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Green Intellectual Capital: A Multidimensional Approach to Sustainable Performance Waste Recycling Management in Algeria

Haddad Amina

PhD, Human Resources, Abou Beker Belkaid University, Tlemcen, Algeria, <https://orcid.org/0000-0002-0147-5521>

Hagain Faouzia

PhD, Entreprenariat, Abou Beker Belkaid University, Tlemcen, Algeria, <https://orcid.org/0009-0003-8882-8725>

Lefilef Abdelhak*

Permanent Teacher, Finance and Banking, Abdelhafid Boussouf University Center, Mila, Algeria, <https://orcid.org/0000-0002-2170-1872>

Roucham Benziane

Professor, Management, Tahri Mohammed University, Bechar, Algeria, <https://orcid.org/0000-0001-5389-9839>

Muhammad Abdullah Alkhalaf

Bachelor's, Finance and Banking, Saudi Arabia, <https://orcid.org/0009-0002-2677-9246>

***Corresponding Author:** abdelhak.lefilef@center-univ-mila.dz.

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Abstract: This research investigated the relationship between the green intellectual capital (GIC) and the sustainable performance in Algeria's waste recycling management sector. Acknowledging the importance of Global Information Communication (GIC) in achieving organizational success, this

research investigates how it is utilized and its effects. Using structural equation modeling (SEM) with the PLS-V3 software, the study examines information gathered from 400 entrepreneurs who oversee waste recycling businesses in Algeria. The study focused on three primary components of GIC: green relational capital, green structural capital, and green human capital. The hypotheses were formulated to assess the influence of each component on sustainable performance. The results supported all four proposed hypotheses, showing a positive link between the Green Intellectual Capital (GIC) and the sustainable performance. Specifically, the combined effects of relational, structural, and human capital enhanced sustainability outcomes. The research showed the significance of the waste recycling industry implementing strategies that make the most of Green Intangible Capital (GIC) elements. This includes connecting with stakeholders who prioritize environmental preservation, sharing knowledge, and working together. Green structural capital refers to the systems and processes that support eco-friendly practices, like environmental management systems and sustainable supply chain management. Green human capital focuses on employees' skills and knowledge in sustainability, highlighting the importance of training and opportunities for professional development. This study adds value to existing knowledge by clarifying how GIC plays a role in fostering a future. It offers insights for waste recycling firms, policymakers, and other interested parties in Algeria and beyond. By emphasising the significance of GIC in achieving performance, this research provides practical implications for crafting strategies and policies that leverage green intellectual assets for economic and environmental advantages. The study underscored organisations' need to invest in nurturing their GIC to promote sustainable business practices and attain enduring success.

Keywords: green intellectual capital; green relational capital; green structural capital; green human capital; sustainable performance; waste recycling.

Introduction

Since 1974, Algeria has been changing its laws to protect the environment and maintain balance. These legal efforts have focused on environmental issues and promoting sustainable development practices in the country. The development of Algeria's framework related to ecological balance and environmental conservation highlights its dedication to reducing environmental harm and encouraging a harmonious relationship between nature and human activities. By implementing and revising laws and regulations, Algeria aims to ensure protection, integrate ecological concerns into decision-making processes, and raise awareness for environmental conservation (MEER, 2022).

In an era where worldwide worries about sustainability are on the rise, the idea of green intellectual capital (GIC) is essential for organisations to succeed. This study examines how the Algerian Waste Recycling Corporation can improve its performance by incorporating green intellectual capital into its operations.

The OECD (2011) emphasises the importance of these intellectual assets and their role in competitiveness and value creation in its reports on the circular economy and green growth to provide the resources and environment services on which our well-being relies according to the "UNDP", Algeria included policies that encourage and facilitate waste management investment into its national laws as a means of achieving the 2030 sustainable development goals. Laws and regulations promoting the growth of new businesses to boost national economies have been put into place. The report on Algeria's Development Plan for 2023 details these initiatives. Therefore, the main aim of this study is to explore the intricate connection between intellectual property, environmental responsibility, and business sustainability in Algeria's waste recycling industry (UNDP Algeria, 2023).

Despite a growing recognition of the importance of "GIC," there is a notable gap in understanding how it is applied and its impact in specific industries, especially in the conversion of waste materials

into valuable products. This presents a unique opportunity for environmental sustainability and economic growth. However, the extent to which Algerian companies in this sector are utilising "GIC" to improve their sustainable practices is not well understood.

This research is significant as it has the potential to address critical environmental and economic issues in Algeria and globally. By examining the role of "GIC" in waste recycling companies, it aims to provide valuable insights for strategic decision-making, policy formation, and sustainable business strategies.

The main goal of this research is to investigate how incorporating "GIC" can enhance sustainable practices in Algerian waste recycling companies. The study aims to:

- Evaluate the current awareness and use of "GIC" among waste recycling companies in Algeria,
- Identify the key factors influencing the adoption and implementation of "GIC" practices in this sector,
- Explore the relationship between "GIC" and sustainable performance.

Research Problem

Previous research has highlighted the significance of green intellectual capital (GIC) in advancing environmentalism and economic development. However, more academic effort is required to map out the relevance and enactment of GIC in the waste recycling firm. This gap is especially noticeable in the conditions of developing countries, for example, Algeria, where waste recycling remains a relatively weak and developing sector. Thus, despite the prior research on environmental sustainability and business performance, the research gap regarding GIC's dimensions (green human capital, green structural capital, and green relational capital) regarding sustainable performance in the waste recycling sector.

Although it is widely recognised that green intellectual capital (GIC) holds significance, there remains a lack of clarity on its application within specific industries, particularly waste recycling management companies. This represents a valuable opening to promote environmental and economic progress, yet further insights are required to discern how Algerian companies leverage GIC to enhance sustainability.

As discussed above, how does Algeria leverage green intellectual capital to improve its sustainability performance in this sector?

This research aimed to bridge this gap by investigating the following:

What government policies, regulations, and pressures from other stakeholders affected the application of GIC that helped to increase the efficiency of recycling activities in the context of sustainable performance in the waste recycling companies of Algeria?

Research Aim and Hypotheses

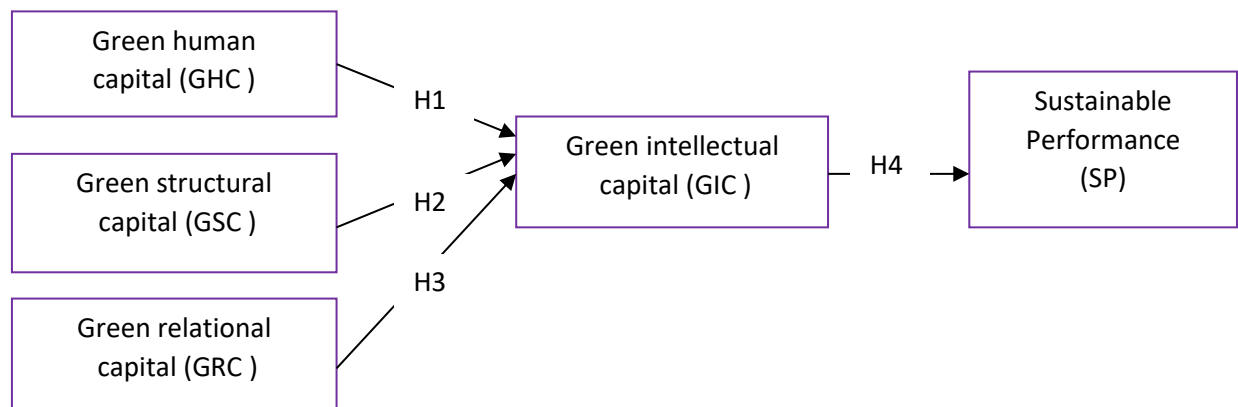
In this study, the primary objective was to investigate the impact of green intellectual capital on the sustainable performance of waste management corporations in Algeria. The research aimed to address the following inquiries:

1. To what extent do Algerian waste recycling management corporations utilise the green intellectual capital?
2. What are the key factors influencing adopting and implementing GIC practices within Algerian waste recycling management corporations?
3. What is the relationship between GIC and sustainable performance in Algerian waste recycling management corporations?

4. How do the green human capital, structural capital, and relational capital influence the integration of green intellectual capital in the waste recycling management sector?
5. What are the implications of the findings for developing effective strategies and policies to promote the adoption and utilisation of GIC for enhanced sustainable performance in the Algerian waste recycling corporations? To answer this question, the following research hypotheses are proposed (Figure 1).

Figure 1

Proposed Research Model



Source: Authors' own development.

Green Human Capital (GHC). According to Mansoor et al. (2021), the green human capital is crucial to an organisation. It is one of green intellectual capital's most important, effective, and efficient components. Managing and developing green human capital improves positive results for all stakeholders and increases the company's market value. This is similar to what Nisar et al. (2021) found. Based on this, the following hypothesis was proposed:

H1 : The green human capital will significantly predict employee commitment to sustainable performance and their willingness to contribute to the organization's environmental goals.

Green Structural Capital (GSC). Knowledge creation, storage, and dissemination are essential factors in learning organisations, practically in the age of technology and the contributions of intelligent processes and applications to environmental protection (Jirakraisiri et al., 2021). These administrative and organisational processes serve as management mechanisms that effectively and creatively contribute to engineering organizational activities. According to Bontis et al. (2000), contemporary organisations must rely heavily on organizational processes, particularly structural capital. In today's business environment, organizations must seek environmentally friendly processes and sustainable activities facilitated by green structural capital. GSC significantly contributes to environmental sustainability and achieving sustainable performance (Amores-Salvadó et al., 2021). Based on this, the following hypothesis was proposed:

H2 : The green structural capital will significantly predict organisational culture's commitment to sustainable performance and willingness to contribute to the organisation's environmental goals.

Green Relational Capital (GRC). In growing markets, it is vital for small and medium enterprises (SMEs) to maintain strong connections with stakeholders in order to improve their environmental practices. Research conducted by Zahoor and Gerged (2021) indicates that these relationships, especially those that are well-established, play a key role in enhancing environmental performance by promoting the exchange and integration of environmental knowledge. Despite this, many SMEs struggle

to effectively manage their relationships with stakeholders, underscoring the importance of focusing on leveraging these connections to enhance environmental sustainability efforts.

Building on the findings of Wu and Yu (2023), it is evident that establishing strong relationships with stakeholders along the supply chain can enhance both operational efficiency and environmental performance. However, relying too heavily on these relationships can have a negative impact on overall performance. With this in mind, we have put forward the hypothesis that green relational capital will have a significant influence on an organisation's cultural commitment to sustainable practices and willingness to contribute to environmental goals.

Green Intellectual Capital (GIC). Given the tripartite nature of green intellectual capital, encompassing human, structural, and relational capital, and the established understanding of their contributions to sustainable performance, based on this, the following hypothesis was proposed:

H4: The green intellectual capital will have a positive relationship with sustainable performance.

Literature Review

As measuring intangible assets, particularly those related to ecology and environmentally friendly processes, can be challenging, previous research is utilized to define the study variables. This also helps determine the statistical methods employed and identifies gaps that need to be addressed, specifically in selecting companies focused on combating environmental degradation.

Much of the research on Green Innovation and sustainable performance has been conducted in developed countries, leaving a noticeable gap in understanding how the green value chain is established in developing nations like Algeria, particularly within the waste recycling sector. Previous studies have shown a relationship between Green Innovation in industries with a high level of environmental consciousness, but similar research in the waste recycling industry is lacking. This sector presents unique challenges and opportunities for applying Green Innovation, necessitating further exploration and comprehension.

As well as Considerable research highlights the crucial role of knowledge-based capabilities, mainly green intellectual capital (Wang & Juo, 2021), in aligning organisational dynamics with the external natural environment (Al-shami & Rashid, 2021). The Green Intellectual Capital Act eases a bridge between external knowledge and internal organizational drivers. Despite the acknowledged importance of corporate greening strategies in promoting environmental well-being. Scientific attention to green intellectual capital, particularly in the context of green business strategies, has been inconsistent (Shah et al., 2021). Additionally, the knowledge embedded within the workforce is paramount for sustainability (Jilani et al., 2020).

An organisational commitment to green principles cannot be achieved without a corresponding alignment of its intellectual capital with green ideals (Wei et al., 2023). GIC facilitates the dissemination of employee expertise and promotes awareness of green ideologies and energy-saving methodologies (Tariq et al., 2014). Moreover, the conditions under which green intellectual capital develops green strategies could be different norms, expectations, and government regulations (Begum et al., 2022).

The idea of green intellectual capital (GIC) has undergone significant development since it was first introduced as knowledge assets focused on environmental sustainability within organisations. Recently, the understanding of GIC has expanded to include its role in driving green initiatives and contributing to overall sustainable performance. GIC is now viewed as a crucial component of the resource-based view theory, playing a key role in enhancing sustainable business performance through collaboration and innovation. This shift highlights the growing recognition of the strategic importance of GIC in achieving environmental and economic objectives.

Although not explicitly referred to as GIC, Hart (2007) laid the foundation for the concept by

advocating for companies to consider natural resources as strategic assets. Chen (2007) defined green intellectual capital as encompassing all of an organisation's intangible assets, such as knowledge, skills, and connections related to ecosystem sustainability and environmentally friendly innovation at both individual and organisational levels.

The research of Huang and Kung (2011) reinforces the importance of GIC by highlighting the role of environmental consciousness within organisations. They argue that (environmental consciousness) is a key driver for developing and utilizing GIC (Marco-Lajara et al., 2022). Recently, research by Sharma et al. (2023) defined GIC as a valuable resource for achieving environmental and economic goals (Ahlawat et al., 2023). Their definition is mainly consistent with previous work, but they specifically highlight the importance of GIC in driving sustainable business performance (Marco-Lajara et al., 2022).

So, the evolution of the GIC definition demonstrates a growing recognition of its critical role in driving organizational sustainability (Bombiak, 2022). GIC goes beyond simply knowing environmental issues; it encompasses the skills, capabilities, relationships (Martínez-Falcó et al., 2023; 2024), and systems that enable organizations to effectively manage their environmental impact and contribute to a more sustainable future. By investing in GIC, organizations can achieve long-term success while creating positive environmental and social impact (Shahbaz et al., 2024).

The Dimensions of Green Intellectual Capital

The components of green intellectual capital refer to change, Chang and Chen (2012) highlighted its three core dimensions. This framework provides a structured approach to understanding and managing GIC within organizations (Xi et al., 2022). Instead of only focusing on one component of GIC, the organization should prioritize a comprehensive approach to sustainability by investing in all three components. This entails dedicating resources to green training, cultivating strong partnerships with eco-friendly partners, and implementing effective green management systems (Andoko & Prastomo, 2021).

Green Human Capital. This refers to the skills and knowledge of employees related to sustainability. It includes their understanding of environmental issues (Unsworth et al., 2021), expertise in developing and implementing sustainable practices, and ability to contribute to the organization's environmental responsibility culture (Wang et al., 2023).

Green Structural Capital. This refers to systems and processes that support green practices within the organization. This includes environmental management systems, the green technology infrastructure (Sahoo et al., 2022), sustainable supply chain management, and internal communication systems that promote environmental awareness and engagement (Mishra et al., 2022).

Green Relational Capital. This encompasses relationships with stakeholders who are committed to sustainability. These stakeholders can include customers, suppliers, investors, government agencies, and community organisations (Pfajfar et al., 2022). Substantial green relational capital allows organisations to access valuable knowledge, resources, and support for their sustainability initiatives (Xu et al., 2022).

The link between green intellectual capital and sustainable performance.

Indeed, sustainable performance in business refers to the ability of organizations to achieve long-term success while minimizing negative environmental and social impacts (Aagaard, 2022). This concept has gained prominence as businesses recognize to meet the requirements of the present without compromising the potential of future generations to meet their own needs, organisations must integrate sustainability into their strategy (Elsawy & Youssef, 2023). Achieving sustainable performance involves adopting practices that promote economic viability, environmental stewardship, and social responsibility (Le, 2022).

By effectively managing resources, reducing carbon footprints, enhancing stakeholder relationships, and collaborating (Chan, 2021). This confirms that the link between organizational factors influencing self-initiated behavior and the concept of green intellectual capital lies in their mutual reinforcement of environmentally responsible practices (Rana & Arya, 2023). Organizational factors such as culture, product quality, eco-labeling awareness, and technological proficiency play a crucial role in fostering green behaviors among employees and promoting the adoption of sustainable practices (Huang et al., 2024).

These elements nurture green intellectual assets, which comprise the expertise, abilities, and advancements essential for crafting eco-friendly products and strategies (Khan et al., 2023). Embedding conscious principles into organizational decision-making further enriches this intellectual wealth, empowering companies to attain both environmental and financial advantages while aligning with ethical business practices and sustainable growth principles (Isaak, 2017). By prioritising both environmental responsibility and profitability, businesses create a culture that values and utilizes sustainable practices, driving continuous progress in environmental initiatives and maintaining a competitive advantage in sustainable business strategies (Chen, 2007). Building on the preceding examination, we can now consolidate the findings derived from previous studies.

To begin with, the significance of intellectual capital for sustaining performance lies in;

Promoting sustainable behaviours;

Green intellectual capital equips organisations with the knowledge and tools to formulate and execute eco-conscious practices. Additionally, green innovation facilitates the development of sustainable solutions and technologies that collectively contribute to improved sustainable performance.

Enhancing Competitive Advantage. Leveraging green intellectual capital and innovation can differentiate organisations in the market; attract environmentally conscious consumers and investors, driving competitive advantage and long-term success.

Fostering Continuous Improvement

Green intellectual capital fosters a culture of continuous improvement and adaptation to changing environmental demands, ensuring organizations remain relevant, resilient, and thriving in the long-term.

GIC a Competitive Advantage. In today's business context, there is a growing acknowledgment of the pivotal role played by environmental sustainability. This acknowledgment has led to a greater emphasis on green intellectual capital, referring to the combined knowledge, abilities, and experience within companies that drive efforts towards environmental regulations, the development of sustainable technologies, and the fostering of a corporate culture that values environmental responsibility (Zhang, 2024).

GIC is a Multifaceted Return. The advantages of investing in green intellectual capital are manifold. It enables enterprises to curtail their environmental footprint by enhancing resource efficiency. Such endeavors can yield cost efficiencies and bolster competitive advantage, particularly as consumers increasingly favour sustainable offerings. Furthermore, firms demonstrating a steadfast commitment to sustainability tend to attract a committed and loyal workforce, fortify their brand equity, and engender trust among stakeholders, including investors and clientele (Kandpal et al., 2024).

Empowerment for a Sustainable Future. Nevertheless, cultivating and sustaining green intellectual capital necessitate deliberate and strategic methodologies. This entails fostering a corporate culture that values environmental responsibility, attracting and retaining talent equipped with specialised green competencies, and establishing robust frameworks for monitoring and appraising

environmental performance. Embracing this comprehensive approach empowers enterprises to transcend mere regulatory compliance and emerge as vanguards of sustainability. Such proactive engagement contributes to a more favourable planetary trajectory and positions organisations favourably for achieving success in an era increasingly defined by environmental consciousness.

This research addresses a gap in current literature by examining the long-term effects and viability of green intellectual capital strategies in organisations. Specifically, it focuses on a waste recycling management company in the Algerian economy, given Algeria's heavy reliance on oil and gas. This sector is important for studying the application of green intellectual capital for two main reasons: it prioritises environmental sustainability, and quantifying intangible resources is a challenge in implementing green initiatives. The study builds upon existing literature on green intellectual capital in various sectors, laying the foundation for further research in this area.

Materials and Methods

This study used a quantitative research design to investigate the impact of green intellectual capital on sustainable performance at Algerian Corporation, a waste recycling company. The research framework examined three dimensions of green intellectual capital: green human capital, green structural capital, and green relational capital, and their combined impact on the organisation's long-term performance.

Structural Equation Models

The composite indices were utilised in the building process of the current analysis model. Based on the recent studies (Rigdon, 2024), the partial least squares technique can be important because the composite measurement model has sufficient validity evidence (Hair, 2014). In the present situation, the estimates generated by PLS path modeling can be deemed consistent with the finding of (Wang et al., 2023), which confirms that this helps prevent bias. With the use of smart PLS V3, a technique known as component-based analysis, or PLS, was used to conduct a semi-analysis.

Population and Sample

To start, a diverse sample group was chosen to include large, medium, and small companies involved in waste recycling, many of which had already incorporated eco-friendly practices. The research was conducted between June and December 2023, reaching out to a total of 1039 firms across the country of Algeria. According to Taherdoost (2017), a sample size of 30 percent or more of the target population is considered sufficient for reliable results and to prevent sampling errors.

The final sample analysed in this study included 400 companies who were willing to participate, resulting in a response rate of 38.49% for this particular population.

This research aimed to analyse the impact of green intellectual capital on sustainable performance in Algerian waste recycling companies using a quantitative research design. The construction of the research framework studied three perspectives of GIC which were (green human capital, green structural capital, and green relational capital) and their influence on sustainable (long-term) performance. This study's target sample consisted of 400 entrepreneurs participating in waste recycling operations at Algerian corporations. To ensure exhaustive data collection and statistical analysis, structural equation modeling smart pls v3 technique was used, whereby all members of the target sample were surveyed.

Data Collection

The questionnaire was made up of four elements: green human capital GHC (1-6), green structural capital GSC (7-11), green relational capital (12-18), sustainable performance (19-30), as shown in Table 1.

Table 1

Measurement Instruments and Variables

Variable	Measurement instrument
GHC – green human capital	GHC1 : We participate in environmentally friendly production activities and contribute to environmental awareness activities.
	GHC2 : compared to our competitors, our company's employees contribute more to environmental preservation.
	GHC3 : our company's employees are more knowledgeable about environmental protection than our competitors.
	GHC4 : the company's personnel offer superior environmental protection products and/or services compared to our competitors.
	GHC5 : compared to our competitors, our company has a higher level of cooperative effort regarding environmental preservation.
	GHC6 : we fully help our staff members accomplish their environmental protection objectives (Zalfa & Novita, 2021).
GSC – green structural capital	GSC1 : this company has a high percentage of environmental management staff relative to its total number of employees.
	GSC2 : this firm has a beneficial knowledge management system regarding the environment.
	GSC3 : we have a team that monitors environmentally friendly operations.
	GSC4 : we have detailed environmentally friendly business regulations.
	GSC5 : we have a reward system for employees who have implemented environmentally friendly business efforts (Ullah et al., 2021).
GRC – green relational capital	GRC1 : our firm designs products and/or services that align with the environmental preferences of our customers.
	GRC2 : Customer satisfaction regarding our firm's environmental protection efforts exceeds that of major competitors.
	GRC3 : the collaborative relationships related to environmental protection between our firm and our upstream suppliers are robust and stable.
	GRC4 : the collaborative relationships concerning environmental protection between our firm and downstream clients or channels are stable.
	GRC5 : our firm maintains collaborative, solid relationships regarding environmental protection with our strategic partners (Yusliza et al., 2020).
	GRC6 : the collaborative relationships concerning environmental protection between our firm and academic institutions are stable
	GRC7 : Our firm and local community's collaborative relationships concerning environmental protection are stable (Trevlopoulos et al., 2024).
SP – sustainable performance	SP1 : enhanced compliance with standards.
	SP2 : decrease in air emissions.
	SP3 : reduction in energy consumption.
	SP4 : decrease in material usage.
	SP5 : cost reduction in materials purchasing.
	SP6 : cost reduction in energy consumption
	SP7 : reduction in waste treatment fees.
	SP8 : reduction in waste disposal fees.
	SP9 : improved overall welfare of stakeholders.
	SP10 : enhancement in community health and safety.
	SP11 : decrease in environmental impacts and risks to the general public.
	SP12 : improved occupational health and safety of employees (Yusliza et al., 2020).

Source: Adapted by authors from cited authors.

A press was performed after the questionnaire was developed on 30 individuals and company representatives who knew the subject. The research found that the questions on the questionnaire were accurately designed to measure all model concepts and that respondents understood them. This was achieved by including all recommended changes, enabling respondents to understand them more quickly and allowing them to respond organically. This questionnaire was done through Google Forms, and a personalized link was sent to the respondents. A second email, which led to the final sample analysis, was mailed following the initial communication.

Profiles of the Studied Firms

Demographic data indicated that there are more medium-sized companies than large and small ones. In the medium sample, most respondents were 45%, large-sized companies were 35%, and 20% were from small companies. Table 2 indicates the profiles of the companies.

Table 2

Profiles of Participating Companies

Criterion	Companies	Percentage
Employment number		
10-49 employees	80	20%
50-250 employees	180	45%
over 250 employees	140	35%
Company experience		
Up to 5 years	70	17.5%
5-10 years	90	22.5%
10-20 years	210	52.5%
Over 20 years	30	7.5%

Source: Authors' own development.

Result

The study depends on the estimation of a quantitative model that can predict latent variables that can be measured through other indicators. This helps identify important interrelationships and allows for testing hypotheses regarding measurement and structural models (Kiefer et al., 2023).

Assessment of Measurement Model

Fornell and Larcker (1981) introduced the Fornell-Larcker criteria as a necessary evaluative tool for SEM researchers interested in assessing the reliability of measures within the context of construct validity in reflective measurement models, emphasizing this analysis. This criterion is aimed at proving discriminant validity. The procedure looks at the correlations between one construct's AVE's square root and those of others (Fornell & Larcker, 1981). According to the basic assumption of this criteria, the square root of AVE associated with an idea must be greater than its relationships with other constructs to satisfy discriminant validity.

Table 3*Variance Inflation Factor (VIF) Values for Model Variables*

GHC	VIF	GRC	VIF	GSC	VIF	SP	VIF	SP	VIF
GHC1	0.848	GRC1	0.922	GSC1	0.820	SP1	0.869	SP7	0.874
GHC2	0.828	GRC2	0.930	GSC2	0.896	SP2	0.910	SP8	0.728
GHC3	0.812	GRC3	0.912	GSC3	0.924	SP3	0.870	SP9	0.817
GHC4	0.808	GRC4	0.905	GSC4	0.654	SP4	0.869	SP10	0.734
GHC5	0.834	GRC5	0.984	GSC5	0.909	SP5	0.843	SP11	0.600
GHC6	0.950	GRC6	0.937			SP6	0.876	SP12	0.370
		GRC7	0.935						

Source: Authors' own development.

Interchangeability is used to confirm the internal consistency of constructs by using reliability to estimate all the items that establish a construct. The reliability findings can also be used to assess the suitability and appropriateness of the chosen indicators for use in the study. The final selection of variables for the scales includes green intellectual capital, green human capital, green structural capital, green relational capital, and sustainable performance. This aspect of the research aims to introduce and evaluate a potential multi-scale model, which is anticipated to be a key outcome of the study. Therefore, the assessment of this research can incorporate not only the traditional Cronbach's alpha for data reliability but also an examination of the composite reliability of the constructs.

The Cronbach's alpha values that have been attained differ slightly in that they range from 0.836 to 0.922, which can be considered sufficient, as they are greater than 0.70. The specific values of the coefficients are next discussed (Hair et al., 2010; Nunnally, 1978).

Others have argued that to interpret the composite reliability, recommendations made by Nunnally and Bernstein (1994) were used as following values above 0.7. In the cited author's opinion, values larger than 0.7 are considered enough for the research to be relatively basic; higher-level research relies on the use of a value equivalent to or more than 0.836, it can noted from Table 4 that the values for all the constructs of the model have a value of 0.8. namely between 0.836 and 0.922. According to the results, the reliability of the constructs is confirmed to be very high.

Table 4*Constructs Composite Reliability and Convergent Validity*

Construct	Alpha cron	Fiabilité comp	CR	AVE
GHC	0.894	0.926	0.896	0.758
GRC	0.922	0.941	0.922	0.763
GSC	0.836	0.889	0.848	0.668
GIC	0.853	0.911	0.853	0.774
SP	0.916	0.941	0.916	0.779

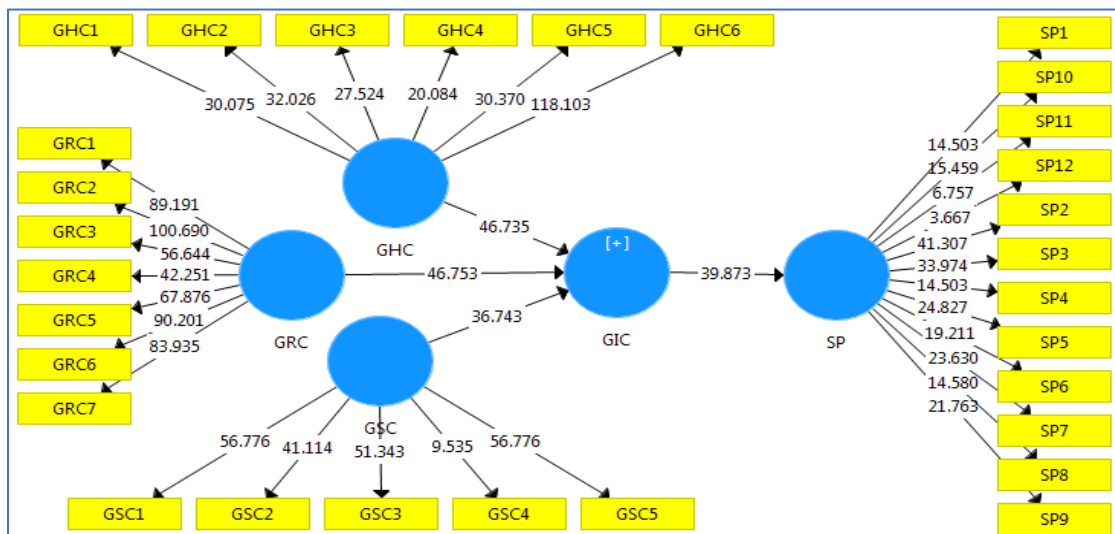
Source: Authors' own development.

Table 5*Discriminant Validity Assessment Using Fornell-Larcker Criterion*

	GHS	GRC	GSC	GIC	SP
GHC	0.871				
GRC	0.785	0.874			
GSC	0.582	0.630	0.817		
GIC	0.757	0.775	0.533	0.880	
SP	0.743	0.765	0.570	0.816	0.894

Source: Authors' own development.

Table 5 shows that the diagonal figures are the square roots of the AVE for each corresponding construct. Nevertheless, non-diagonal elements highlight the interrelationship between variables. For example, 0.871 for green human capital represents the square root of its AVE, while 0.785 on its row shows how it relates to green relational capital. In accordance with the Fornell-Larcker criterion, the numbers on the diagonal should be larger than those in the row and columns. The results show that all of the constructs under study meet the established discriminant validity criteria ($0.871 > 0.785$; $0.874 > 0.785$ and $0.874 > 0.630$; $0.817 > 0.630$ and $0.817 > 0.533$; $0.880 > 0.533$), so discriminant validity was confirmed. Figure 2 presents the model's nomogram.

Figure 2*Research Model Nomogram*

Source: Authors' own development.

Measurement of Path Model

The hypotheses examine the influence of concepts of green intellectual capital and their essential role in sustainable performance. The statistical analysis is based on p-values and a 5% significance level to evaluate these relationships. According to this study, H1 shows a strong relationship between green human capital and sustainable performance. (moyenne 0.275 ;t value36.230 , p- value=0.000). Green human capital has a statistically significant positive effect on sustainable performance, as the p-value is below the 0.05 cutoff point. Thus, H2 is accepted. It says a strong relationship exists. Green structural capital statistically significantly influences sustainable performance, as the p-value is below the 0.05 cutoff point. Thus, H2 is accepted. H3 says a strong relationship exists between green relational capital and sustainable performance (moyenne 0.407;t value 39.742, p- value=0.000). Green relational capital

has a statistically significant positive influence on sustainable performance as the p-value is below the 0.05 cutoff point. Thus, H3 is accepted. H4 says a strong relationship exists between green intellectual capital and sustainable performance (moyenne 0.901; t value 39.973, p-value=0.000). The green intellectual capital has a statistically significant positive influence on sustainable performance as the p-value is below the 0.05 cutoff point. Thus, H4 is accepted. Green organizational practices, green human resources, green innovation, and the company's information and green relationships are crucial to efficient and sustainable business operations. So, using the green intellectual capital theory in Algerian companies can improve sustainable performance. These are the elements that, when combined, contribute to the enhancement of a company's sustainability amidst a constantly evolving and fiercely competitive business landscape.

Table 6

Comparison of Hypotheses Results

	VARIABLE	Moyenne	Valeurs t	Valeurs-P	Résultat	
H1	GHC--SP	0.275	36.230	0.000	acceptable	
H2	GSC--SP	0.246	23.810	0.000	acceptable	
H3	GRC--SP	0.407	39.742	0.000	acceptable	R ²
H4	GIC--SP	0.901	39.973	0.000	acceptable	0.717

Source: Authors' own development.

Discussion

Consequently, this research's findings helped establishing the relationship between GIC and sustainable performance within the Algerian waste recycling companies. The research design is sufficiently sound. SEM, along with the PLSv3 technique integrated with composite indices, is applied to examine the mediating impact of GIC's elements, including green human capital, green structural capital, and green relational capital on sustainable performance.

Significant impact of GIC: Therefore, in light of the above finding, the study unambiguously confirms the positive and significant relationship between GIC and sustainable performance. All four hypotheses were valid; this meant that green investments in human capital, structural capital, and regional capital were seen to enhance the green performance of the Algerian waste recycling companies.

The first hypothesis (the green human capital will significantly predict employee commitment to sustainable performance and their willingness to contribute to the organisation's environmental goals.) The green human capital is a key driver. The research also concluded that GHC was valuable, as the traditional model suggested, and had a positive and statistically significant relationship with performance. It was supported and the result aligned with the study of Mansoor et al. (2021), Nisar et al. (2021), and study of Jirakraisiri et al. (2021) but was contrary to the study of Marco-Lajara et al. (2022). Due to this discovery, organizations are encouraged to focus on training, developing, and motivating their workforce in environmental management practices. Regarding this matter, the outlined partnership between the National Agency for the Support of Youth Employment (ANSEJ), the National Waste Agency (AND), and the National Conservatory for Environmental Training (CNFE) shall spearhead the creation and growth of enterprises in the environmental domain. This framework provides a template for consultation, cooperation, and coordination for the up skilling of enterprises in the area of environmental projects, and these efforts play an essential role in the enhancement of green human capital formation because training, mentorship, and access to expertise help young entrepreneurs build sustainable organisations for environmental enhancement and economic growth.

The second hypothesis (the green structural capital will significantly predict organizational culture's commitment to sustainable performance and willingness to contribute to the organization's

environmental goals.) was supported and aligned with the study of Asiaei et al. (2022) but was contrary to the study of Mansoor et al. (2021) and Marco-Lajara et al. (2022). This is due to the fact that Algeria is among the countries exporting technology and mechanism to assist in regulatory work.

The third hypothesis (relational capital will significantly predict organisational culture's commitment to sustainable performance and willingness to contribute to the organisation's environmental goals) was supported and aligned with the study of Mansoor et al. (2021) and Marco-Lajara et al. (2022) but was contrary to the study of Nisar et al. (2021) this is due the strategic importance of green relationships, and the study also stresses the significance of the category of green relational capital, which encompasses a vast share of their sustainability undertakings.

This underscores the importance of nurturing good account relationships as the bedrock of organizational environmentalism. In this regard, Algeria's Ministry of Environment signed a memorandum of understanding with the UNEP in 2019, which can be considered an indicator of formal international cooperation in advancing environmental management. These demonstrated agreements complement this multilateral initiative with bilateral agreements with partners such as Tunisia, UAE, Ethiopia, Congo, Serbia, UK, Germany, Spain, South Korea, and Italy, depicting this as a strategic approach to building green relation capital. Bilateral and multilateral partnerships entail mutual understanding and collective responsibility for taking action, which helps to improve Algeria's stance as a responsible actor who owns the global environmental agenda.

The regression value of the model, $R\text{-squared} = 0.717$, states that the elements of green intellectual capital account for 71% of the institutional memory. Hence, the imagery explains the total variation in sustainable performance. Although this proportion suggests a trend towards sustainable performance, there is the possibility that there are other antecedent variables influencing this trend that could be considered in this study.

This paper offered an essential knowledge that can be useful for Algerian policymakers and companies in understanding the potential role of GIC as one of the necessary conditions for sustainability within the waste recycling company. The conclusions can help the companies form a strategy for investments in environmentally friendly activity and choose the course for further practical and sustainable functioning.

The study compared its findings to previous research to show that green intellectual capital does impact sustainable performance, contrary to some past studies. Algeria's implementation of green strategies in less than seven years has intensified competition among waste recycling companies striving for sustainable performance. The discussion highlights various potential reasons for the differences observed, including green skills, processes, competency, organizational culture, laws, and company nature. The paper emphasises the importance of understanding environmental practices and the need for specialised knowledge in green practices. The significance of subjective green relational capital in enhancing an organisation's sustainable performance is supported in the study, aligning with the research of Mansoor et al. (2021) and Shahbaz et al. (2024). This consistent support reduces fluctuations in results and reinforces the validity of the research.

Limitation

The sample size of 400 companies that were studied is considered to be significant, even though the focus was solely on an Algerian waste recycling company. This limits the generalisability of the research results to other industries or regions.

The use of cross-sectional, self-completion surveys in the study means that it cannot prove a direct cause-and-effect relationship between Green Innovation Capability (GIC) and sustainable performance. In the future, research on GIC could benefit from using longitudinal designs to provide more in-depth understanding of how GIC evolves over time.

While this study mainly looks at global aspects of sustainable performance, future research on transportation and sustainability could explore additional dimensions such as economic, social, and environmental factors to provide a more comprehensive understanding of the topic.

Conclusions and Implications

The primary aim of this study was to investigate the relationship between green intellectual capital (GIC) and sustainable performance within waste recycling corporations in Algeria. All four hypotheses were found to be supported, indicating that green human capital, green structural capital, and green relational capital have a positive impact on sustainability in this sector. The results suggest that Algerian waste recycling companies recognise the importance of implementing GIC but may need assistance in fully realizing its potential. While there is a level of awareness, it is crucial for organizations to develop specific action plans and adopt coherent strategies.

The study highlights the significance of three key dimensions of GIC - green human capital, green structural capital, and green relational capital - in enhancing the sustainable performance of companies. The knowledge and skills of employees, efficient systems and processes, and strong stakeholder relationships are identified as key drivers for sustainability. Establishing strong relationships with stakeholders is particularly crucial for achieving sustainable outcomes beyond the organisational boundaries.

Going back to the context of waste recycling companies, it is recommended that they prioritize investments in all three aspects of GIC. This could involve providing environmental education and training to employees, implementing improved environmental management systems, and forging long-term partnerships with environmental organizations, among other initiatives.

Government authorities are urged to promote the adoption of GIC strategies within the waste recycling industry by offering financial incentives, non-financial support, and creating a favorable regulatory environment. Encouraging the integration of GIC practices can lead to enhanced sustainable performance and ultimately contribute to a more environmentally responsible waste recycling sector in Algeria.

Suggestions for Future Research

Comparing data from different industries and countries can help determine the impact of results, and identify similarities and differences in factors influencing GIC adoption and effectiveness. Qualitative research can provide deeper insights into how GIC is understood and implemented in specific organisations, as well as offer practical guidance.

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Conflict of Interest

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