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Research Article

Green Intellectual Capital And Smart City Sustainability

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ABSTRACT

Implementing a smart city programme will address the difficulties arising from the fast-paced urbanisation process and promote resilient urban development. The process of converting a city into a smart city is intricate and requires the collaboration of multiple stakeholders to achieve strategic objectives. The purpose of developing smart cities is to enhance the competitiveness of cities and demonstrate a country's dedication to global initiatives such as sustainable development goals (SDGs). Regarding this issue, numerous environmentally friendly techniques have been developed as a result of increased awareness of sustainability. However, there have been few studies that specifically examine the concept of green intellectual capital, which refers to the knowledge and skills that enable organisations to gain a competitive edge while also reducing their environmental effect and adhering to stringent international environmental rules. Therefore, this study emphasises that the concept of green intellectuals is crucial and plays a significant role in the creation of smart cities to accomplish the SDGs. The objective of this study is to analyse the significance and contribution of green intellectual capital (which includes green human capital, green structural capital, and green relational capital) in enhancing the economic, social, and environmental systems of smart cities, to achieve SDGs. This study employed a deductive methodology utilising a survey-based strategy. Eight intelligent cities were selected to participate using purposive sampling. The data were examined by SPSS and Smart PLS software. The investigation yielded several noteworthy discoveries. This study validates the favourable correlation between green human capital, green structural capital, and green relational capital with sustainable smart cities. Furthermore, this study also presents the ramifications, constraints, and suggestions for further research.

Keywords: Green Intellectual Capital, Green Human Capital, Green Structural Capital, Green Relational Capital, Sustainability, Smart City

1. Introduction

According to the United Nations Development Programme (2018), over 60% of the global population is projected to reside in urban areas by 2030, primarily in Asia and Africa as a result of fast urbanisation. According to the predictions, cities will experience ongoing transformations in their physical compositions over the next several decades. As the global urban population continues to rise, there is an increasing demand for novel approaches to effectively handle the intricacies of urban living. Urbanisation is the movement of individuals from rural to urban regions to enhance their quality of life through increased employment possibilities, transportation options, cleanliness, security, and a sustainable environment (UN Sustainable Development Goals, 2016). Given the recognised difficulties and projected growth in the global urban population, there is a growing imperative for city governments, policymakers, and academic experts to develop

a strategy to address urbanisation challenges. This is necessary to provide citizens with a secure and environmentally friendly standard of living (Kumar et al., 2018; UN Sustainable Development Goals, 2016).
Over the past ten years, the idea of smart cities has become increasingly popular. This concept aims to improve the living conditions of residents by addressing their housing, transportation, energy, and other infrastructure needs. Additionally, smart cities are seen as a crucial strategy for addressing issues such as poverty, inequality, unemployment, and energy management (Winskowska et al., 2019). Furthermore, the smart city concept is a widely implemented urban strategy aimed at improving the quality of life for residents in urban areas (Bibri & Krogstie, 2017; Kumar et al., 2018). The notion of a smart city posits that a city should be an innovative and environmentally sustainable space that enhances the standard of living and fosters economic growth (Lee et al., 2014). In addition, implementing smart city projects can address the issues posed by growing urbanisation and help the development of resilient urban areas (Neirotti et al., 2014).
The Stockholm Environment Institute's scientists have determined that four of the Earth's nine Planetary Boundaries have already been breached. These include climate, biodiversity, land system changes, and biogeochemical cycles. The risks will escalate as the population expands to an estimated 9 billion by 2050, resulting in a greater need for food, materials, and energy. Simultaneously, contemporary civilization is experiencing increasing social and economic pressure due to escalating inequality, young unemployment, automation, and global instability. The United Nations' 17 Global Goals for Sustainable Development (SDGs) provide a framework for addressing the current global concerns. The SDGs offer a comprehensive plan of action for both humanity and the environment to be achieved by the year 2030.
The creation of smart cities aims to enhance the competitiveness of cities and demonstrate a country's commitment to global agendas such as the SDGs. Sustainable development is crucial for future competitiveness and ensures that the current requirements of society do not conflict with the needs of future generations (WCED, 1987). In these discussions, knowledge is frequently regarded as the fundamental element of the smart city (Dameri and Ricciardi, 2015). There is a growing recognition that information is not only the key resource for achieving company success, but also, more crucially, for addressing the significant ecological, social, and demographic challenges that our societies are currently confronting. Hence, the utilisation of knowledge-based strategies in management is essential to enhance the sustainability and liveability of social ecosystems.
Furthermore, Wasiluk (2013) argued that effectively addressing current environmental issues relies greatly on the strategic utilisation of knowledge resources, as explored in the developing field of green intellectual capital. Prior researchers have defined green intellectual capital as intellectual capital that fulfils the requirements of environmental management (Chen, 2008b; Liao et al., 2008). Green intellectual capital refers to all tangible assets or information associated with green innovation or protection, as described by Chen (2008b). Dumay and Garanina (2013) emphasised the potential of knowledge resources to be utilised at the city, regional, and national levels to establish a robust social environment conducive to the growth of thriving organisations.
To advance the Sustainable Development Goals (SDGs), it is necessary to go beyond current models. However, as far as we know, there has been no scholarly research conducted on the concept of green intellectual capital and smart cities. Previous research has predominantly focused on the conventional perspective of the IC notion. In this context, Dameri and Ricciardi (2015) introduced a paradigm for intellectual capital in smart cities. A framework must be developed to assess a smart city scenario using the views of green intellectual capital. Hence, the primary aim of this study is to investigate the correlation between green intellectual capital and sustainable smart cities. The suggested approach is designed to apply to both the IC and smart communities and introduces a new managerial perspective on smart city government entities.

2. Literature Review

2.1 Smart City

The current body of research examines the smart city concept, which encompasses several social, economic, urban, institutional, technological, and environmental issues in a broad manner (Selada, 2014). The concept of a smart city is still in its early stages of development, with several definitions put out by specialists in the field. The definition of a smart city is varied, but certain cohesive components appear in all of the respective definitions. Technology is a prevalent element in the definition since many cities consider themselves smart by integrating ICTs into their delivery of city services (Zubizarreta et al., 2015). The criteria also highlight the importance of key infrastructure, including physical infrastructure and network infrastructure. This is because the gadgets in the city need to be interconnected to produce a unified output (Giffinger et al., 2007). The provision of high-quality services to the population is consistently highlighted as a crucial aspect (Angelidou, 2017).
Several scholars have emphasised that the integration of systems and infrastructure interconnection is a crucial feature that qualifies a city to be labelled as "smart" (Dameri & Benevolo, 2016; Lee et al., 2014). Networked infrastructure is utilised in certain contexts to facilitate social, environmental, economic, and cultural growth (Zygiaris, 2013). According to Dameri and Benevolo (2016), multiple authors conceptualise a smart city as a highly efficient and future-oriented urban area that serves as a source of inspiration. The residents are a crucial component of a smart city. Meeting the demands of citizens is an essential element in the definition of a smart city (Zubizarreta et al., 2015). In addition, it is important to note that the mere installation of technology does not ensure the success of smart city initiatives. Technology serves as a facilitator in the development of smart

cities (De Jong et al., 2015). However, it is crucial to prioritise the resolution of pressing ecological, socioeconomic, and demographic challenges that our societies are currently confronting. Hence, the utilisation of knowledge-based strategies in management is employed to enhance the sustainability and liveability of social ecosystems.

2.1.1 Smart City Sustainability

The smart city aspects encompass several perspectives that contribute to the development of smart cities (Angelidou & Psaltoglou, 2017). The integration of many elements of a smart city will augment the level of intelligence of the city (Selada, 2014). The literature studies consistently include the six dimensions: Smart Government, Smart Mobility, Smart Living, Smart People, Smart Environment, and Smart Economy (Camboim, 2018). Smart governance refers to the integration of city services via the use of information and communication technologies (ICTs). The purpose is to establish connections between governmental, private, and civil organisations to enhance the efficiency of executing and managing smart city initiatives through a uniform paradigm. The next phase of intelligent mobility offers a secure, environmentally friendly, and linked transport system within urban areas. Smart Living aims to enhance the quality of life by providing a joyful, well-being, and secure living environment in a technologically advanced city. The Smart People dimension refers to individuals who possess sufficient expertise in computing, possess the ability to adjust to technological progress, have access to education, and can work in an environment that is facilitated by information and communication technology (ICT). The intelligent ecosystem encompasses intelligent energy, intelligent grid, pollution management and monitoring, sustainable construction, and the establishment of a conducive environment for human well-being. The smart economy focuses on leveraging e-business and e-commerce to enhance productivity through the implementation of smart computing in manufacturing, leading to innovation in products and services.

2.2 Green Intellectual Capital

Chen (2008) was the pioneering researcher who initially introduced the notion of GIC. Prior studies have proposed that environmental capital is a component of intellectual capital (Claver-Cortés et al., 2007). Maditinos et al. (2011) have incorporated a green element into IC. Subsequently, several academics argued that GIC is a negligible area in the field of management literature, which is why there are very few definitions available (Mohd Yusoff et al., 2019; Yong et al., 2019). Chen (2008) defined GIC as the collective amount of intangible assets, knowledge, talents, and relationships related to environmental protection or green innovation, both at the human and organisational levels inside a corporation. In 2010, Liu defined GIC as the incorporation of green and environmental knowledge sources, together with a company's ability to enhance their competitive advantage. Lopez-Gamero et al. (2011) proposed that GIC, or Global Intellectual Capital, refers to the collective knowledge that an organisation might utilise to enhance its environmental management practices and acquire a competitive edge.

According to Chen (2011), environmentalism has gained popularity in the business world due to its focus on reducing environmental consequences and regulating climate change. This, in turn, encourages organisations to develop green innovation. Nevertheless, the increased level of consumer consciousness regarding environmental concerns has compelled firms to develop more effective approaches to align with environmental trends by incorporating environmental management practices to enhance their eco-friendly reputation and competitive edge. Huang and Kung (2011) asserted that GIC assists organisations in complying with stringent international environmental rules, generating value for the organisation, and satisfying elevated customer expectations about environmental matters. According to Chen (2008), companies must possess environmental knowledge to effectively implement an environmental strategy. This information will enable them to discover opportunities for making changes to their processes and products. GIC reduces environmental impact and offers organisations a competitive edge by reducing expenses (Chang, 2011; Chen, 2008).

2.2.1 Dimension of Green Intellectual Capital

Prior researchers have developed their categorization of intellectual capital (IC) based on the subjects and backgrounds of their research, but there is currently no standardised definition.

2.2.1.1 Green Human Capital

According to Brooking (1996), human capital (HC) refers to human-centred assets that encompass the combined knowledge, creativity, problem-solving ability, leadership, entrepreneurial skills, and managerial skills possessed by the personnel of an organisation. According to Brooking (1996), HC refers to the attributes that constitute individuals. According to Roos et al. (1997), HC refers to the characteristics of persons that make them valuable resources for a firm, and these characteristics cannot be substituted by machines or documented on paper. These resources encompass factors such as expertise, mindset, proficiency, implicit knowledge, personal connections, and similar attributes. Roos et al. (1997) observed that HC exhibits the phenomenon of

increasing marginal returns. This concept can be encapsulated by the following statement: "The greater one's knowledge about a subject, the more one realises the vastness of what remains unknown."
According to Roos, Roos, Dragonetti, and Edvinsson (1997), human resources are not universally owned, but rather under the control of each individual. Human capital is widely acknowledged as the most crucial intangible assets that significantly enhance organisational performance and improve employee happiness (Allameh, 2018). However, the majority of the existing research has mostly concentrated on human capital (HC), with limited attention given to the idea of green human capital (GHC) (Mohd Yusoff et al., 2019b). This study cites the definition of GHC from Chen (2008), which defines GHC as the aggregation of employees' knowledge, skills, capabilities, experience, attitude, wisdom, creativity, and commitment to environmental protection or green innovation. According to Chen, GHC is inherent in employees rather than organisations.

2.2.1.2 Green Structural Capital
According to Brooking (1996), structural capital (SC) refers to the essential assets of an organisation, such as technology, techniques, and processes, that enable its functioning. Supply chain management (SC) is crucial as it establishes structure, safeguards, accuracy, and excellence inside the company. Strategic communication (SC) also offers a structure for employees within the business to collaborate and exchange information. In their book "Managing Intellectual Capital in Practice," Roos et al. (1997) define organisational capital as the assets that remain within an organisation even after employees have left, but are not reflected on the balance sheet. This concept was eloquently expressed by Lef Edvinsson. These encompass various assets such as trademarks, patents, methodologies, frameworks, operational frameworks, hierarchical arrangements, physical records or digital databases, and similar items. According to Roos et al. (1997), it is possible for the organisation to own and have control over SC. These resources are exclusively owned and controlled by organisations, in contrast to the other two. Supply chain (SC) refers to the collection of non-human assets within an organisation, as defined by Yusliza et al. (2020). For instance, intangible assets include databases, strategies, and organisational charts (Jardon & Martos, 2012). Similar to GHC, there have been limited studies that have focused on the concept of green structural capital (GSC). Therefore, this study defines GSC according to Chen (2008) as "the collection of organisational capabilities, organisational commitments, knowledge management systems, managerial philosophies, organisational culture, company images, patents, copyrights, and trademarks, etc. related to environmental protection or green innovation within a company".

2.2.1.3 Green Relational Capital
According to Brooking (1996), relational capital (RC) is the value that an organisation possesses because of intangible assets related to the market, such as brands, loyal customers, repeat business, distribution channels, and various contracts and agreements like licencing and franchises. Market assets are crucial as they provide organisations with a competitive edge in the market. According to Roos & Roos (1997), RC refers to the various connections that organisations have with entities such as customers, consumers, intermediaries, representatives, suppliers, partners, owners, lenders, and similar parties. Roos, Roos, Dragonetti, and Edvinsson (1997) observed that the organisation could not control or possess RC. Nevertheless, it could potentially influence the connection. Put simply, the organisation does not possess its relationship, but rather empowers itself to have an impact on it. Similar to the other two components of GIC, there have been limited research that have focused on the idea of green relational capital (GRC). This study adopts GRC's definition of Chen (2008) which defines it as "the accumulation of interactive relationships that a company has with its customers, suppliers, network members, and partners in the realm of corporate environmental management and green innovation. This accumulation allows the organisation to achieve financial success and obtain a competitive edge."

2.3 Hypotheses development
2.3.1 Green Human Capital and Smart City Sustainability
In the present era, an organisation must acknowledge and address the environmental dimension. According to the Natural Resource Based View (NRBV) thesis, for an organisation to gain a competitive advantage in the future, they must incorporate environmentally friendly components into their intangible assets (Hart, 1995). Furthermore, Chen, Lai, and Wen (2006) contended that for an organisation to discover environmentally friendly solutions and generate innovative ideas, it necessitates a sustainable workforce. According to Chen (2008), investing in GIC can lead to both environmental management and a competitive advantage. Consequently, it is crucial to investigate the function of GHC and its influence on the long-term viability of businesses. In their study, Yong et al. (2019) discovered empirical evidence indicating that green human resource management is positively influenced by global human capital. Erinos and Rahmawati (2017) discovered data that confirms the beneficial impact of GHC on financial performance.
Furthermore, Chen and Chang (2013) substantiated the connection between greenhouse gas emissions and the performance of green innovation in their research. Additionally, they proposed strengthening GHC to bolster the connection between corporate environmental ethics and two specific areas: green innovation performance and green relationship learning in manufacturing firms. Huang and Kung (2011) demonstrated that GIC (Green Innovation Capability) enables organisations to comply with stringent international environmental requirements, generate value for the organisation, and satisfy heightened customer expectations about

environmental concerns. Nevertheless, research is scarce regarding the correlation between green human capital and its connection to the long-term viability of businesses. According to Chen's (2008) recent research, incorporating environmentally friendly practices into the management of structural capital is necessary to gain a competitive edge. Prior studies have demonstrated the significance of intellectual capital in attaining sustainability (Akhtar et al., 2015; Cavicchi & Vagnoni, 2017; Massaro et al., 2018; Sunday, 2017). Therefore, this study proposes the following hypothesis:

H1. There is a positive relationship between green human capital and smart city sustainability.

2.3.2 Green Structural Capital and Smart City Sustainability

Prior studies have repeatedly demonstrated that the presence of green structural capital has a significant and advantageous effect on performance outcomes. Chen (2008) and Firmansyah (2017) provided evidence of the correlation between green structural capital (GSC) and a competitive advantage. Huang and Kung (2011) discovered that GSC (Green Supply Chain) has a positive influence on environmental proficiency and behaviours related to dedication. Delgado-Verde et al. (2014) found a direct relationship between green organisational capital and green product innovation. Erinos and Rahmawati (2017) found empirical data supporting the positive influence of GSC on financial success. Gürlek and Tuna (2017) established a significant association between the presence of a green organisational culture and the occurrence of green innovation. In their study, Mohd Yusoff et al. (2019) asserted that there exists a clear and direct relationship between green structural capital and the sustainable longevity of a corporation.

The latest study conducted by Yusliza et al. (2020) has shown a direct and favourable relationship between Global Innovation Capability (GIC) and company performance. In their study, Huang and Kung (2011) found that Green Innovation Capability (GIC) allows organisations to comply with strict international environmental regulations, generate value for the organisation, and meet the heightened environmental demands of customers. However, there is a lack of study on the relationship between green structural capital and its impact on the long-term sustainability of firms. Chen's (2008) study highlights the importance of integrating eco-friendly practices into the management of structural capital to achieve a competitive advantage. Previous studies have shown that intellectual capital is essential for achieving sustainability (Akhtar et al., 2015; Cavicchi & Vagnoni, 2017; Massaro et al., 2018; Sunday, 2017). Thus, this study presents the subsequent hypothesis:

H2. There is a positive relationship between green structural capital and smart city sustainability.

2.3.3 Green Relational Capital and Smart City Sustainability

Prior research has consistently demonstrated a substantial and beneficial impact of green relational capital on performance outcomes. Chen (2008) and Firmansyah (2017) discovered empirical support for a correlation between green relational capital (GRC) and competitive advantage. In a similar vein, Huang and Kung (2011) demonstrated the beneficial impact of GRC on environmental competence and commitment-related endeavours. According to Delgado-Verde et al. (2014), the presence of green social capital within an organisation is crucial for fostering cooperative networking among employees and achieving success in environmental product innovation. Erinos and Rahmawati (2017) discovered data that confirms the beneficial influence of the GRC on financial performance. Yong et al. (2019) discovered empirical evidence supporting the notion that the Green Resourcefulness Construct (GRC) has a beneficial impact on the administration of environmentally conscious human resources. Nevertheless, research is scarce on the correlation between green structural capital and its connection to the long-term viability of businesses. According to Chen's (2008) recent study, incorporating the green component into the management of relational capital is necessary to attain a competitive edge. Previous studies have demonstrated that intellectual capital plays a crucial role in attaining sustainability (Akhtar et al., 2015; Cavicchi & Vagnoni, 2017; Massaro et al., 2018; Sunday, 2017). This study postulates that:

H3. There is a positive relationship between green relational capital and smart city sustainability.

2.4 Research Framework

Figure 1 shows the framework illustrating all the hypothesised relationships, i.e., H1 to H3.

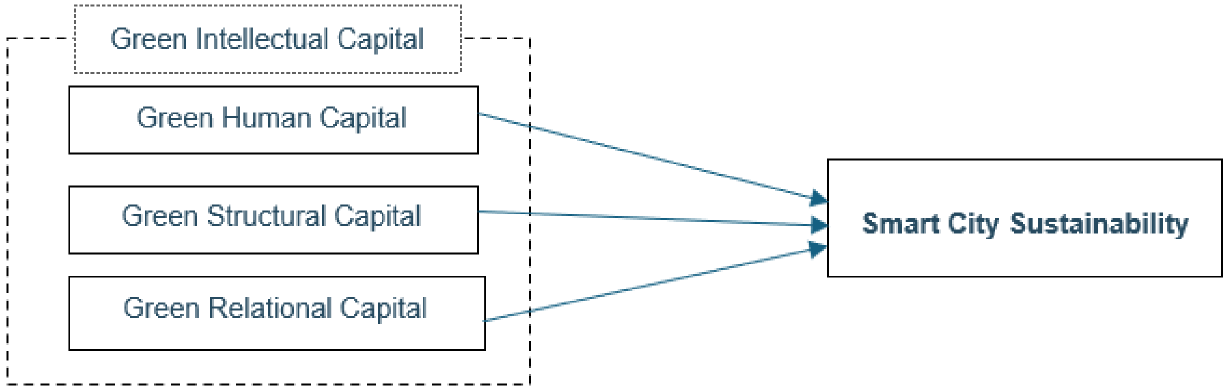

Figure 1. Research Framework.

3. Methodology

3.1 Survey and data collection

This study employed a deductive method using a survey strategy. The study included seven intelligent cities: Selangor, Putrajaya, Iskandar Malaysia, Kuala Lumpur, Kota Kinabalu, Kuching, and Kulim. The study used purposive sampling to collect data from certain target groups (Sekaran & Bougie, 2013). The participants are municipal council personnel who are engaged in smart city initiatives. The rationale for prioritising these groups is their pivotal role in advancing the sustainable development agenda within smart city projects. Consequently, they possess the concepts and expertise about the subject matter. Therefore, they are under the researcher's supervision. The data was examined using the SPSS and Smart PLS software. For the final analysis, a total of 119 questionnaires were included, with a response rate of 20.2 per cent. The response rate of this study is deemed satisfactory, as indicated by Sekaran and Bougie (2010), who claimed that the optimal response rate for social science studies falls within the range of 5 per cent to 35 per cent. Visser et al. (1996) found that a lower response rate, often around 20%, tends to yield better accurate results.

3.2 Measurements

Green intellectual capital (GIC) consists of three components: green human capital (GHC), green structural capital (GSC), and green relational capital (GRC). This concept was derived from Huang and Kung's (2011) work and encompasses a total of 18 items. Huang and Kung (2011) utilised this measurement to incorporate several adjustments that corresponded with the significance of green structural capital, as outlined in the research conducted by Menguc and Ozanne (2005). The measuring scale was assessed using a 7-point Likert-type scale that ranged from 1 (indicating significant disagreement) to 7 (indicating strong agreement). Furthermore, this metric has also been employed in other prior research projects, such as those conducted by Firmansyah (2017) and Omar et al. (2017). The concept of measuring sustainable smart cities was derived from Chow and Chen's (2012) work. The respondents were asked to evaluate the city's performance in three primary areas: economic, social, and environmental. The total number of questions for rating was 16. Table 2 displays the measurement employed in this investigation.

Table 1 Construct/Items used in the questionnaire

Construct	Item	Source
Green Human Capital	Our employees make positive productivity and contribution toward environmental protection.	Huang and Kung (2011)
	Our employees have adequate competence towards environmental protection.	
	Our employees offer high-quality products and services to protect the environment.	
	The cooperative level of teamwork to protect the environment is carried out at a high level in our organization.	
	Our management can fully support their employees to achieve their jobs of environmental protection	
Green Structural Capital	Our organization has a superior management system of environmental protection.	
	Our organization has a high proportion of environmental management employees among its total employees.	
	Our organization makes an adequate investment in environmental protection facilities.	
	The overall operation of environmental protection processes in our organization operates effectively.	

Construct	Item	Source
	The knowledge management system in our organization is favourable to the accumulation and sharing of knowledge of environmental management.	
	Our organization has set up a committee to make progress on key environmental issues.	
	Our organization has set up a committee to make progress on key environmental issues.	
	Our organization has set up a reward system for carrying out environmental task	
Green Relational Capital	In our organization, we appreciate the existence of informal contacts among employees to exchange information about the environmental aspects of the activity.	
	In our organization, we appreciate the existence of constructive discussions among employees to solve the environmental problems of the city.	
	In our organization, the employees are willing to share their environmental knowledge and experiences.	
	In our organization, the employees assist each other in generating new ideas.	
	In our organization, the employees assist each other to improve environmental performance.	
Smart City Sustainability (Economical)	This city decreases costs for materials purchasing.	Chow and Chen (2012)
	This city decreases the costs of energy consumption.	
	This city decreases fees for waste treatment.	
	This city decreases fees for waste discharge.	
	This city decreases fines for environmental accidents.	
Smart City Sustainability (Social)	This city improved overall stakeholder welfare.	
	This city improved community health and safety.	
	This city reduced environmental impacts and risks to the public.	
	This city reduced environmental impacts and risks to the public.	
	This city communicates the environmental impacts and risks of the firm to the public	
	This city improved awareness and protection of the claims and rights of people in the community served	
Smart City Sustainability (Environmental)	This city improves compliance with environmental standards	
	This city reduces air emissions.	
	This city reduces air emissions.	
	This city reduces material usage.	
	This city reduces the consumption of hazardous materials.	

4. Results

4.1 Data analysis
This study used the SmartPLS 3.2.7 application to assess the research model proposed by Ringle et al. (2015). The CB-SEM analysis could not be conducted due to the inadequate sample size of 168, which was considered too small. Therefore, we employed PLS-SEM for our small sample, as recommended by Hair et al. (2012).

4.1.1 Measurement Model
The study employed the usage of Partial Least Squares (PLS). The study utilises Smart PLS 3.2.7 (Ringle et al., 2015) to evaluate the measurement and structural model. The measuring model was employed to assess the internal consistency of the construct item. This study employs non-parametric evaluation concepts based on bootstrapping and blindfolding techniques. The study utilised confirmatory factor analysis (CFA) to assess the extent to which the indicators effectively and systematically evaluate the construct of the research model, as opposed to exploratory factor analysis (EFA). This decision was made since the study drew inspiration from previous investigations (Hair et al., 2010). CFA offers a theoretical metric that identifies the hidden variable that aligns with the observed data.

Unlike EFA, just the latent variables extracted from the statistical findings are represented. Four constructs, namely green human capital, green structural capital, green relational capital, and sustainable smart cities, were classified as reflective constructs by the principles outlined by Hair et al. (2014) and Jarvis et al. (2003). These reflecting constructs subsequently assessed the reliability and validity of each indicator. Furthermore, the created model incorporated a second-order factor for the dependent variables, specifically focusing on sustainable smart cities. The validity and reliability of the first order, as well as the second order, were subsequently assessed. The study employed factor loadings, average variance extracted (AVE), and composite reliability (CR) to assess convergent validity, followed by an evaluation of discriminant validity. The subsequent subsection presented a lucid depiction of the discoveries.

Table 2 Measurement Model

First Order	Second Order	Loadings	CR	AVE
Green Human Capital		0.819	0.921	0.727
		0.781		
		0.931		
		0.882		
		0.901		
Green Structural Capital		0.799	0.943	0.795
		0.812		
		0.856		
		0.861		
		0.918		
		0.925		
		0.832		
		0.821		
Green Relational Capital		0.819	0.925	0.814
		0.931		
		0.838		
		0.932		
		0.864		
Economical		0.714	0.838	0.526
		0.812		
		0.724		
		0.696		
		0.721		
Social		0.699	0.885	0.623
		0.752		
		0.816		
		0.759		
		0.691		
		0.712		
Environmental		0.769	0.913	0.614
		0.765		
		0.684		
		0.794		
		0.672		
	Smart City Sustainability	0.782	0.912	0.768
		0.891		
		0.912		

Note: CR = Composite Reliability; AVE = Average Variance Extracted

4.1.2 Convergent Validity

Convergent validity is observed when two distinct items exhibit a correlation with one other, indicating that they are both assessing the same underlying construct (Henseler et al., 2009). The standard metric used to assess convergent validity is the Average Variance Extracted (AVE) value. Convergent validity is obtained when the Average variation Extracted (AVE) value is more than 0.5. This indicates that the constructs explain more than half of the variation of their indicators and have adequate convergent validity (Hair et al., 2010). The average value (AVE) of the constructs varies between 0.727 and 0.814 seconds, as indicated in Table 4. This exceeds the value of 0.5, which is the suggested threshold. The findings indicate that the measuring model employed in this investigation possesses sufficient convergent validity.

Table 3 Average Extracted Variance (AVE)

Constructs	CR	AVE
Green Human Capital	0.921	0.727

Green Structural Capital	0.943	0.795
Green Relational Capital	0.925	0.814
Business Sustainability	0.912	0.768

4.1.3 Discriminant Validity

Discriminant validity is a method used to verify that the constructs being measured are distinct and not overlapping in terms of their underlying concept or ideas. The heterotrait-monotrait ratio (HTMT) criterion, as proposed by Henseler et al. (2015), was used to verify the data. The thresholds for HTMT, suggested by Gold, Malhotra, and Segars (2001), indicate that a correlation coefficient below 0.90 is considered acceptable for demonstrating discriminant validity. As indicated in Table 4, all values satisfy the HTMT0.90 criterion, indicating that discriminant validity has been established and confirming that all constructs are genuinely separate from one another. Applicable for evaluating the structural model in the following section.

Table 4 Heterotrait-Monotrait Ratio (HTMT) of the Measurement Model

	S	GHC	GRC	GSC
S				
GHC	0.751			
GRC	0.721	0.825		
GSC	0.714	0.812	0.845	

Another way to measure discriminant validity is to analyse the loadings of the indicator about the correlation of all constructs. The Smart PLS algorithm function generates the cross loading output. Displays the results of cross-loading analysis conducted on the relationship between constructs and indicators. The table also indicates that all measurement items exhibited larger loadings on their specified latent variable relative to other variables. Furthermore, the findings also indicated that the load of any individual block is greater than any other block within the same rows and columns. The loading effectively distinguishes each latent variable as postulated in the conceptual model. Therefore, the cross-loading output has verified that the second assessment of the measurement model's discriminant validity has been met. Consequently, this study affirms that the measurement model has successfully demonstrated its ability to differentiate across different constructs.

4.2. Structural Model Assessment

The coefficients of PLS-SEM were tested for their significance using the non-parametric bootstrap approach (Davison & Hinkley, 1997; Efron & Tibshirani, 1986).

4.2.1 Path Coefficients and Hypothesis Testing

Referring to Table 6, the assessment of the path coefficient shows that all hypotheses are supported (HI, H2 and H3). The result indicates that GHC (β = 0.189, t-value = 1.782, p>.05), GSC (β = 0.252, t-value = 1.823, p<.05) and GRC (β = 0.261, t-value = 1.860, p<.05) are positively significant to the sustainable smart cities.

Table 5 Structural Model Direct Effect

Hypothesis		**std Beta**	**Std error**	**t-value**	**p-value**	**LL**	**UL**	**Decision**
H1	GHC → S	0.189	0.075	1.782	0.000	0.115	0.315	A
H2	GSC → S	0.252	0.08	1.823	0.000	0.134	0.41	A
H3	GRC → S	0.261	0.092	1.860	0.000	0.328	0.761	A

Notes:
A one-tailed test was conducted on the hypothesised direct relationships
A= Accepted
R = Rejected
LL = Bias corrected interval lower limit, UL = Bias corrected interval upper limit
Accepted when: p <0.05, t > 1.65 (one-tailed test)
p-values extracted from Smart PLS 3.2.7 have been adjusted (manually) for one-tailled test results as the researcher ran the software only once for a two-tailed test.

5. Discussion

5.1To examine the relationship between green human capital and smart city sustainability.

The findings demonstrated a substantial correlation between GHC and the development of sustainable smart cities. Therefore, the H1 hypothesis was confirmed. The results aligned with the study, indicating a positive correlation between GHC and various other variables that were tested, including competitive advantage (Chen, 2008a; Huang & Kung, 2011), green innovation performance (Chen and Chang, 2013), productivity (Chen et al., 2014), green human resource management (Yong et al., 2019), and sustainability performance (Yusliza et al., 2020). The study conducted by Allameh, Abbasi, and Shokrani (2010) further supports the notion that green human resources play a significant role in ensuring the long-term viability of a business.

The observed correlation between GHC and sustainable smart cities in this study could be attributed to various factors. The Smart City Project's smart cities unit or department is highly interested in environmental management and has integrated green protection into its human capital. Human capital is the most valuable asset that makes a significant contribution to sustainability (Akhtar et al., 2015; Cavicchi & Vagnoni, 2017; Karchegani et al., 2013; Massaro et al., 2018; Sunday, 2017). In addition, these specific organisations demonstrate a strong commitment to innovation and allocate significant resources to research and development. Consequently, they seek individuals who possess exceptional qualifications and skills. In this scenario, the businesses possess skilled workers who possess extensive environmental knowledge and experience. They possess sufficient training to enhance their abilities and competencies, particularly in the present era of knowledge. These training sessions are essential for incorporating environmental knowledge into the organization's people resources to capitalise on business market opportunities and fulfil customer expectations.

5.2 To examine the relationship between green structural capital and smart city sustainability.

The findings indicate that green structural capital (GSC) has a beneficial impact on sustainable smart cities (S). Therefore, H2 has been corroborated. This finding aligns with the results of the prior study conducted by Mohd Yusoff et al. (2019), which showed a favourable correlation between GSC and sustainability. In a study conducted by Chen (2008), it was shown that GSC (Global Supply Chain) exhibited a substantial correlation with a competitive advantage. Prior research has consistently demonstrated the role of structural capital in promoting the long-term viability of organisations (Akhtar, et al., 2015; Cavicchi & Vagnoni, 2017; Massaro et al., 2018; Sunday, 2017). In addition, it is acknowledged that Supply Chain (SC) plays a crucial role in enhancing business performance, including financial growth (Sardo & Serrasqueiro, 2017), heightened productivity (Chen et al., 2014), and overall better performance (Hsu & Wang, 2012).

Lopez-Gamero et al. (2011) contend that to attain sustainability, organisations frequently require enhancements in structural capital, the establishment of new environmental divisions, and the adoption of new technology. Furthermore, this finding aligns with the outcome of Ramayah et al. (2013), which demonstrated a positive correlation between the green production phase and manufacturing performance in terms of reducing costs, enhancing product quality, and improving delivery performance. Manufacturers should embrace Green Supply Chain (GSC) practices to increase their sustainability, which in turn enhances their economic, environmental, and social performance. Consequently, implementing this plan will mitigate the negative impact of commercial activities, improving the overall quality of life and safeguarding future generations against the consequences of resource shortage.
The study's notable and affirmative results demonstrate that smart cities have recognised the significance of GSC in promoting sustainability. Sustainability necessitates organisations to confront emerging market issues, therefore making structural capital vital in facilitating this endeavour.

5.3 To examine the relationship between green relational capital and smart city sustainability.

The study's results demonstrated that the GRC has a beneficial effect on the development of sustainable smart cities. Therefore, H3 has received support. Jabbour, de Sousa Jabbour, and Sarkis (2018) have demonstrated a positive correlation between the utilisation of supply chain tools and both environmental performance and economic performance, leading to a competitive advantage. In addition, Gelhard and Von Delft (2016) discovered a direct correlation between consumer integration and sustainable performance. This is achieved by utilising customer feedback as important information about their demands, which also addresses environmental and social concerns.

The study's findings indicate that the connection between smart cities and their stakeholders relied on the exchange of knowledge and collaborative efforts. Supporting the development of the GRC is regarded to be beneficial through a collaborative approach. This strategy promotes the adoption of sustainable practices by smart cities, particularly if its governance, risk, and compliance (GRC) aspect include a desire to share ideas and the advantages of sustainability measures. Furthermore, smart cities have the potential to utilise the Global Reporting Initiative (GRC) as a means of fostering open communication among their various stakeholders. This dialogue aims to minimise the negative effects on the environment and promote the development of environmentally friendly goods, ultimately resulting in enhanced sustainability.

6. Conclusion

Smart cities must prioritise both economic growth and environmental sustainability while also ensuring the well-being of their residents. Regarding this matter, GIC seems to be a potential approach for attaining sustainable smart cities. The study polled 119 employees to gather their perspectives on the implementation of the GIC in Malaysia and its connection to sustainable smart cities. In general, the findings indicate that smart cities in Malaysia have acknowledged that GIC (Green Infrastructure and Connectivity) is a crucial element that may greatly enhance sustainability. The results of this study will undoubtedly offer valuable insights and expertise to scholars and professionals in the field of green intellectual capital and sustainability.

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