Reaching for net zero: The impact of an innovative university-led business support programme on carbon management strategy and practices of small and medium-sized enterprises

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Reaching for net zero: The impact of an innovative university-led business support programme on carbon management strategy and practices of small and medium-sized enterprises

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Abstract

Small and medium-sized enterprises (SMEs) are at the heart of the economy, representing the majority of businesses in the United Kingdom and the European Union, and employ a high percentage of people. With this positive impact comes an environmental footprint. SMEs account for around half (43–53%) of the greenhouse gas emissions, yet typically, they lack the support that larger organisations have in-house and are often hard to reach in terms of engagement, policy and practical interventions. SMEs face a range of barriers to implementing carbon management and are still a misunderstood sector both in their approach to carbon management and how best to provide business support for change. This research addresses that challenge by investigating the impact of an innovative university-led business support programme to help SMEs develop a carbon management strategy and practices. The research adopted a quantitative approach with a pre- and post-intervention survey to gather data from 101 SMEs in the context of the Sustainability in Enterprise (SiE) programme at Nottingham Trent University, United Kingdom. The study shows that universities have an important role, and the SiE programme had a significant impact on SMEs' transition to net zero through policy and strategy development, resource monitoring, carbon footprinting, target setting and carbon management maturity. The research highlights the importance of business support for SMEs, specifically in carbon management, while segmenting based on size and sector to meet ambitious local, national and global net zero targets.

KEYWORDS
business support, carbon emissions, carbon management, net zero, small and medium-sized enterprises, sustainability

Abbreviations: COP, Conference of Parties; EMCCA, East Midlands County Combined Authority; ESIF, European Structural and Investment Fund; EU, European Union; ERDF, European Regional Development Fund; FSB, Federation of Small Businesses; GDP, gross domestic product; ISO, International Organisation for Standardisation; NTU, Nottingham Trent University; SiE, sustainability in enterprise; SIC, standard industrial classification; SMEs, small and medium-sized enterprises; UK, United Kingdom; UKSPF, United Kingdom Shared Prosperity Fund.

1 | INTRODUCTION

Climate change represents one of the greatest challenges facing humanity at present (Wright & Nyberg, 2017). Globally, 2023 was the hottest year on record according to the figures released by the UK's Met Office (2024), and it feels like we are trapped in an annual cycle of hope and disappointment as successive global 'Conference of Parties (COPs)' call for meaningful climate action to limit global warming to 1.5° (UN, 2022). In light of this, the pressing question remains: who is responsible, and how does it change? A major cause of the global problem and the key to its solution are business organisations emitting carbon emissions due to their core business operations (Cadez et al., 2019). In the business world, the focus is often on the large and highly visible corporations with a huge global economic and carbon footprint, while small and medium-sized enterprises (SMEs) often go under the radar when it comes to carbon reduction and sustainability. Definition of SMEs includes micro (less than 10 employees and an annual turnover under €2 million), small (less than 50 employees and an annual turnover under €10 million) and medium-sized (less than 250 employees and an annual turnover under €50 million) businesses (Department for International Trade, 2020). SMEs account for 99% of all businesses in the European Union (EU), employ over 100 million people and account for over half of Europe's gross domestic product (GDP) (European Commission, 2020). In the United Kingdom, around half (43–53%) of the greenhouse gas (GHG) emissions are produced by businesses (British Business Bank, 2021; International Energy Agency, 2022). Definitions focusing on their size often mask a complex picture, though, as the term 'SME' hides myriad types of organisations from small shops, manufacturers, offices, property companies and theatres, to name a few.

Research by the British Business Bank (2021) has shown that most smaller businesses are at an early stage of transition to a low-carbon economy, with 76% yet to implement a carbon management strategy for their business and the majority (69%) do not know how to measure their carbon emissions to establish a baseline. While awareness is growing, attitudes are split, with 57% of those surveyed aware of the government's commitment to net zero, but only 47% stated that carbon reduction was a high or very high priority in business. Only 6% of SMEs in the United Kingdom have measured their carbon footprint in the last 5 years as part of their carbon management strategy (British Business Bank, 2021). In terms of impact, SMEs' cumulative emissions are significant and key in shaping the environmental behaviours of other businesses, individuals and communities. Business support is vital as a tool for these statistics to change, and yet, in the United Kingdom, there is no government-specific decarbonisation plan or strategy for SMEs to facilitate change as required (Hampton et al., 2023). Sporadic business support programmes exist in regions to provide SMEs with free advice and guidance as well as some grants to take action to reduce carbon emissions and become sustainable. In addition, there is a history of business support for SMEs covering other areas of operation/change, such as digital transformation or general support for growth and investment (Weatherall et al., 2022). Afolabi et al. (2022) argue that specific support and training from the UK government to motivate and guide SMEs for the transition to net zero need to be explored. Universities have been instrumental in delivering these support programmes. However, there is a gap in understanding the impact of these support interventions in a systematic way to inform future policy and practice with regard to carbon management. Studies have identified a research gap in the context of SMEs' managerial and operational environmental insights (Madrid-Guijarro & Duréndez, 2024).

Therefore, this paper explores the impact of an innovative university-led business support programme to help SMEs develop their carbon management strategy and practices to become more sustainable. The study explores the carbon management strategy and practices of SMEs and details the impact of the innovative university-led Sustainability in Enterprise (SiE) business support programme in Nottingham, United Kingdom. Consideration of SME size and sector is given as part of segmentation. The research questions considered are as follows: (1) what is the impact of a university-led business support programme to help SMEs develop carbon management strategy and practices? And (2) how does the size and sector of SMEs affect carbon management activity as a result of university-led business support? The paper proceeds as follows: first, the relevant literature on SMEs, carbon management and business support is reviewed before introducing the research methodology including the case study. This research uses data collected from SMEs in the Greater Nottingham area that participated in the SiE programme, utilising a pre-and post-intervention survey approach. Finally, results and findings are presented and discussed before offering final conclusions, recommendations and limitations.

2 | LITERATURE REVIEW

2.1 | The SME policy and practice context

The challenge of climate change requires socio-economic transformations that must be considered for SMEs' successful implementation of sustainable business practices (Hendrichs & Busch, 2012). However, regulatory policies and rules for sustainability and carbon management practices have focused mainly on large businesses (Conway, 2015; Doda et al., 2016). Previous research studies have explored how business organisations manage their carbon emissions through appropriate actions, including corporate carbon management practices. Environmental and carbon management studies have focused on large and carbon-intensive business organisations (Cadez & Czerny, 2016; Conway, 2015). For example, Yunus et al. (2016) conducted a study that examined the top 200 public companies in Australia and provided evidence to show that companies adopting carbon management strategies voluntarily have an environmental management system, an environment committee, a larger executive board and the independence of an executive board. In addition, they stated that the adoption of carbon management strategies is associated with the size of the company, the leverage and the environmental sensitivity of the company's industry. Similarly, Dhanda and

Malik (2020) indicated that larger companies are more likely to adopt carbon management strategies and reveal carbon emission amounts as part of their sustainability journey. However, they could not find a relationship between the likelihood of direct and indirect emission disclosures and the leverage. Further work is required to provide a strategic perspective to understand the role of business in a low-carbon future (Busch & Schwarzkopf, 2013; Wade & Griffiths, 2020). Christy et al. (2024) argue that there are standards and guidance for organisations to support climate mitigation. However, there needs to be alignment in high-level guidance, such as the Greenhouse Gas Protocol and the Science-Based Target Initiative, as clarity and consistency are essential to effectively assess, manage and reduce carbon footprint.

Due to their size, SMEs are exempt from some mandatory legal requirements imposed on large enterprises (Conway, 2015). Despite uncertainty about carbon emissions reduction targets, carbon management policies regarding SMEs often rely on voluntary interventions (Afolabi et al., 2022). Nevertheless, a few have started implementing carbon management and reporting on their activities (Font et al., 2012; Kazemian et al., 2022). Policy incentives such as grants and loans often support SMEs in reducing energy use by highlighting potential cost reduction (Hampton et al., 2023). These incentives see SMEs as consumers (e.g., of energy) or as enablers such as creating environmental products and services; less attention is on the potential of SMEs as influencers, particularly to other bigger organisations for which SMEs often act as suppliers or collaborators (Hampton et al., 2023). Therefore, the UK government plans for SME decarbonisation to enable more joined-up and cross-departmental policy making to address the net zero challenges for SMEs. There also needs to be a clear regulatory timetable as a central part of the plan and a joined-up business support framework (Weatherall et al., 2022). Furthermore, Hakovirta et al. (2023) highlight the importance of start-up companies in corporate innovation and sustainability strategies while implementing their ambitious corporate net zero carbon targets and commitments. Overall, at present, SMEs are an under-developed area when it comes to carbon management practice and research.

Jalo et al. (2021) note that energy management practices in SMEs are underdeveloped, and most of the energy efficiency and carbon reduction potential is left untapped. Policies still largely overlook SMEs in the United Kingdom and EU, particularly those related to energy efficiency, which leads to carbon reduction (Fawcett & Hampton, 2020). For example, Blundell and Hampton (2021) produced an evidence review of SMEs' role in contribution to net zero. Alongside noting the increased attention SMEs are getting with regard to their environmental impact, they explore the policy context surrounding them, which, for now, mostly consists of local environmental legislation (e.g., pollution prevention), voluntary codes and participation in ISO standards such as 14001 (Environmental Management) and 50001 (Energy Management System). SMEs' capacity to implement and monitor carbon emissions and environmental issues significantly differs from larger enterprises (Fawcett & Hampton, 2020). SMEs' particular features by which they are generally characterised, such as limited human and financial resources, partially explain their slower adoption of information management systems that enable them to measure, manage and plan the transition to a low-carbon economy (Shields & Shelleman, 2017). A study conducted in Derbyshire (United Kingdom) indicates that most SMEs do not monitor or set targets for carbon management (Conway, 2015) and that 77% of SMEs do not know how to measure their carbon emissions and need support to develop strategies (HM Government, 2021). This suggests that SMEs face a range of barriers to carbon management, including finance, knowledge and skills, which need addressing.

The scarcity of SME examples implementing carbon management is not surprising as it is still considered an add-on that is pursued outside the normal activities of businesses. A study with SMEs related to restaurants, architectural practices and building firms in the United Kingdom showed SMEs do not see the benefits of environmental reforms when they already need to deal with day-to-day activities driven by regulation, including health and safety and employment rights (Revell & Blackburn, 2007). Often, this is led by the need to prioritise activities due to a lack of resources, including expertise, finance and time, to pursue them, which is only supported by initiatives such as grants and loans. On the one hand, if carbon management is to continue being mainly a voluntary practice in SMEs, one relies on each business to engage in activities to implement a carbon management strategy. This will likely be different between organisations due to the heterogeneity of SMEs. In some SMEs, changes will be driven by their local economies, others by regional and national networks where they are embedded, which leads to multi-scalar and spatial challenges (Hampton et al., 2023). On the other hand, if carbon management becomes regulated in SMEs, it might drive a measure of carbon. However, SMEs would still likely rely on mostly public resources such as grants to guarantee compliance. Revell and Blackburn (2007) discuss how SMEs perceive regulation as the main driver to encourage environmental practices, but only if it does not cost the business. However, according to Baranova and Paterson (2017), most SMEs do not access governmental grants to improve energy efficiency, and there is an issue of lack of investment.

2.2 | Opportunities for carbon management and business support for SMEs

Recent studies conducted in this field have shown that SME owners tend to be uninformed about the environmental effects of their companies, and transformations in the transition to sustainability are challenging (Revell et al., 2010). A fundamental problem that prevents the implementation of carbon emissions reduction strategies is that institutions hesitate to act until they have a clear picture of how an initiative will affect the value of the business (Renukappa et al., 2013). SMEs operate in complex and poorly supported local environments; for example, they experience a huge variety of building types and facilities management. Janda et al. (2014) highlighted these barriers' SMEs often find, for example, in energy data collection, as many SMEs do not have energy managers and have 'legacy' metres, i.e., non-smart metres that do not allow for up-to-date readings and force companies to rely on estimated billing impacting energy

efficiency and carbon reduction activities. Energy and carbon reduction are challenging in rented premises (often via leasing); the changes SMEs can make to the premises to collect data or implement changes for carbon reduction are limited. The tenant–landlord relationships can be a particularly complex issue, especially when the landlord is a public sector organisation such as a local government, which is associated with restrictive resources (Domingues et al., 2023). SMEs often occupy premises in buildings that are not purposely created for their activities, which leads to energy inefficiencies and increased carbon emissions (Domingues et al., 2023; Mazhar et al., 2022). Crucial to this, Janda et al. (2014) note the relevance of the role of a dedicated energy manager in measuring and managing data, including interpreting results and implementing measures to reduce energy and carbon emissions. Due to the size of some SMEs and resource constraints, this role might likely be occupied by an external consultant to help realise opportunities for energy and carbon management (Janda et al., 2014). Busch et al. (2022) studied corporate carbon performance identifying the issues around data, and they argue that the data on direct emissions (Scopes 1 and 2) are more consistent ensuring better management than indirect emissions (Scope 3).

In terms of business support for SMEs, there has been a significant focus on energy rather than broader sustainability aspects. Revell et al. (2010) show that the potential cost savings from energy or other resource efficiency measures is one of the key drivers for SMEs implementing environmental practices. Hampton (2019) suggests that business advisors are key in steering energy management practices, besides reflecting on how energy management practices influence processes of knowledge production and organisational meaning-making. SMEs are less likely to pay for external expertise than larger companies, and therefore, they seek advice and support through informal and professional relationships (Hampton et al., 2022). Evidence from arts and cultural organisations in Nottingham, United Kingdom, indicates that SMEs still face implementation issues beyond measuring environmental performance (Domingues et al., 2023). In recent years, there has been an increase in studies focusing on examining the contributions of support policies to SMEs' transition to sustainability and carbon management practices. Owen (2021) states that properly financing clean technology innovation for early-stage SMEs can initiate disruptive low-carbon reduction effects in various sectors to achieve net zero targets. In their study identifying factors that influence organisational change during the transition to carbon management practices in SMEs, Domingues et al. (2023) drew attention to five interrelated factors: the role of funding institutions, local policies and networks, organisational culture, leadership, lack of resource and property-tenant relationships. Journeault et al. (2021) identified key collaborative roles that stakeholders could play in SMEs' adoption of sustainability practices, such as trainers, analysts, coordinators, specialists and financial providers. In their study investigating the role of various intermediary forms in supporting SMEs to contribute to sustainability transition, Kundurpi et al. (2021) observed that collaboration with business networks and other businesses was the most significant form of interaction to exploit opportunities. However, they stated that diverse intermediaries support SMEs' sustainability actions in different ways.

Although market drivers have the potential to promote environmental action, studies have shown that SMEs generally consider the market to be a barrier rather than a driver in good environmental practices (Revell et al., 2010). The main reason for SMEs' tendency towards such consideration can be the lack of motivating and incentive policies and external support interventions for SMEs. Bennett (2008) argues that government support appears to fulfil market failures and is likely ineffective at realistic cost–benefit ratios. However, to support SMEs in reducing GHG emissions, multiple criteria beyond cost-effectiveness need to be used, such as SMEs' capacity to deliver that change. Drivers for SMEs to act are multiple and include cost saving, being in line with a strategic goal to be a low-carbon business, responding to customer opportunities, keeping up with competitive trends and keeping up with regulatory or tax direction (particularly as large business and public sector look at their value chain emissions) and reputation (British Business Bank, 2021). However, Conway (2015) discusses how SMEs make efforts to reduce carbon, which is related to internal stakeholders' values and when SMEs are pressured from the supply chain.

Most studies have focused on determining SMEs' general tendencies towards sustainability and carbon management practices, the barriers they have encountered and the promoting drivers so far (Caldera et al., 2019; Collins et al., 2010; Eweje, 2020; Fahad et al., 2022). Studies have been conducted that delve into contributions in more detail to improve the design and implementation of business support programmes aimed at assisting SMEs' sustainability transitions (Hampton et al., 2022; Journeault et al., 2021; Kundurpi et al., 2021). Hampton (2018) states that public funds are now invested in low-carbon advisors to support SMEs in reducing carbon emissions on a regional basis. However, Baranova and Paterson (2017) state that financial grants are required to improve energy and carbon efficiency in businesses. Baranova et al. (2020) argue that business support mechanisms need to move beyond a singular focus on energy efficiency and shift towards a holistic approach to capacity building for sustainable development. However, there is a gap in understanding the true impact of business support programmes. Hampton et al. (2023) raise questions about who should influence and govern SME decarbonisation strategies in regions.

Collaboration between universities and businesses such as SMEs can support the transition to a low-carbon economy. Caldera et al. (2019) specified six barriers to SMEs' transition to sustainable business practices, namely, the lack of financial resources, time and knowledge; risks related to the implementation of a new sustainable practice, current policies and regulations; and organisational culture. Universities can support SMEs with the necessary knowledge to implement carbon management strategies supported by public funds. In the United Kingdom, business-university collaboration is not unique. Universities are embedded in the economy and communities through different ways such as spin-offs, start-ups, consultancy, contract/collaborative research and continuing professional development programmes (Higher Education Statistics Agency, 2024). However,

most published research in the field relates to research-led initiatives based on co-creation processes (e.g., Ward et al., 2017) and partnerships for innovation (e.g., Minshall et al., 2016).

Over the years, business support programmes have existed, and many of them are delivered and led by universities. Although these programmes provide evidence of the efficiency, effectiveness and value for money as part of the summative assessment, they do not appear to assess the impact of their activities in a more systematic, comprehensive and in-depth manner. This is a gap and can jeopardise the potential of these programmes to inform future business support programmes' design, policy and business practice. SME decarbonisation support has mostly been delivered via localised programmes, such as those funded by the European Regional Development Fund (ERDF) and the UK Shared Prosperity Fund (UKSPF). Many of these programmes are university-led and support SMEs in various aspects of business strategy and carbon management/sustainability in local regions. SMEs are calling for more support, and surveys from both the British Business Bank (2021) and the Federation of Small Businesses (FSB) (2021) say they want more help with sustainability and transition to net zero. Therefore, this type of research investigation is important for both impact measurement and lessons learned as well as business practice sharing for net zero. This research will address both academic and practice gaps when it comes to the role of business support programmes in helping SMEs to develop their carbon management strategy for net zero future.

3 | RESEARCH METHODOLOGY

3.1 | Case study description: Sustainability in enterprise (SiE) programme

This research was carried out in Nottingham, United Kingdom, a relatively large city in the East Midlands with 330,000 inhabitants and a strong industrial heritage of mining, textiles and engineering (see map in Figure 1). Nottingham Trent University (NTU) secured £3.9 m ERDF funding to deliver a low carbon business support programme, Sustainability in Enterprise (SiE), aimed at supporting SMEs to transition to net zero. The funding enabled a range of services, including free, practical support from specialists in sustainable business strategy and

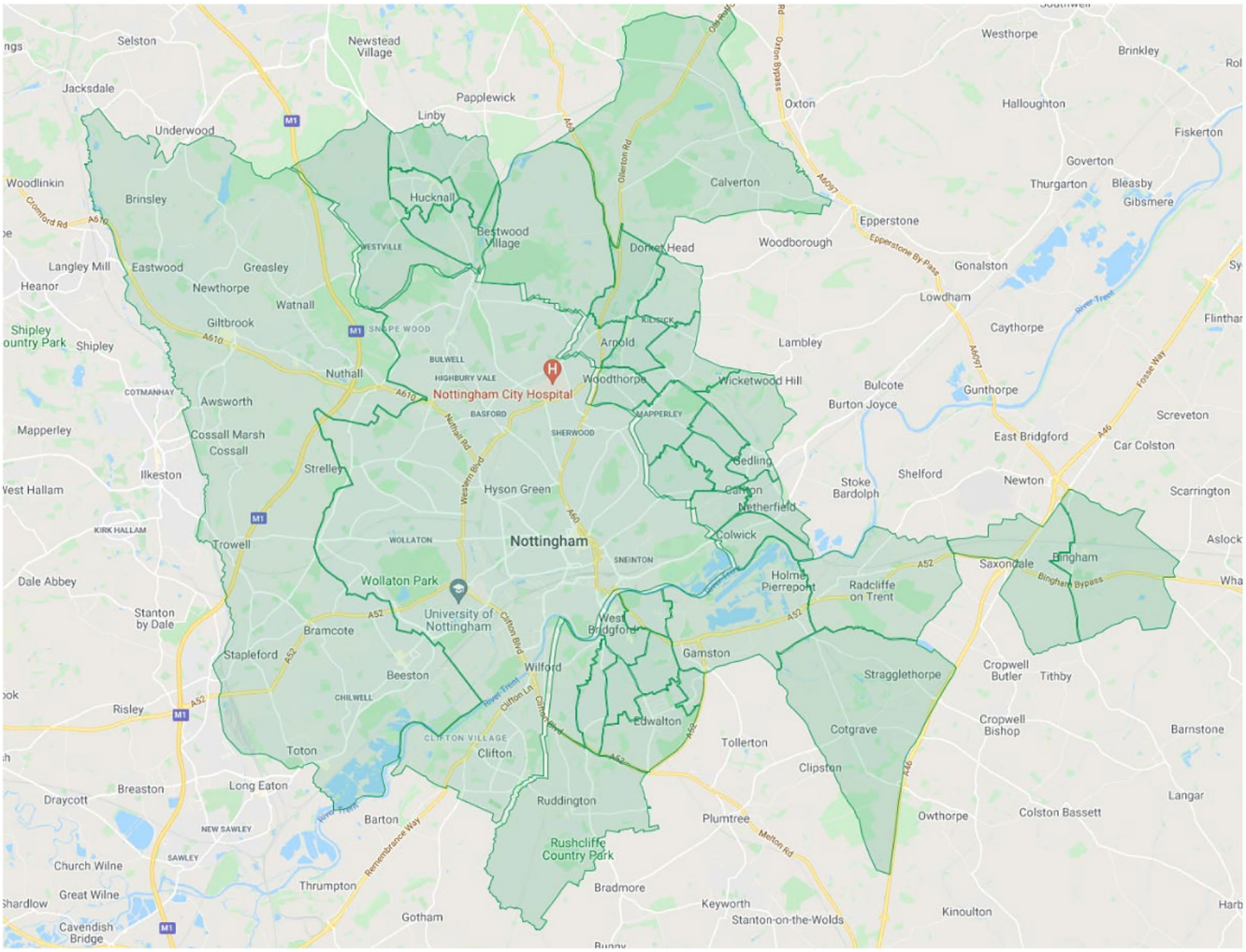

FIGURE 1 The Greater Nottingham area for the Sustainability in Enterprise programme.

operations, building management, product design, and employee training and engagement. SMEs had to sign up to seek support, provided they met the eligibility criteria in terms of size and location. The SiE support services included (i) free carbon management and sustainability consultancy from academics, NTU sustainability practitioners and students from the multi-disciplinary teams; (ii) financial grants were available to help companies implement projects and initiatives to reduce carbon emissions; (iii) financial grants for graduate talent to gain human resources; and (iv) carbon management workshops for SMEs to build their in-house capacity and knowledge. SiE has been a unique business support programme due to the involvement of final-year undergraduate students from Nottingham Business School and the School of Architecture, Design and the Built Environment at NTU, where they supported SMEs through in-curriculum and extra-curricular carbon management consultancy. The SiE programme also involved NTU's own award-winning sustainability team for consultancy and environmental audits for businesses. This research investigates the impact of this innovative university-led business support programme in helping businesses to transition to a low carbon business model.

3.2 | Research design

The SiE programme was used as a case study. A broad understanding of the case study approach was utilised, as it was viewed that the NTU SiE programme was a relevant and comprehensive example of university-led business support to SMEs even though it is one project in one geographical region. However, lessons can be drawn from the in-depth understanding of the business support ecosystem and what works, what does not, and why. The scale and nature of support as well as the stakeholders involved make it a unique programme in the United Kingdom. The range of support and type of SMEs provided sufficient scope for analysis such that this single case study could produce knowledge that is replicable to a wider context nationally and internationally to help achieve a net zero economy. Flyvbjerg (2006) and Dubois and Gadde (2002) provide a defence for the use of a single case study being critical to the development of knowledge. Flyvbjerg (2006) notes that cases are important to develop a 'nuanced view of reality' and, second, that they are important for researchers' own learning processes. In this context, while there is a 'case'—the SiE programme delivered by NTU, it was felt that a quantitative approach to survey design would engage most SMEs and enable the most comprehensive picture possible of the impact of support. Therefore, quantitative pre- and post-intervention surveys were carried out where SME managers completed the survey. Results of the data collected from SMEs that were included in the SiE programme regarding carbon management were measured and compared through this research design.

3.3 | Data collection and sampling

Data were collected from SMEs included in the SiE programme using an online survey from September 2021 to January 2023. The survey was part of the documentation in DocuSign, which was required for SMEs to complete to sign up for the SiE support. The research team did not select the SMEs directly, but SMEs joined the programme based on their priorities and needs. SMEs had to go through an eligibility check, which was the funding body's requirement. Participating SMEs were given the choice of whether they would like to offer their consent for the survey data to be used for research or not. The selection process helped get SMEs of all sizes and types from different sectors as the SiE business development and marketing team was tasked with securing businesses and referring to relevant business support strands of the programme. This sampling process helped address the issue of bias from a research perspective. SME managers and directors were required to complete the survey, providing insights on behalf of their business. Data characteristics of SMEs, such as turnover, number of employees and company registration date, were also collected using background questions. Data were anonymised to allow confidentiality. The number of participants who responded to the pre-intervention survey was 215, and the number of participants who responded to the post-intervention survey was 124. Only SMEs who responded to both pre- and post-intervention surveys were included in this study to measure the impact of business support intervention on SMEs and how this had an impact on the development and/or progression of carbon management strategy. After the elimination of the participants who had not responded to both surveys and those who had not given consent to use their data for the research, the final study sample was 101.

Both pre- and post-intervention surveys comprised close-ended questions adapted from Mazhar (2017) and Mazhar et al. (2017) who explored strategic carbon management within the UK higher education sector. The survey was validated with the help of a multi-disciplinary SiE programme team, which included academics from the business school and school of architecture, design and the built environment and sustainability professionals from the sustainability team at NTU. The pre- and post-intervention surveys consisted of the same set of questions, which were divided into six categories. Question 1 (Q1) focused on the sustainability/carbon management policies of SMEs, while Q2 dealt with the areas where SMEs implemented carbon reduction activities. Q3 explored the resources monitored by SMEs, while Q4 investigated whether SMEs have measured their emissions and, if so, which emissions sources were measured. Q5 examined whether SMEs set carbon reduction targets and, if so, which emission sources were targeted as part of the carbon management strategy. Finally, Q6 assessed the carbon management maturity of SMEs using various indicators. Table 1 describes each variable included in the study and how these variables are measured and coded.

3.4 | Data analysis

Data were transferred from DocuSign to Microsoft Excel for pre-processing, and in the next stage, data were analysed using IBM SPSS Statistics 28.0.1.1. The study used descriptive statistics to

TABLE 1 Description and coding of the variables included in the study.

Variable	Brief description
Dependent variables of interest	
Sustainability/carbon management policies and strategy	For each item in the scale of sustainability/carbon management policies and strategy implemented in SMEs, a dichotomous scale was used. Items were coded as one (1) if there was an implementation and zero (0) if not.
Carbon reduction activities	For each item in the scale related to carbon reduction activities implemented in SMEs, a dichotomous scale was used. Items were coded as one (1) if there was an implementation and zero (0) if not.
Monitoring resource use	For each item in the scale related to regular monitoring of resource use in SMEs, a dichotomous scale was used. Items were coded as one (1) if there was an implementation and zero (0) if not.
Carbon emissions/footprint	For activities related to measuring carbon emissions (carbon footprint) in SMEs, it was coded as zero (0) if there was no implementation, one (1) if it was in the in progress/developing stage, two (2) if there was an implementation and three (3) if it was unknown; a multinominal scale was used. However, it was observed that the rate of response for the 'Don't know' option of the participants was quite low, and for the sake of brevity, the option 'Don't know' was considered as 'No' for both pre-and post-intervention surveys.
Carbon reduction targets	For the development of carbon reduction targets in SMEs, it was coded as zero (0) if there was no development, one (1) if it was in the progress/developing stage, two (2) if there was development and three (3) if it was unknown; a multinominal scale was used. However, it was observed that the rate of response for the 'Don't know' option of the participants was quite low, and for the sake of brevity, the option 'Don't know' was considered as 'No' for both pre-and post-intervention surveys.
Scopes of carbon emission/footprint	For the scopes (1, 2 and 3) that SMEs focus on when measuring carbon emission sources, a dichotomous scale was used. It was coded as one (1) if there was a measurement and zero (0) if not.
Scopes of carbon reduction targets	For the scopes (1, 2, and 3) that SMEs focus on when determining carbon reduction targets, a dichotomous scale was used. It was coded as one (1) if a target was set and zero (0) if not.
Carbon management maturity	Carbon management maturity in SMEs was measured using a 5-point Likert scale. The scale was scored as 1, *strongly disagree*; 2, *disagree*; 3, *neither/nor*; 4, *agree*; and 5, *strongly agree*.
Independent variables of interest	
Size	Medium-sized SMEs are any organisation that have fewer than 250 employees and a turnover of less than €50 million. Small-sized SMEs are any organisation that has fewer than 50 employees and a turnover of less than €10 million. Micro-sized SMEs are any organisation that has fewer than 10 employees and a turnover of less than €2 million (UK Government, 2022).
Sector	The SMEs included in the study were classified according to the UK Standard Industrial Classification (SIC) hierarchy. However, due to the low number of SMEs in certain sectors, some sectors were combined to ensure the robustness of the analyses. The sector categories are as follows: • Professional, scientific & technical (including financial & insurance; admin & support services) • Manufacturing (including electricity, gas, steam & aircon) • Wholesale & retail (including repair of automotives; transportation & storage) • Construction & real estate • Arts, entertainment & recreation • Information & communication • Other services (including education; human health & social work; accommodation & food service)

provide insights such as the mean, standard deviation, percentage and frequency of the variables in the dataset. Before further analyses, a reliability analysis was conducted to evaluate the reliability of the measurement tool. Cronbach's alpha is widely used to measure internal consistency and evaluate the instrument's reliability (Cronbach, 1951; Sharma, 2016). Cronbach's alpha coefficient can be used in both scales, including dichotomous response options and the one with multi-item response options to evaluate the survey instrument's reliability (Sharma, 2016). This research used Cronbach's alpha coefficient to calculate the reliability of the measurement instrument.

McNemar's test is frequently used to compare the differences between a dichotomous dependent variable's pre- and post-intervention results in matched pairs (Adedokun & Burgess, 2012; Sun & Yang, 2008). This study used McNemar's test to compare the differences between the pre- and post-intervention results of the dichotomous variables such as carbon management policies, carbon reduction activities, monitoring of resource use, scopes of the carbon emissions measured and scopes of carbon reduction targets. Furthermore, McNemar–Bowker test compares the differences between the pre- and post-intervention results of a matched multinominal variable (Abdullah et al., 2020). This study used the McNemar–Bowker test to compare the differences between the pre- and post-intervention results of the multinominal variables, such as measuring carbon emissions and determining carbon reduction targets.

The differences between the pre- and post-intervention results of the carbon management maturity variable measured using a 5-point Likert scale were compared by performing a normality test to

determine which one of the parametric or non-parametric tests would be performed. The assumption of normality was not violated, as indicated by Shapiro–Wilk's test ($p = .430$). Therefore, the differences between the pre- and post-intervention results of the carbon management maturity scale were compared using a paired *t* test, which is a parametric test. Additionally, the analysis of variance (ANOVA) was applied to compare the differences in carbon management strategy and practices on the basis of SME size and sector to generate further insights. *P* values < .05 were considered statistically significant at 95% confidence interval.

4 | RESULTS AND FINDINGS

4.1 | Descriptive statistics

Table 2 shows the annual turnover, number of employees, size and age of the SMEs included in the study. It was identified that most SMEs seeking support via SiE programme have an annual turnover of under or equal to 2 million euros (70%) and have between 10 and 49 employees (46%). Hence, they are considered small businesses (47%). The company's age varies as 21% of companies are between 6 and 10 years, 32% are between 11 and 20 years and 26% are between 21 and 40 years.

Figure 2 shows the SME sectors included in the research. The majority of SMEs (68%) belong to professional, scientific and technical (25%); manufacturing (15%); wholesale and retail (14%); and other services (14%). In total, 101 SMEs used in the present study are a reflection of the high diversity of companies defined as SMEs and, consequently, the high diversity of activities and potential impacts they are responsible for.

4.2 | Reliability assessment

A reliability analysis was conducted based on the pre- and post-intervention survey data in the context of SiE programme. Table 3 shows the pre- and post-intervention Cronbach's alpha values in calculating the internal consistency reliability. A Cronbach's alpha value higher than .7 demonstrates the scale's reliability. However, values higher than .6 are also accepted (van Griethuijsen et al., 2015). Internal consistency reliability of the measurement instrument was considered acceptable for both the pre- and post-intervention measurements.

TABLE 2 Descriptive statistics of SMEs in the study.

Criteria	Characteristics	Frequency	Percent (%)
Annual turnover (€)	≤2,000,000	71	70
	2,000,001–10,000,000	27	27
	10,000,001–50,000,000	3	3
Number of employees	Less than 10	35	35
	10–49	47	46
	50–249	19	19
Size	Micro	34	34
	Small	48	47
	Medium-sized	19	19
Company age	0–5 years	10	10
	6–10 years	21	21
	11–20 years	33	32
	21–40 years	26	26
	≥41	11	11

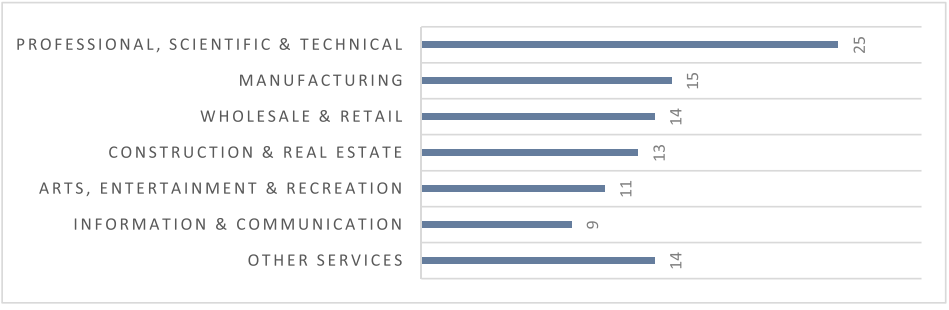

FIGURE 2 SME sectors included in the study.

4.3 | Sustainability/carbon management policies and strategy in SMEs

Sustainability and carbon management policies and strategy in SMEs are key to reach towards net zero emissions. Figure 3 compares the pre- and post-intervention levels of sustainability/carbon management policies and strategy implemented in SMEs using a McNemar's test. A McNemar's test determined that the difference was statistically significant ($p < .05$). Thus, SiE business support intervention significantly impacted the implementation of sustainability/carbon management policies and strategy in SMEs. After the intervention, the implementation rate increased substantially for policies and strategy assessed. In the case of the carbon management action plan/strategy, the increase was 47%. However, some strategies still need to be implemented in the SMEs, even after the intervention, such as a sustainable procurement policy, low carbon or energy policy and biodiversity policy.

TABLE 3 Reliability of the impact measurement constructs.

Variables	Number of items	Pre-intervention Cronbach's alpha	Post-intervention Cronbach's alpha
Sustainability/carbon management policies	7	.637	.814
Carbon reduction activities	7	.916	.703
Monitoring resource use	6	.752	.694
Carbon management maturity	9	.906	.879

Sustainability and carbon management policies and strategy were analysed based on the size and sector of SMEs using the Analysis of variance (ANOVA) test. Table 4 shows that there is no statistically significant difference in sustainability/carbon management policies and strategy before and after the support intervention according to the size and sector of SMEs ($p > .05$).

4.4 | Carbon reduction activities

Carbon reduction activities were investigated to establish SMEs' efforts to reduce carbon emissions from their business operations and value chain before and after the support. Figure 4 compares the pre- and post-intervention rates of carbon reduction activities implemented in SMEs using McNemar's test. After the SiE support intervention, the rates of implementing carbon reduction activities increased in different areas. A McNemar test determined that the difference was statistically significant ($p < .001$). These results suggest that the SiE business support programme significantly impacted the implementation of carbon reduction activities in businesses, particularly related to building energy such as electricity and gas usage. Nevertheless, other activities, such as those related to own transport fleet and water, are still poorly implemented which may need attention.

Table 5 demonstrates a statistically significant difference in the implementation of carbon reduction activities among SMEs according to their size following the intervention ($p < .05$). According to the results of the Tukey post hoc test, it is observed that medium-sized SMEs implemented carbon reduction activities at a higher level as compared to micro-sized SMEs after the intervention. However, no significant difference is observed in the implementation of carbon reduction activities before and after the intervention based on the sector ($p > .05$).

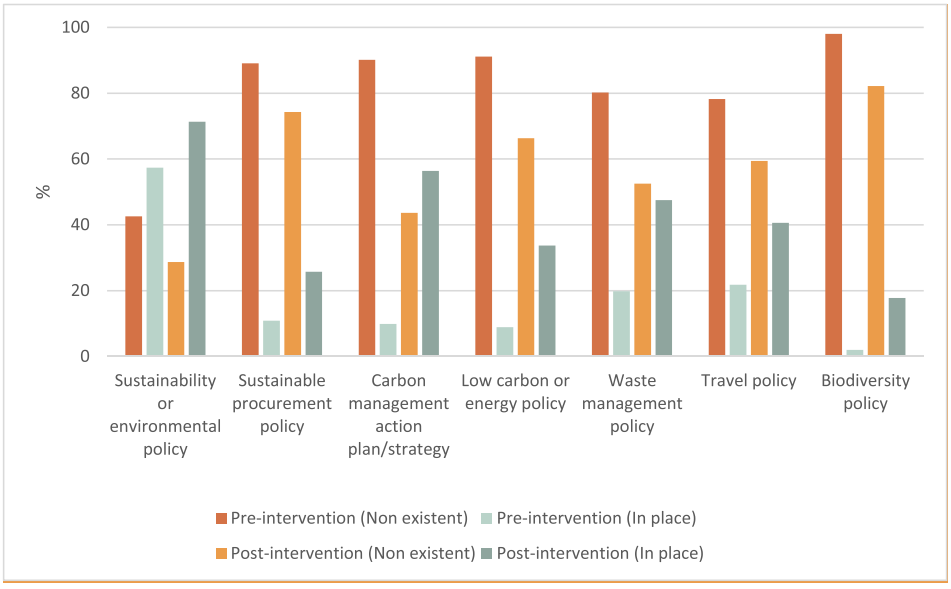

FIGURE 3 Comparison of pre- and post-intervention results of the sustainability/carbon management policies and strategy implemented in SMEs.

TABLE 4 Analysis of variance (ANOVA) test results for comparing sustainability/carbon management policies and strategy based on SMEs size and sector.

Sustainability/carbon management Policies and strategy		Pre-intervention					Post-intervention			
		n	Mean	SD	*F*	*p*	Mean	SD	*F*	*p*
Size	Micro	34	1.05	1.45	0.882	.417	2.38	2.03	1.823	.167
	Small	48	1.39	1.26			3.33	2.41		
	Medium	19	1.52	1.54			2.89	2.02		
		n	Mean	SD	*F*	*p*	Mean	SD	*F*	*p*
Sector	Professional, scientific & technical	25	1.08	1.11	1.165	.332	3.08	2.21	0.876	.516
	Manufacturing	15	1.46	1.24			2.80	2.67		
	Wholesale & retail	14	2.00	2.18			3.78	2.25		
	Construction & Real Estate	13	1.53	1.39			2.15	1.40		
	Arts, entertainment & recreation	11	1.27	1.27			2.36	1.62		
	Information & communication	9	1.11	1.45			3.55	2.74		
	Other services	14	0.78	0.80			2.71	2.49		

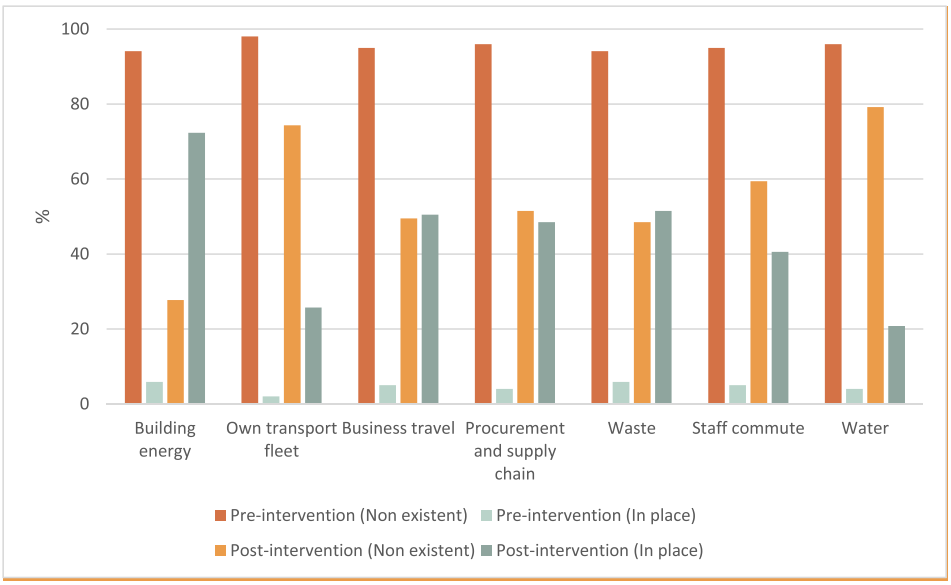

FIGURE 4 Comparison of pre- and post-intervention results of the carbon reduction activities implemented in SMEs.

4.5 | Monitoring resource use

Monitoring resource use is key to measuring carbon footprint and developing a carbon management strategy and plan. Figure 5 shows the results obtained by comparing the pre- and post-intervention rates of regular monitoring of resource use in SMEs using McNemar's test. After the SiE support intervention, overall, the number of SMEs that regularly monitored resources increased, particularly 32% for electricity and 30% for waste. A McNemar test determined that the difference between the pre- and post-intervention rates of regular monitoring of the use of these resources in SMEs was statistically significant ($p < .05$), except for water use ($p = .134$). These results suggest that the support intervention significantly impacted the monitoring of electricity, gas, fuel and refrigerant gas usage and waste generation in SMEs. This will help SMEs in future carbon footprinting and management. Nevertheless, refrigerant gases are still poorly monitored.

Table 6 illustrates a statistically significant difference in resource use monitoring among SMEs based on their sizes both before and after the intervention ($p < .05$). According to the results of the Tukey post hoc test, it is observed that medium-sized SMEs monitored resource use at a higher level compared to micro-sized SMEs both before and after the intervention. However, significant differences in resource use monitoring among SMEs are evident based on the sector they operate in before the intervention ($p < .05$). Results from the Games–Howell post hoc test indicates that SMEs in the arts, entertainment and recreation sector monitored resource use at a higher level compared to those in the manufacturing, and information and

TABLE 5 Analysis of variance (ANOVA) test results for comparing carbon reduction activities based on SMEs size and sector.

Carbon reduction activities			Pre-intervention				Post-intervention			
		n	Mean	SD	*F*	*p*	Mean	SD	*F*	*p*
Size	Micro	34	0.17	0.75	0.909	.406	2.61	1.70	3.654	.029*
	Small	48	0.29	1.07			3.04	2.05		
	Medium	19	0.63	1.92			4.10	1.99		
		n	Mean	SD	*F*	*p*	Mean	SD	*F*	*p*
Sector	Professional, scientific & technical	25	0.32	1.06	0.757	.606	3.04	1.98	1.189	.319
	Manufacturing	15	0.00	0.00			3.33	2.28		
	Wholesale & retail	14	0.85	2.21			4.21	2.51		
	Construction & Real Estate	13	0.30	1.10			2.92	1.84		
	Arts, entertainment & recreation	11	0.36	1.20			3.00	1.18		
	Information & communication	9	0.00	0.00			2.44	1.23		
	Other services	14	0.28	1.06			2.50	1.91		

*Significance level denoting $P < .05$.

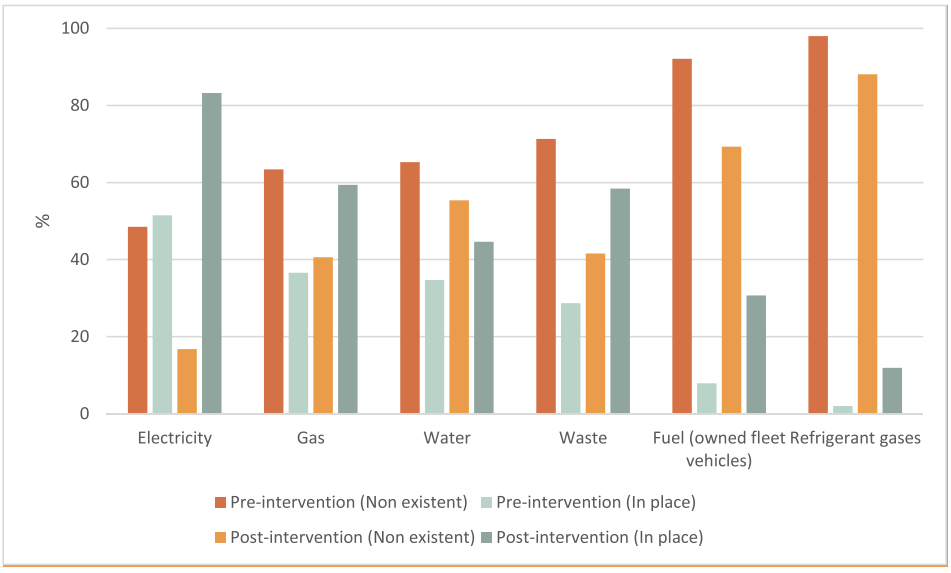

FIGURE 5 Comparison of pre- and post-intervention results of monitoring resource use in SMEs using a McNemar's test.

communication sectors. However, no significant differences are observed in resource use monitoring among sectors after the intervention ($p > .05$).

4.6 | Carbon emissions/footprint and targets

Carbon footprint and carbon reduction targets are key to net zero journey of a business. Figure 6 compares the pre- and post-intervention rates of measuring SMEs' carbon emissions (carbon footprint) using a McNemar–Bowker test. After the SiE business support intervention, the number of SMEs indicating that they measured their carbon emissions increased by 25%, which is significant. In addition, the number of SMEs indicating that the carbon emission measurement process was in progress increased by 28%. The McNemar–Bowker test determined that the difference was statistically significant ($p < .001$). Therefore, the analysis suggests that SiE has significantly helped SMEs in measuring their carbon footprint and help set carbon reduction targets.

Figure 7 illustrates the results of measuring carbon emissions/footprint combined with the results obtained by comparing the pre- and post-intervention rates of the carbon reduction targets for reducing carbon emissions in SMEs using a McNemar–Bowker test. The McNemar–Bowker test determined that the difference was statistically significant ($p < .001$). After the SiE intervention, the number of SMEs indicating they had set a target for reducing carbon emissions increased by 7%. At the same time, there was a substantial increase in SMEs stating that establishing carbon reduction targets was in progress. However, it can be seen in Figure 7 that there is a misalignment between measuring carbon emissions and setting

TABLE 6 Analysis of variance (ANOVA) test results for comparing monitoring resource use based on SMEs size and sector.

			Pre-intervention				Post-intervention			
Monitoring resource use		***n***	**Mean**	**SD**	***F***	***p***	**Mean**	**SD**	***F***	***p***
Size	Micro	34	1.35	1.43	3.375	.038*	2.32	1.38	3.804	.026*
	Small	48	1.45	1.68			3.00	1.68		
	Medium	19	2.47	1.71			3.57	1.92		
		n	**Mean**	**SD**	***F***	***p***	**Mean**	**SD**	***F***	***p***
Sector	Professional, scientific & technical	25	1.44	1.41	2.434	.031*	2.64	1.75	0.896	.502
	Manufacturing	15	1.13	1.35			2.93	1.79		
	Wholesale & retail	14	2.00	1.70			3.42	1.78		
	Construction & Real Estate	13	1.92	2.32			3.53	1.80		
	Arts, entertainment & recreation	11	2.90	1.30			2.72	1.34		
	Information & communication	9	0.55	0.88			2.55	1.42		
	Other services	14	1.42	1.65			2.42	1.65		

*Significance level denoting $P < .05$.

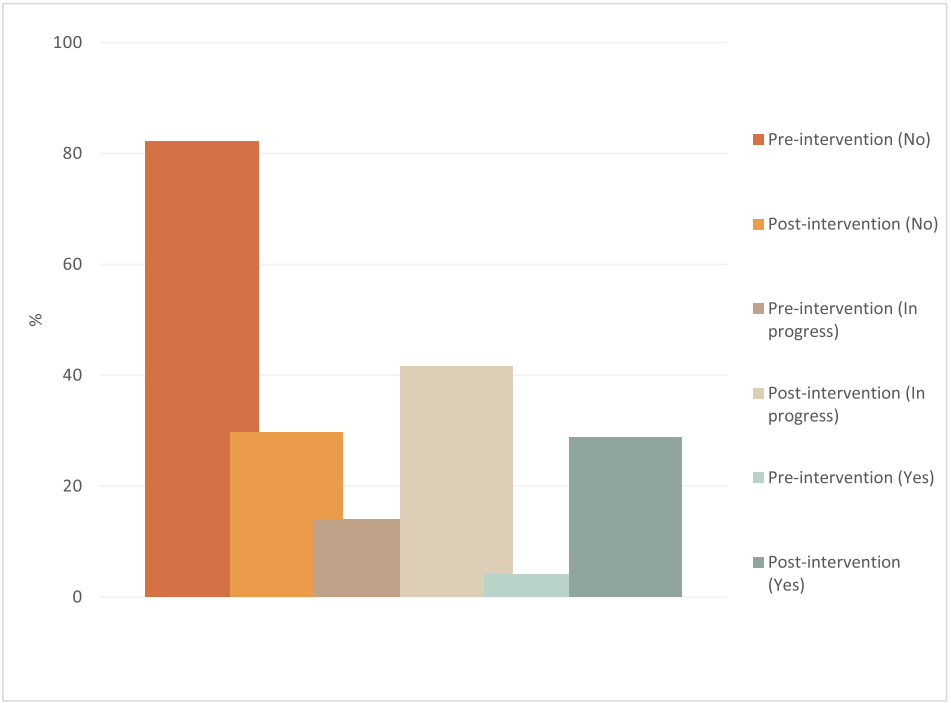

FIGURE 6 Comparison of pre- and post-intervention results of measuring the carbon footprint in SMEs using a McNemar-Bowker test.

targets for their reduction. Businesses have measured carbon emissions but have not set targets, and similarly, some businesses claim to have set a carbon reduction target without measuring a baseline for carbon emissions.

The pre- and post-intervention rates of the scopes SMEs focused on were compared using McNemar's test (Figure 8). After the intervention, the number of SMEs indicating that they measured their emission resources within Scopes 1–3 increased by 12%, 16% and 13%, respectively. McNemar's test determined that the difference between the pre- and post-intervention rates related to carbon emissions scopes was statistically significant ($p < .05$). These results suggest that the SiE support intervention significantly impacted measuring carbon scope emissions in SMEs. However, still, a significant number of SMEs do not measure their carbon emissions particularly related to Scope 3. This is because Scope 3 is indirect emissions and is complex due to the unavailability of the required data for measurement.

Figure 9 depicts the pre- and post-intervention rates of the carbon emission scopes combined with targets for reducing emissions scopes. This was achieved by using McNemar's test. After the SiE support intervention, the number of SMEs with a target for reducing carbon emissions, particularly Scope 1 targets increased by 23% and,

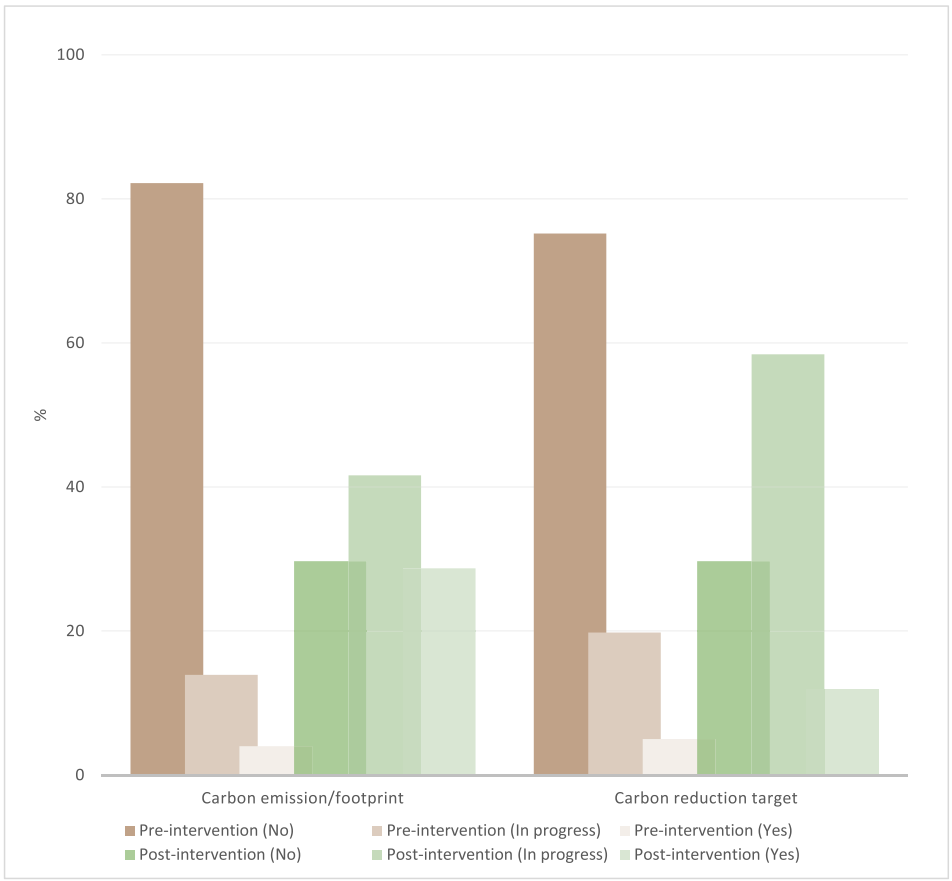

FIGURE 7 Comparison of pre- and post-intervention results of measuring the carbon footprint and targets for reducing carbon emissions in SMEs using a McNemar-Bowker test.

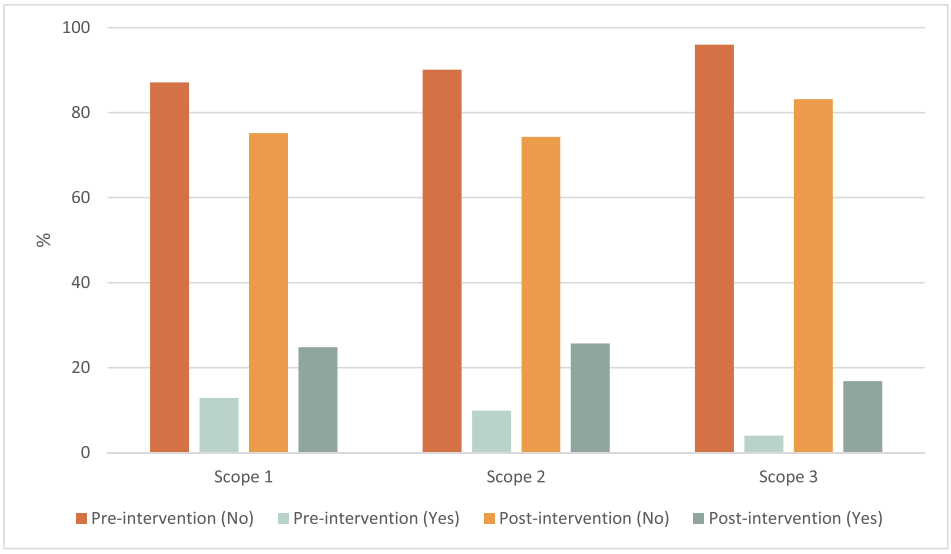

FIGURE 8 Comparison of pre- and post-intervention results of the scopes SMEs focused on while measuring the carbon emission resources using a McNemar's test.

Scope 2 targets by 20%. A McNemar's test determined that the difference between the pre- and post-intervention rates was statistically significant ($p < .05$). These results show that the SiE programme support significantly impacted the development of carbon reduction targets according to scopes in SMEs.

Tables 7 and 8 indicate that there is no statistically significant difference in SMEs' carbon emission measurement and carbon reduction target rates before and after the intervention, neither based on their sizes nor the sectors they operate in ($p > .05$). However, according to Table 9, there is no statistically significant difference in the scopes of carbon emissions between SMEs before and after the intervention, based on their sizes or sectors. Nevertheless, Table 10 reveals a statistically significant difference in the scopes of carbon reduction targets before the intervention based on the sizes of SMEs ($p < .05$). It is

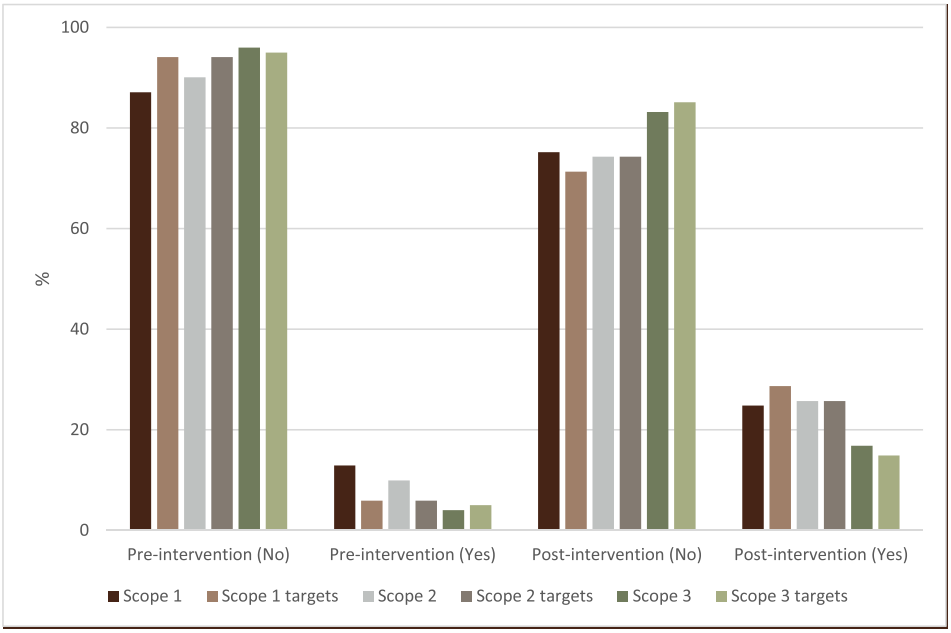

FIGURE 9 Comparison of pre- and post-intervention results of the scopes SMEs including in targets using a McNemar's test.

TABLE 7 Analysis of variance (ANOVA) test results for comparing carbon emissions/footprint based on SMEs size and sector.

			Pre-intervention				Post-intervention			
Carbon emissions/footprint		***n***	**Mean**	**SD**	***F***	***p***	**Mean**	**SD**	***F***	***p***
Size	Micro	34	0.14	0.43	1.206	.304	0.97	0.79	1.592	.209
	Small	48	0.20	0.50			0.89	0.69		
	Medium	19	0.36	0.59			1.26	0.87		
		n	**Mean**	**SD**	***F***	***p***	**Mean**	**SD**	***F***	***p***
Sector	Professional, scientific & technical	25	0.12	0.33	1.175	.326	0.96	0.78	0.740	.619
	Manufacturing	15	0.26	0.70			1.00	0.92		
	Wholesale & retail	14	0.21	0.57			1.35	0.63		
	Construction & Real Estate	13	0.23	0.43			1.00	0.81		
	Arts, entertainment & recreation	11	0.54	0.68			0.90	0.83		
	Information & communication	9	0.22	0.44			0.88	0.60		
	Other services	14	0.07	0.26			0.78	0.69		

observed that medium-sized SMEs had higher levels of carbon reduction targets based on scopes compared to small and micro-sized SMEs before the intervention.

4.7 | Carbon management maturity

This section assesses the maturity of carbon management in SMEs based on organisational factors required to deliver carbon reductions. Table 11 compares pre- and post-intervention results of carbon management maturity using a paired *t* test. It shows no significant difference between the pre-intervention and post-intervention levels of awareness of the risks and opportunities related to carbon emissions in SMEs ($p = .170$). The awareness of risks and opportunities related to carbon emissions in SMEs was high both before (M = 4.31, SD = 0.85) and after (M = 4.43, SD = 0.59) the SMEs' involvement in SiE. However, there was a significant difference between SMEs' pre-intervention (M = 2.18, SD = 1.03) and post-intervention (M = 3.81, SD = 0.92) levels of having the knowledge and skills to calculate the carbon footprint internally ($p < .001$). SMEs reported having more knowledge and skills to calculate their carbon footprint after the SiE programme support intervention. Likewise, SMEs stated that they managed carbon emissions more effectively and implemented carbon reduction projects more successfully after the intervention (M = 3.63, SD = 0.80) compared to the pre-intervention period (M = 2.17, SD = 0.88) ($p < .001$). This is because there have been financial and human resources as well as consultancy support for SMEs through SiE.

TABLE 8 Analysis of variance (ANOVA) test results for comparing carbon reduction targets based on SMEs size and sector.

			Pre-intervention				Post-intervention			
Carbon reduction targets		***n***	**Mean**	**SD**	***F***	***p***	**Mean**	**SD**	***F***	***p***
Size	Micro	34	0.20	0.53	2.163	.120	0.88	0.68	1.761	.177
	Small	48	0.27	0.49			0.70	0.50		
	Medium	19	0.52	0.69			1.00	0.74		
		n	**Mean**	**SD**	***F***	***p***	**Mean**	**SD**	***F***	***p***
Sector	Professional, scientific & technical	25	0.20	0.40	0.827	.552	0.76	0.59	1.373	.234
	Manufacturing	15	0.26	0.59			0.66	0.48		
	Wholesale & retail	14	0.28	0.61			1.21	0.57		
	Construction & Real Estate	13	0.38	0.65			0.92	0.75		
	Arts, entertainment & recreation	11	0.54	0.68			0.81	0.75		
	Information & communication	9	0.44	0.72			0.66	0.50		
	Other services	14	0.14	0.36			0.71	0.61		

TABLE 9 Analysis of variance (ANOVA) test results for comparing scopes of carbon emissions/footprint based on SMEs size and sector.

			Pre-intervention				Post-intervention			
Scopes of carbon emission/footprint		***n***	**Mean**	**SD**	***F***	***p***	**Mean**	**SD**	***F***	***p***
Size	Micro	34	0.11	0.40	1.697	.189	0.58	0.98	1.516	.225
	Small	48	0.29	0.74			0.58	1.00		
	Medium	19	0.47	0.90			1.05	1.26		
		n	**Mean**	**SD**	***F***	***p***	**Mean**	**SD**	***F***	***p***
Sector	Professional, scientific & technical	25	0.20	0.64	0.424	.861	0.72	1.13	0.134	.992
	Manufacturing	15	0.26	0.79			0.53	1.06		
	Wholesale & retail	14	0.28	0.72			0.71	0.99		
	Construction & Real Estate	13	0.38	0.96			0.69	1.18		
	Arts, entertainment & recreation	11	0.45	0.68			0.63	1.02		
	Information & communication	9	0.33	0.70			0.88	1.16		
	Other services	14	0.07	0.26			0.57	1.01		

TABLE 10 Analysis of variance (ANOVA) test results for comparing scopes of carbon reduction targets based on SMEs size and sector.

			Pre-intervention				Post-intervention			
Scopes of carbon reduction targets		***n***	**Mean**	**SD**	***F***	***p***	**Mean**	**SD**	***F***	***p***
Size	Micro	34	0.02	0.17	5.510	.005*	0.52	0.92	1.542	.219
	Small	48	0.10	0.47			0.66	1.03		
	Medium	19	0.57	1.16			1.05	1.26		
		n	**Mean**	**SD**	***F***	***P***	**Mean**	**SD**	***F***	***p***
Sector	Professional, scientific & technical	25	0.24	0.83	0.260	.954	0.88	1.16	0.386	.887
	Manufacturing	15	0.13	0.35			0.86	1.24		
	Wholesale & retail	14	0.21	0.80			0.64	1.00		
	Construction & Real Estate	13	0.23	0.83			0.69	1.18		
	Arts, entertainment & recreation	11	0.18	0.60			0.54	0.82		
	Information & communication	9	0.11	0.33			0.44	0.88		
	Other services	14	0.00	0.00			0.50	0.94		

*Significance level denoting $P < .05$.

TABLE 11 Comparison of pre- and post-intervention results of carbon management maturity in SMEs using a paired *t* test.

Carbon management maturity	Pre-intervention ($N = 101$)		Post-intervention ($N = 101$)		*t* value	*p* value
	Mean	SD	Mean	SD		
We are aware of the risks and opportunities associated with carbon emissions	4.31	0.85	4.43	0.59	1.38	.170
We have the required knowledge and skills to calculate the carbon footprint of our business	2.18	1.03	3.81	0.92	12.67	<.001*
We are effectively managing our carbon emissions and successfully implementing carbon reduction projects as planned	2.17	0.88	3.63	0.80	12.41	<.001*
We are effectively tracking and reviewing progress towards our carbon management target	2.17	0.93	3.57	0.92	10.95	<.001*
Carbon management is effectively integrated into our procurement process	2.17	0.88	3.29	0.85	9.10	<.001*
Carbon management is central to our business activities and decision making	2.61	1.13	3.58	0.87	7.46	<.001*
We communicate our carbon reduction targets, strategies and performance to all relevant stakeholders	2.18	1.00	3.42	0.92	9.42	<.001*
We have carbon reduction behavioural change and awareness raising programmes for staff	2.23	1.07	3.56	0.97	11.27	<.001*
We are able to manage the conflicts between carbon management and core business activities/growth	2.71	1.05	3.63	0.83	7.84	<.001*

Note: Scale—1, *strongly disagree*; 2, *disagree*; 3, *neither/nor*; 4, *agree*; and 5, *strongly agree*.
Abbreviations: *N*, total number of participants; SD, standard deviation.
*$p < .05$ statistically significant.

TABLE 12 Analysis of variance (ANOVA) test results for comparing carbon management maturity based on SMEs size and sector.

Carbon management maturity			Pre-intervention				Post-intervention			
		n	Mean	SD	*F*	*p*	Mean	SD	*F*	*p*
Size	Micro	34	23.94	6.30	0.756	.472	33.32	5.68	.157	.855
	Small	48	22.12	7.06			32.63	5.59		
	Medium	19	22.42	6.71			33.05	5.33		
		n	Mean	SD	*F*	*P*	Mean	SD	*F*	*p*
Sector	Professional, scientific & technical	25	22.52	6.59	0.249	.959	33.96	5.19	1.448	.205
	Manufacturing	15	23.73	7.67			31.33	6.03		
	Wholesale & retail	14	23.42	7.35			35.28	5.15		
	Construction & Real Estate	13	23.92	4.90			32.30	5.31		
	Arts, entertainment & recreation	11	22.45	7.03			33.00	7.34		
	Information & communication	9	21.66	7.43			34.15	4.37		
	Other services	14	21.57	7.15			30.28	4.54		

*Significance level denoting $P < .05$.

The analysis shows that there was a significant difference between the SMEs' pre-intervention and post-intervention levels in effectively tracking and reviewing the progress towards carbon management targets ($p < .001$). The SMEs' post-intervention level ($M = 3.57$, $SD = 0.92$) of effectively tracking and reviewing the progress towards the carbon management goals was higher than their pre-intervention level ($M = 2.17$, $SD = 0.93$). In addition, a significant increase was observed after the intervention ($M = 3.29$, $SD = 0.85$) compared to the pre-intervention ($M = 2.17$, $SD = 0.88$) in the level of effective integration of carbon management into procurement (Scope 3) processes in SMEs ($p < .001$). However, the level to which SMEs considered carbon management to be a central part of their business activities increased significantly after the intervention ($M = 3.58$, $SD = 0.87$) compared to the pre-intervention ($M = 2.61$, $SD = 1.13$) ($p < .001$).

SMEs' levels of communication with the relevant stakeholders (internal and external) regarding their carbon reduction targets,

strategies and performance increased significantly after (M = 3.42, SD = 0.92) the SiE support compared to the pre-intervention (M = 2.18, SD = 1.00) ($p < .001$). Moreover, the SMEs' level of having carbon reduction behavioural changes and awareness-raising programmes for employee engagement was higher after the intervention (M = 3.56, SD = 0.97) compared to the pre-intervention period (M = 2.23, SD = 1.07) ($p < .001$). Finally, SMEs' levels of management of the conflicts between carbon management and core business activities/growth showed a significant increase after the intervention (M = 3.63, SD = 0.83) compared to the pre-intervention (M = 2.71, SD = 1.05) ($p < .001$). These results suggest that the SiE programme significantly improved carbon management strategy and maturity of SMEs across different areas of business, as reflected in Table 11.

According to Table 12, there is no statistically significant difference observed in the carbon management maturity scale among SMEs before and after the intervention, based on their size or sector of operation ($p > .05$).

5 | DISCUSSION

This study has explored how a university-led innovative business support programme can help SMEs develop a carbon management strategy as part of their net zero journey. The analysis was also carried out based on the size and sector of SMEs to generate deeper insights. The results show that NTU's SiE business support programme significantly impacted the implementation of sustainability/carbon management policies and strategy in Nottingham-based SMEs across all sizes and sectors. Many SMEs were in the early stages of their carbon management journey, which aligns with the findings of the British Business Bank (2021). The support has put them on a pathway to bring transformative change for carbon management to help reach net zero. Previous studies have predominantly discussed how most carbon management strategies are implemented by large companies (e.g., Dhanda & Malik, 2020; Yunus et al., 2016). On the other hand, SMEs can act as significant change agents for decarbonisation, as they represent the dominant population of businesses globally. The findings evidence a range of initiatives which businesses have now adopted (Mazhar et al., 2022). However, SMEs often lack human and financial resources, which might limit their engagement in carbon reduction activities beyond what is mandatory. This is particularly due to a lack of a structure to facilitate strategy formulation (Shields & Shelleman, 2015). At the same time, SMEs have recently faced various disruptions and challenges due to the Covid-19 pandemic and, consequently, financial uncertainty as well as the cost of living crisis. Many SMEs are simply focused on surviving and issues like carbon management and sustainability are an afterthought for them unless they can see a tangible business case, and this mirrors the findings of previous studies (Conway, 2015).

This research shows that programmes such as SiE, by providing support free of charge for SMEs, can help implement carbon management strategies and practices. The main changes in the SMEs were directly related to the low carbon focus of the SiE programme. It significantly impacted the implementation of sustainability/carbon management policies and strategies across different SMEs, particularly a carbon management action plan/strategy. Similar results were obtained concerning the carbon reduction activities implemented in SMEs, such as reducing building energy concerning electricity and gas consumption. The study found that medium-sized businesses implemented carbon reduction activities at a higher level than micro-sized businesses after the intervention. However, there was no significant difference based on the sector. These areas represent the main reduction potential in the short term, as at the end of the 2-year project, the team needed to show a practical carbon reduction effect as per funding requirements. Even though programmes such as SiE can significantly support SMEs in implementing carbon management strategies, these programmes usually run for a fixed and relatively short period of time. There is a risk that some of the strategies will be abandoned after some time if they continue to be implemented voluntarily, or it needs to be clarified how to reduce costs for SMEs with carbon reductions continuously in the long term. Other studies found that EU-funded programmes lead to time-limited engagement durations between a university, large organisations and a group of SMEs (Ward et al., 2017). This happens due to the need to reach required targets, which in the case of the current research were the number of organisations supported and the amount of carbon savings. Besides cost savings, the possibility of attracting new customers, retaining more staff and having good publicity have attracted SMEs to becoming a low-carbon business (British Business Bank, 2021; Revell et al., 2010). Thus, there might be a need to offer more support from similar sources in implementing more long-term strategies due to limited access to resources SMEs often face. This is similar to what Afolabi et al. (2022) state that there needs to be more support from the UK government to motivate and guide SMEs to transition to net zero.

This SiE programme aimed to minimise the effects of short-term support by enhancing knowledge and skills in SMEs related to carbon management. Besides a lack of resources, knowledge is often considered one of the barriers to SMEs' implementation of sustainable management strategies (Caldera et al., 2019). After the SiE programme, the findings show that carbon management is now becoming a more central part of SMEs' business activities and decision-making, reflecting an increased awareness of the risks and opportunities associated with carbon emissions, both before and after the support. At the same time, SMEs increased resource monitoring due to the vitality of its potential to identify the main areas of carbon reduction. Medium-sized SMEs monitor resource use at a higher level compared to micro-sized SMEs before and after the intervention. However, significant differences in resource use monitoring are evident based on the sector before the intervention, and there are no significant differences among sectors after the intervention. Resource use is receiving more attention as energy prices have gone up, so finance is a strong driver for SMEs when it comes to energy and carbon reduction, as highlighted by Revell et al. (2010).

Once SMEs know their baseline carbon emissions against a particular year, they can set a carbon reduction target and start managing and tracking performance periodically. The SiE supported SMEs in

measuring their carbon footprint and establishing carbon reduction targets. SMEs have more knowledge and skills to calculate their carbon footprint after the SiE programme as they were powered through the training and consultancy offers. Still, a significant number of SMEs do not measure carbon emissions, particularly related to Scope 3. The programme support significantly impacted the development of carbon reduction targets with no significant difference in SMEs' carbon emission measurement and carbon reduction target rates before and after the intervention, neither based on their sizes nor the sectors. There is a difference in the scopes of carbon reduction targets before the intervention based on the size, and medium-sized SMEs had higher levels of carbon reduction targets based on scopes compared to small and micro-sized SMEs before the intervention. There was an increase in measuring emissions according to the different scopes and targets, but less for Scope 3 emissions, which need addressing through supply chain engagement. Scope 3 emissions rely on other entities outside SMEs, which they can control, making it difficult to grasp the data needed. At the same time, SMEs often lack the data needed to support the development of targets across the three scopes of emissions. Previous studies highlighted this barrier as linked to the lack of resources SMEs have to manage data collection and analysis (Janda et al., 2014). Busch et al. (2022) identified the issues around Scope 3 data, stating that the data on direct emissions (Scopes 1 and 2) are more consistent than data on indirect emissions (Scope 3). Due to this, the number of companies reporting Scopes 1 and 2 increases as compared to Scope 3. The SiE programme improved the carbon management maturity of SMEs in different areas and it was found that there is no significant difference in carbon management maturity in terms of their size and sector.

The overall results reflect the SMEs' dependence mostly on public funding to implement the strategies and practices needed to reduce carbon emissions. This financial dependence leads to SMEs being reliant on the areas that were given priority to public funding, such as carbon emissions, potentially jeopardising other sustainability issues (Domingues et al., 2023). Considering the high heterogeneity of SMEs, they are imperatively associated with different activities, which will lead to different impacts and, thus, potentially need different strategies to reach net zero. This work shows a need to engage in a more holistic policy to support SMEs in implementing carbon management strategies, including a broader range of aspects beyond carbon equivalent emissions and a long-term solution of continued support for sustainable development. In addition, the absence of a specific plan or policies for SMEs concerning carbon management strategies can minimise the impact of these strategies in implementing practices as highlighted by Hampton et al. (2023). Place-based funding has proved crucial for the success of this project. The UK Government is now creating the Mayoral Combined Local Authorities, which could potentially push the agenda forward with net zero and green growth as a priority area. For the East Midlands region, for example, the East Midlands County Combined Authority (EMCCA) was established through a devolution deal in August 2022, marking the creation of the first county combined authority under the Levelling Up and Regeneration Act 2023 in the United Kingdom. It comprises four upper-tier local authorities and is chaired by the East Midlands mayor elected in May 2024. This presents a significant opportunity for more joined-up policy support for businesses in Nottinghamshire and Derbyshire, including low-carbon and green skills. The EMCCA will hold devolved powers in areas such as transport, skills, regeneration and economic development. This is in addition to the UKSPF that is the government's domestic replacement for the European Structural and Investment Fund (ESIF), but it is unclear how this will address increasing SME needs building the legacy of various successful ERDF programmes across the country.

6 | CONCLUSION, RECOMMENDATIONS AND LIMITATIONS

This research is one of the largest studies of the impact of low-carbon business support for SMEs provided by a university. It has investigated the impact of an innovative SiE business support programme in Nottingham, United Kingdom, and provided novel contributions and insights into the support SMEs need to decarbonise. From a theoretical perspective, the paper contributes to knowledge in this area by investigating decarbonisation efforts in SMEs, an important but underdeveloped topic with a few exceptions. The research provides insights into the carbon management strategies of Nottingham-based SMEs. The focus on university-led business support helps identify the impact it can have on SMEs in low carbon transition. Our results clearly show that this vital place-based business support can enable SMEs to develop their carbon management strategy to become sustainable businesses. Segmentation is made based on the size and sector of participating SMEs to deepen the analysis and understand which interventions work best for SMEs to help inform future policy and business practice. Another contribution of this paper is the collection of data from SMEs seeking support through a funded programme. This is often lacking and leads to ineffective policy and governance, as it is not possible to set targets and measure the effect of interventions to, consequently, invest in areas where the impact is significant (Hampton et al., 2023).

The findings indicate that the SiE programme had a significant impact on SMEs transition to carbon management practices. Nevertheless, it can be noted that SMEs are still in the early stages of their net zero journey. The study contributes to the systematic measurement and evaluation of the impact of external supports on SMEs transition to carbon management practices. This study contributes to the knowledge in the field by examining carbon management strategy and subsequent practices in SMEs, which is an under-researched sector. Additionally, it provides empirical insights into the impact of support on SMEs efforts to transition to low-carbon practices. It can be stated that this study's utilisation of student knowledge exchange through consultancy as one of the multiple support providers for SMEs' transition to carbon management adds to the uniqueness of the study. This shows two-way learning, learning for both SMEs and students as future sustainable managers and leaders.

However, in most cases, this research found that environmental and carbon management is still seen as an add-on to business activities and need development for sustainable business strategy. At present, SMEs do not have a formal systematic approach to managing environmental and carbon data and impacts. To address this, recommendations are made. First, SMEs need to develop their in-house capacity and their managers need to gain technical knowledge, skills and competencies to deliver carbon management. Linked to this is the opportunity to engage with wider networks such as those provided by local universities, Chamber of Commerce's or local government. SMEs can make use of available support from universities and local actors in the ecosystem. There are various synchronous and asynchronous resources for SMEs to utilise to help develop their carbon management strategy to reach net zero. SMEs need to engage with local partners such as universities as knowledge hubs and make use of the existing support system where possible. Constantinos et al. (2010) also emphasised on improved support mechanisms for SMEs and access to network to address barriers. SME managers can benefit from training and courses to develop their 'know-how', which might enable them to measure and manage their business carbon emissions and set targets and actions. Second, access to finance is part of the solution to drive more action. Many organisations can help small businesses on their path to net zero. Some provide grants, matching funds and interest-free loans both locally and nationally. Notably, 11% of UK smaller businesses have already accessed external finance to support net zero actions (British Business Bank, 2021). However, finance is an area that can be streamlined for SMEs with easy access to generate wider impact. In terms of advice and support, Hampton (2018) states that significant public funds are invested in low-carbon advisors to support SMEs in reducing carbon emissions on a regional basis. Therefore, business advisors in growth hubs and local governments can mainstream carbon management in their discussions with businesses and signpost SMEs towards support and resources to build capacity. These advisors need to build their own capacity too to facilitate change. Finally, a clear policy direction, business support mechanism and stakeholder collaboration are vital to give SMEs the confidence to act at pace and scale while investing in net zero strategies. Although this study was placed based, it has national and global implications as carbon reduction is a global issue to fight climate change. Similar models of business support can be adopted in regions globally, and the support system can be led by a university or it can be a partnership of universities to join forces for bigger impact. From a methodological point of view, the study offers a systematic methodology and approach to assess the impact to identify areas of focus for business support and policy tools.

The research has some limitations. The post-intervention survey was completed when the SiE support ended to exit the businesses. More time could have allowed SMEs to further enhance actions generating an even bigger impact. This is because implementing carbon reduction measures takes time. The study is limited in terms of in-depth knowledge of drivers and barriers for change as a result of SiE support as well as insights into which specific SiE interventions had the most impact, for example, consultancy, training or resource allocation despite the fact that the majority of the SMEs had consultancy and then training and development. In the end, SiE supported 218 SMEs, out of which 76 had support from two delivery teams, and 36 were supported by three or more SiE strands of support, resulting in carbon savings of an estimated 1,000t CO_2e. Future research should address the organisational change process, including the drivers and barriers to implementing SiE recommendations as part of their net zero plans. A larger sample size can add further value.

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CONFLICT OF INTEREST STATEMENT

The authors do not have any conflict of interest.

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