainable performance.

2.5 *Mediating effect of environmental knowledge on Green Intellectual Capital and sustainable performance*

Building on the strategic importance of Green Intellectual Capital (GIC), this study introduces environmental knowledge as a critical mediating mechanism that connects GIC to sustainable performance outcomes. In the context of public institutions, where social and environmental accountability is paramount, employees must be equipped with both explicit and tacit environmental knowledge to effectively operationalise sustainability goals (Moraes et al., 2019). Explicit knowledge encompasses data, regulations, and established practices, such as understanding environmental laws and regulations, while tacit knowledge embodies individual experiences, intuition, and understanding, like applying conservation techniques based on site-specific observations.

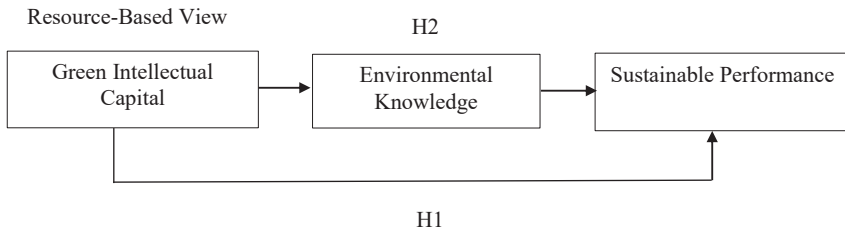
This comprehensive knowledge base empowers employees to contribute to sustainability goals through informed decision-making, efficient resource management (Munawar et al., 2022), and the development of innovative solutions (Moraes et al., 2019). When embedded across organisational culture, environmental knowledge enhances collaboration with stakeholders, including environmentally conscious suppliers and communities (Mohd-Yusoff et al., 2020), to implement sustainable practices throughout the supply chain.

Moreover, knowledge-sharing initiatives enable public institutions to transfer insights across departments, disseminate regulatory updates, and scale sustainable technologies and best practices. Research has shown that green-skilled employees contribute to waste reduction, cost efficiency, and lower resource consumption, reinforcing organisational performance and environmental impact (Jabbour & Santos, 2008; Mohd-Yusoff et al., 2020).

Despite its importance, the mediating role of environmental knowledge in linking GIC to sustainable performance has received limited empirical attention. This study therefore positions environmental knowledge as a pivotal element in activating green resources and advancing innovation, engagement, and sustainability outcomes in public institutions (Chang & Chen, 2012). Based on this rationale, the following hypothesis is proposed:

- H₂ Environmental knowledge mediates the relationship between green intellectual capital and sustainable performance.

Figure 1: Conceptual framework.



3. Methodology

This study employed a cross-sectional survey design to investigate the relationship between green intellectual capital, environmental knowledge, and sustainable performance within Malaysian public institutions. Data were collected through an online questionnaire sent to personnel engaged in sustainability-related practices within their institutions. Potential participants were identified from the Malaysian Government’s official directory covering the federal, state, local government agencies and statutory bodies. Despite being a comprehensive listing via the directory, a stratified and convenience sampling technique was employed to ensure representation across various levels of public institutions.

The survey instrument was carefully developed, drawing upon previously validated measures to ensure construct validity and reliability. Sustainable performance, the dependent variable, was measured using a five-item scale adapted from Gelhard and Von Delft (2016), assessing economic, social, and environmental dimensions. Green intellectual capital, the independent variable, was measured using seventeen items adapted from Huang & Kung (2011) and Yusof et al. (2019), encompassing green human, structural, and relational capital subdimensions. Environmental knowledge, the mediating variable, was measured using a scale adapted from Fawehinmi et al. (2020).

Control variables, including job position and length of working experience, were incorporated into the study design to mitigate potential biases and enhance the precision of the analysis. A total of 195 respondents participated in the survey, yielding 167 usable responses after data cleaning and screening. This robust sample size strengthens the generalizability of the findings to the broader population of Malaysian public institutions. This

research obtained ethical approval from the University Malaya Research Ethics Committee (UMREC) (reference no: UM.TNC2/UMREC_1647).

4. Results and Discussion

4.1 Preliminary analysis

This study acknowledges the potential for common method variance given the use of a single-source, self-reported online survey. Thus, to minimise this risk, the questionnaire employs five-point Likert and seven-point Likert scales, introducing variation in response scales as a mitigation strategy (Podsakoff et al., 2012, 2016). As part of the preliminary analysis, a full collinearity test was performed. This test, assessed using tolerance (greater than 0.10) and variance inflation factor (VIF; less than 10), examined relationships between constructs and ensured the robustness of the model estimation (Bougie & Sekaran, 2020; Sarstedt & Mooi, 2014).

Table 1 presents the common method variance test data, indicating all variables have VIF values ranging from 2.042 to 4.617, below 10. Similarly, all tolerance values are above 0.10. This suggests that multicollinearity is likely not a major concern in our data. Thus, with VIF values within the acceptable range, we have more confidence that the estimated relationships between the independent and dependent variables are not unduly inflated or distorted by multicollinearity.

Table 1: Common method variance test

Variable	EnK	GHC	GSC	GRC
Tolerance	0.490	0.234	0.265	0.217
VIF	2.042	4.267	3.772	4.617

Note: Enk = Environmental Knowledge, GHC = Green Human Capital, GSC = Green Structural Capital, GRC = Green Relational Capital, SP = Sustainable Performance

4.2 Hypothesis testing

This study employed structural equation modelling (SEM) to rigorously examine the hypothesised relationships between constructs. SEM is particularly well-suited for this investigation because it can accommodate

complex relationships where a variable may function as both a dependent and an independent variable across different relationships. This approach provides a more comprehensive view of the interplay between constructs than traditional methods. Furthermore, SEM does not assume homogeneity of variances and covariances for the dependent variable, making it a more appropriate choice for data that may violate this assumption. The following sections detail the specification and assessment of the measurement and structural models, providing a robust evaluation of the hypothesised relationships.

4.3 Measurement model

This research model delves into intricate structures, examining higher-order models, specifically focusing on the Green Intellectual Capital (GIC) as the overarching entity and containing two layers of constructs, also known as hierarchical component models (HCM) (Hair et al., 2017). Within the HCM framework, GIC comprises the higher-order component (HOC), embodying a more abstract perspective, while the lower-order components (LOCs) include Green Human Capital (GHC), Green Structural Capital (GSC), and Green Relational Capital (GRC), representing the subdimensions of GIC (Hair et al., 2017). Notably, our research framework aligns with the Type I model, reflective-reflective HCM, indicating a reflective relationship between GIC and its components. Furthermore, all first-order constructs, including GHC, GSC, and GRC, are evaluated using reflective indicators.

Additionally, this research applied the disjoint two-stage approach, or sequential latent variable score method, incorporating GIC and its subdimensions. In the first stage, latent variable scores determined in PLS-SEM were used without the second-order component. Subsequently, these initial construct scores, including those of green human capital, green structural capital, and green relational capital, served as indicators for the higher-order GIC in a separate second-stage analysis (Chin, 1998; Lohmoller, 1989; Sarstedt et al., 2019). The loadings, composite reliability (CR) and average variance extracted (AVE) were determined for the first- and second-order constructs. Table 2 and Table 3 show the measurement model analysis for the HOC and LOC. According to (Hair et al., 2017) and Ramayah et al. (2018), the loading should exceed the threshold value of 0.708, indicating sufficient indicator reliability, while the CR value (>0.7) and the average variance

extracted value (>0.5) (Hair et al., 2014). The findings show that the AVEs are all higher than 0.5, and the CRs are all higher than 0.7. Following, Figure 2 and Figure 3 present the measurement model for lower-order constructs and higher-order constructs.

Table 2: Measurement model for LOC

Variables	Indicator	Loadings	CR	AVE
Green Human Capital	GHC1	0.907	0.943	0.806
	GHC2	0.892		
	GHC4	0.933		
	GHC5	0.858		
Green Structural Capital	GSC2	0.847	0.948	0.821
	GSC3	0.913		
	GSC4	0.940		
	GSC5	0.922		
Green Relational Capital	GRC1	0.927	0.968	0.909
	GRC4	0.967		
	GRC5	0.967		
Environmental Knowledge	EnK1	0.901	0.942	0.844
	EnK2	0.937		
	EnK3	0.918		

Note: Items GHC3, GSC1, GSC6, GSC7, GRC2 and GRC3 were deleted due to low loadings.

Figure 2: Measurement model for lower order constructs.

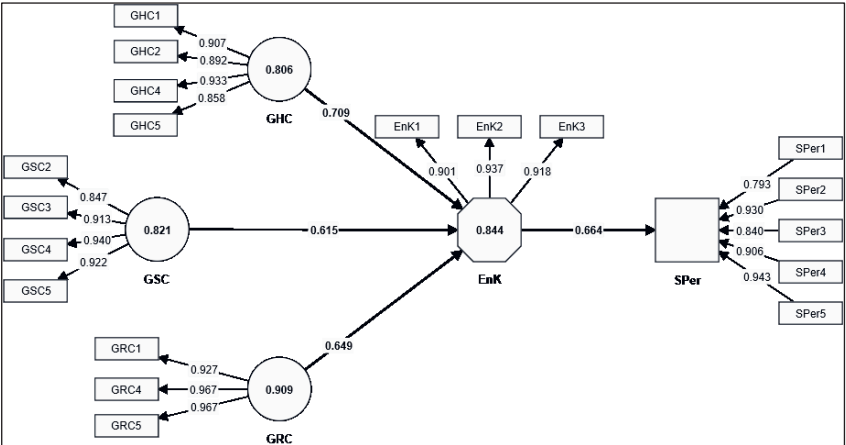
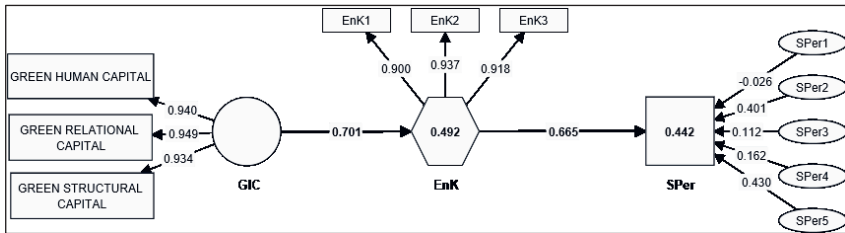


Table 3: Measurement model for HOC

Second Order Constructs	Indicator	Loadings	CR	AVE
Green Intellectual Capital	GHC	0.940	0.959	0.886
	GRC	0.949		
	GSC	0.934		

Figure 3: Measurement model for higher order constructs



Moving on to the next stage, discriminant validity was evaluated using the HTMT criterion, initially proposed by Henseler et al. (2015) and later refined by Franke and Sarstedt (2019). This evaluation is conducted to verify that the measured constructs are distinct. As shown in Table 4, all constructs were lower than 0.90, which indicates that the discriminant is established in the measurement model. Hair et al. (2019) also suggested running bootstrapping to examine whether the HTMT value significantly differed from 1.00. The findings indicate that the confidence interval does not exceed 1.00 on any of the constructs, thus confirming the discriminant validity (Henseler et al., 2015).

Table 4: Discriminant validity (HTMT)

	EnK	GIC	GHC	GRC	GSC
EnK	0.756				
GIC	0.756	0.774			
GHC	0.756	0.774	0.893		
GRC	0.756	0.774	0.893	0.897	
GSC	0.756	0.774	0.893	0.897	0.897

Note: EnK = Environmental Knowledge, GHC = Green Human Capital, GSC = Green Structural Capital, GRC = Green Relational Capital, GIC = Green Intellectual Capital.

4.4 *Measurement model of formative constructs*

This study utilises a formative measurement model to assess the construct of Sustainable Performance (SP). Unlike reflective models, evaluating formative constructs necessitates a distinct approach that emphasises collinearity diagnostics and the significance and relevance of each indicator (Jarvis et al., 2003). It consists of assessing the collinearity issues ($VIF < 5$) and evaluating the significance and relevance ($p\text{-value} < 0.05$) of the formative indicators.

As depicted in Table 5, all SP indicators exhibit VIF values below the recommended threshold of 5, effectively ruling out collinearity concerns. The subsequent step involves determining the significance and relevance of each indicator through a bootstrapping procedure. This procedure yields both outer weights, representing the relative contribution of an indicator when considering all other indicators in the model, and outer loadings, signifying the absolute contribution of an indicator independent of others. Also, reveals that while only two indicators (SP2 and SP5) have significant p-values for their outer weights ($p < 0.05$), all five indicators demonstrate significant p-values for their outer loadings ($p < 0.05$). This suggests that although some indicators may not have strong relative contributions, they all contribute meaningfully to the overall SP construct. Therefore, the formative measurement model for SP satisfies both reliability and validity criteria, allowing for the retention of all indicators and further analysis of the structural model.

Table 5: Measurement model for formative construct

Indicator	VIF	p-value	
		Outer Weights	Outer Loadings
SP1	3.083	0.436	0.000
SP2	4.524	0.017	0.000
SP3	3.171	0.276	0.000
SP4	4.609	0.207	0.000
SP5	3.731	0.017	0.000

4.5 Structural model

Further, the structural model assessment determines the research model's capabilities to predict one or more target constructs and whether the data support the hypotheses presented in the structural model (Hair et al., 2017; Urbach & Ahlemann, 2010). Following the recommendations of Hair et al. (2019) and Ramayah et al. (2018), we reported the R-square, path coefficient, t-values, p-values, and confidence interval bias-corrected (BCI) for the structural model assessment. The approach for calculating the structural model utilised the 10,000 sample re-sample bootstrapping, with the percentile method and slower procedure (Becker et al., 2023; Ramayah et al., 2018). Based on Aguirre-Urreta & Rönkkö's (2018) evaluation, the percentile bootstrap performs best as it estimates the 2.5% and 97.5% percentiles of a parameter value's distribution.

The R square (R^2) value explains the amount of variance in the endogenous constructs explained by the exogenous constructs. According to Hair et al. (2014), the R^2 value should be between 0 and 1. A higher R^2 value (close to 1) indicates a heightened level of predictive accuracy, emphasising the robustness of the model. Various scholars, including Cohen (1988), have established guidelines for interpreting that R^2 values concerning endogenous latent variables are assessed as 0.26 (substantial), 0.13 (moderate), and 0.02 (weak). Chin (1998) suggests higher thresholds at 0.67 (substantial), 0.33 (moderate), and 0.19 (weak), while Hair et al. (2017) propose more stringent criteria for scholarly marketing research, with R^2 values of 0.75 (substantial), 0.50 (moderate), or 0.25 (weak).

In the specific context of our analysis, as presented in Table 6, the findings underline the explanatory power of green intellectual capital. Green intellectual capital explains 49.2% of the variance in environmental knowledge, indicating a strong predictive relationship. This suggests that a deeper understanding and application of green intellectual capital significantly contribute to enhanced environmental knowledge. Similarly, green intellectual capital accounts for 44.2% of the variance in sustainable performance. This underscores the crucial role of green intellectual capital in driving sustainable practices and outcomes.

Table 6: R-square value

	R-square	R-square adjusted
Environmental Knowledge	0.492	0.489
Sustainable Performance	0.442	0.438

To further understand the relationships within our research model, we examined the path coefficients, which reveal the magnitude and significance of direct effects between constructs. Table 7 illustrates that GIC has a strong positive effect on Environmental Knowledge ($\beta = 0.701$, $p = 0.000$). This indicates that higher levels of GIC within an organisation are associated with significantly greater environmental knowledge. Environmental knowledge demonstrates a similarly strong positive effect on Sustainable Performance ($\beta = 0.665$, $p = 0.000$). This suggests that enhanced environmental knowledge drives better sustainable practices and outcomes.

Table 7: Path coefficients (Direct relationships)

	Std Beta	Std Error	t-value	p-value	BCI LL	BCI UL
GIC $\rightarrow$ EnK	0.701	0.042	16.633	0.000	0.613	0.780
EnK $\rightarrow$ SP	0.665	0.045	14.681	0.000	0.580	0.756

Note: GIC = Green Intellectual Capital, Enk = Environmental Knowledge, SP = Sustainable Performance

These findings, supported by the small standard errors and high t-values, confirm the hypothesised positive relationships between GIC, EnK, and SP. The narrow bias-corrected confidence intervals further strengthen the reliability of these results. Overall, this analysis highlights the critical role of green intellectual capital in fostering environmental knowledge, which contributes significantly to improved sustainable performance.

The analysis of indirect relationships provides further support for the mediating role of environmental knowledge in the relationship between green intellectual capital and sustainable performance. Table 8 reveals a significant positive indirect effect of GIC on SP through EnK ($\beta = 0.466$, $p = 0.000$). This finding, corroborated by the bootstrapping procedure (UL = 0.583, LL = 0.362), which does not include zero in its confidence interval, confirms the hypothesised mediating effect. This indicates that GIC directly influences sustainable performance and indirectly enhances it by fostering

environmental knowledge within the organisation. This mediating role of environmental knowledge is statistically significant and strengthens the overall explanatory power of the model.

Table 8: Mediating analysis

Relationship	Std. Beta	Std. Error	t-value	p-value	BCI LL	BCI UL
GIC → EnK → SP	0.466	0.056	8.358	0.000	0.362	0.583

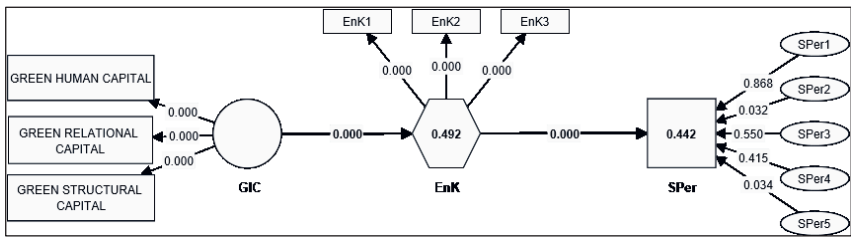
Note: GIC = Green Intellectual Capital, Enk = Environmental Knowledge, SP = Sustainable Performance

The study's findings confirm both proposed hypotheses Table 9. First, GIC demonstrates a significant positive direct effect on sustainable performance, indicating that public institutions with higher levels of GIC are more likely to achieve sustainable performance. Second, environmental knowledge plays a crucial mediating role in this relationship. The analysis reveals a significant positive indirect effect of GIC on sustainable performance through environmental knowledge, suggesting that a clear understanding of environmental issues is a key mechanism through which GIC translates into improved sustainable performance. These findings are supported by direct and indirect effect analyses and robust bootstrapping procedures, providing strong evidence for the hypothesised relationships. Finally, Figure 4 illustrates the structural equation modelling between the constructs of the study.

Table 9: Hypothesis summary

Hypothesis	Relationship	Decision
H1	Green intellectual capital has a positive effect on sustainable performance.	Supported
H2	Environmental knowledge mediates the relationship between green intellectual capital and sustainable performance.	Supported

Figure 4: The research structural equation modelling



5. Discussion

This study contributes substantively to the existing body of literature by offering empirical evidence of the positive relationship between Green Intellectual Capital (GIC) and sustainable performance in public institutions. These results align with the Resource-Based View (RBV), which highlights the role of valuable, rare, and inimitable resources in securing competitive advantage and long-term sustainability. Consistent with previous work by Malik et al. (2020) and Tze San et al. (2022), this study confirms that GIC significantly enhances employees' environmental awareness and commitment, thereby facilitating the achievement of institutional sustainability targets.

This study also applies the RBV framework to the context of Malaysian public institutions to demonstrate how investments in employee knowledge, skills, and competencies lead to sustainability-oriented outcomes. Such an emphasis not only leads to a potential competitive advantage but also contributes to increased sustainable performance. The findings extend RBV by showing that GIC is not only strategically valuable but also directly relevant in driving environmental objectives. Specifically, the roles of green structural capital and green relational capital are emphasised, manifesting public institutions' commitment to fulfilling social obligations and building productive relationships with citizens, suppliers, and other stakeholders.

Further analysis reveals important insights into environmental knowledge and its influence on sustainable performance. A key finding is that employees equipped with a solid understanding of environmental issues and human activities that contribute to ecological degradation are better positioned to anticipate and avoid sustainability challenges. This observation reaffirms Jardon and Dasilva (2017), who found that environmental

knowledge enhances awareness of existing problems, increases interest in ecological issues, and positively affects organisational outcomes.

In addition, one must bear in mind that environmental knowledge is dynamic. Martnez-Martnez et al. (2019) recommend that knowledge of the environment should be periodically reviewed to maintain a reasonable level of knowledge. This is crucial for keeping knowledge relevant, up to date, and for aligning organisational practices with changing notions of sustainable performance. Also, the results are in line with environmental knowledge research in other settings (Bano et al., 2018; Yong et al., 2019; Yusoff et al., 2019). These studies have evidenced that environmental knowledge strongly mediates between GIC dimensions (green human capital, green structural capital and green relational capital) in influencing the organisation's sustainable performance.

By demonstrating the mediating role of environmental knowledge, the study extends RBV beyond static resource possession to dynamic resource activation, providing a richer understanding of how internal capabilities translate into environmental and social outcomes. This complements the Institutional Theory, which emphasises the influence of external factors such as policy mandates, regulatory frameworks, and societal expectations in shaping organisational behaviour (Scott, 2004). In Malaysia, national initiatives such as the Twelfth Malaysia Plan (Economic Planning Unit, 2021), the Green Technology Master Plan, and the widespread adoption of ISO 14001 standards among local authorities offer practical illustrations of this alignment. Collaborations between public institutions and non-governmental organisations (NGOs), such as EcoKnights and WWF Malaysia, also demonstrate how environmental education and community engagement expand the influence of green relational capital.

In sum, GIC and environmental knowledge are not only conceptual tools but practical levers for sustainability transformation. By harmonising internal strengths with external institutional demands, Malaysian public institutions can enhance performance while advancing national environmental goals. This study thus reinforces RBV's applicability, introduces environmental knowledge as a dynamic mediator, and supports the environmentalization of public-sector strategy, which also contributes meaningfully to both theory and practice.

6. Conclusion

In conclusion, this research contributes to the multidimensional interaction between green intellectual capital, environmental knowledge, and sustainable performance in Malaysian public institutions. These findings have global relevance, offering valuable guidance for those developing and implementing sustainable strategies. Importantly, the mediating effect of environmental knowledge underlines the critical importance of cultivating a well-informed workforce to translate internal capabilities into meaningful performance outcomes.

This study has several limitations that offer avenues for future research. First, data collection was conducted using an online, closed-ended questionnaire during the COVID-19 pandemic, which, although accessible and efficient, may have constrained the depth of responses and excluded individuals in areas with limited internet connectivity. Second, the cross-sectional design captured perceptions at a single point in time, limiting the ability to observe changes in green intellectual capital and environmental knowledge as they evolve within institutions.

Future research could benefit from a longitudinal design to explore how these constructs develop and influence sustainable performance over time. Additionally, incorporating qualitative methods such as interviews or case studies may offer richer insights into the mechanisms through which green practices are implemented and internalised. Expanding the research to other sectors or regions, particularly in Southeast Asia, and applying complementary theoretical perspectives such as the Knowledge-Based View or Institutional Theory, could further enhance the generalizability and explanatory power of future studies.

In essence, this research initiates a broader conversation. It is about the transformative power of knowledge, the adaptability of insights across contexts, and the continuous pursuit of sustainable excellence. This marks not an end, but a beginning to a wider discourse on nurturing sustainability within organisations and the world at large.

CRedit author statement

Nur'ain: Conceptualisation. Design of methodology. Data collection and curation. Formal analysis. Writing the original draft preparation and editing.

Nurul Liyana: Supervision. Methodology verification. Corresponding author. Review and editing. **Nur Hairani:** Supervision. Methodology verification. Review and editing.

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