INTEGRATING CARBON FOOTPRINT INTO RISK MANAGEMENT: A SUSTAINABLE STRATEGY FOR THAI SMEs *

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Abstract

Climate change poses serious challenges for economies worldwide, particularly for small and medium enterprises (SMEs) that often lack the resources to adapt. In Thailand, SMEs represent a significant portion of the economy and have a major impact on environmental sustainability. This review article explores the integration of carbon footprint management into risk management strategies for Thai SMEs. It aims to show how understanding and measuring carbon emissions can help these businesses reduce environmental impact and manage operational risks. The review finds that Thai SMEs face several challenges in managing their carbon footprint, including limited awareness, budget constraints, lack of tools, and inadequate government support. Despite these challenges, using carbon footprint data can help SMEs improve risk management, reduce costs, enhance their reputation, and meet regulatory requirements. Practical solutions such as digital tools, training, and collaboration

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networks can support carbon management in SMEs and help align them with sustainable development goals. Integrating carbon footprint into risk management offers a valuable strategy for Thai SMEs to become more sustainable and competitive. With appropriate support, tools, and awareness, SMEs can take active roles in reducing emissions and preparing for climate-related risks. This approach not only benefits the environment but also strengthens the long-term resilience of small businesses in Thailand.

Keywords: Carbon footprint, Risk management, Thai SMEs, Sustainability, Green business

Introduction

Climate change is a serious global issue that affects people, communities, and the environment. Rising temperatures, extreme weather, and changing rainfall patterns are clear signs of this problem (Singh et.al., 2023). These changes are caused mainly by greenhouse gas emissions from human activities. As the effects of climate change become more visible, many countries and organizations are looking for ways to reduce their environmental impact. Addressing climate change is not only a government responsibility but also a shared duty for all sectors (Abbass et.al., 2022). Climate change creates risks for economies and societies, and it challenges the way we live and work. This situation makes it necessary to find new ways of managing these risks. One important solution is to apply sustainable management approaches that help reduce emissions and support long-term development (Kamkankaew et.al, 2025)

Businesses play a key role in the fight against climate change. They are one of the main sources of carbon emissions, especially in sectors like energy, transport, and manufacturing. At the same time, businesses also have the power to create change through their operations and decision-making (Fiedler et.al., 2021). Companies can reduce emissions by using cleaner technologies, improving

energy efficiency, and choosing greener materials. They can also influence their supply chains to follow more sustainable practices. By including environmental goals in their business strategies, companies can improve their reputation and gain support from customers and partners (Caby, Ziane & Lamarque, 2022). This is especially important for small and medium enterprises (SMEs), which make up a large part of the economy in many countries, including Thailand (Kamkankaew et.al., 2022). These businesses may face challenges in adopting sustainability, but they also have many opportunities to make a positive impact.

One effective way for businesses to manage their environmental impact is to measure their carbon footprint. A carbon footprint shows the amount of greenhouse gases a business produces directly and indirectly (Bui, 2017). It includes emissions from energy use, transportation, production, and other activities. By measuring their carbon footprint, businesses can identify which parts of their operations produce the most emissions. This helps them plan how to reduce emissions in a practical way. Carbon footprint tools are useful for setting goals, tracking progress, and reporting to stakeholders (Trinks, Mulder & Scholtens, 2020). For Thai SMEs, using carbon footprint information can help improve risk management, reduce costs, and support sustainability. It also prepares them to meet new regulations and customer expectations related to the environment.

Thai small and medium enterprises (SMEs) are a vital part of the national economy. In 2023, the GDP of SMEs was valued at 6.32 trillion baht, which made up 35.2% of the country's total GDP (Office of Small and Medium Enterprises Promotion, 2024). This shows how important SMEs are to economic growth. Their contribution increased from the previous year, even when the overall economic growth slowed down. The service, manufacturing, and trade sectors were the main areas that supported this growth. However, some challenges remained, such as high household debt and limited access to financial loans. Despite these, private consumption, tourism, and foreign investment helped SMEs expand.

These businesses are not only drivers of the economy but also important players in creating sustainable development. Because of their large share in GDP and employment, it is important to help Thai SMEs adopt practices that are environmentally responsible (Tobarameekul & Worathanakul, 2021). One important tool is carbon footprint management. This helps measure greenhouse gas emissions from business operations. It is also useful for identifying risks and planning ways to reduce environmental impact. Therefore, using carbon footprint in risk management is a good strategy for making Thai SMEs more sustainable in the long term.

Thai small and medium enterprises (SMEs) face unique challenges in this area. Many SMEs do not have the tools, staff, or budget to track and report carbon data. Larger companies can afford to hire experts and use advanced systems, but smaller businesses often lack this support (Leenoi, 2025). As a result, the level of carbon footprint reporting is much lower among SMEs. However, this does not mean that SMEs can ignore the issue. New laws and global trade rules, such as the EU's Carbon Border Adjustment Mechanism (CBAM), are likely to impact Thai exports. If Thai SMEs do not prepare for these changes, they may lose access to international markets (Munkongtum & Moryadee, 2023).

This review article aims to connect the concept of carbon footprint with risk management in Thai small and medium-sized enterprises (SMEs). Climate change is a serious global problem, and it affects businesses in many ways. Thai SMEs need to understand how their activities impact the environment. Carbon footprint is a useful tool that helps measure greenhouse gas emissions. It can show which parts of a business create the most emissions. When businesses know this, they can manage risks better. They can plan for changes in laws, customer demands, and environmental conditions. This article review discusses how using carbon footprint in risk management can support sustainable business practices for Thai SMEs.

The Overview of Carbon Footprint

The carbon footprint is the total amount of greenhouse gases released into the atmosphere because of human and business activities (Wiedmann & Minx, 2008). These gases include carbon dioxide, methane, and other emissions that trap heat in the atmosphere. When businesses produce goods, use energy, or transport products, they create emissions. The carbon footprint helps measure these emissions in terms of their impact on the environment. It is often measured in units of carbon dioxide equivalent (CO_2e) (Mülle et.al. 2020). This concept helps businesses understand how their actions affect climate change. By knowing their carbon footprint, businesses can find ways to reduce emissions and become more environmentally friendly. In this way, the carbon footprint is a useful tool for planning sustainable business practices and managing risks related to climate change. Measuring the carbon footprint helps businesses understand how much they contribute to environmental problems (Trinks, Mulder & Scholtens, 2020). This knowledge is the first step toward reducing emissions and making business practices more sustainable.

Carbon emissions are divided into three main types (Pandey, Agrawal & Pandey, 2011). The *first type* is called direct emissions. These come from sources that are owned or controlled by the business. For example, fuel burned in company vehicles or machines used in production are direct emissions. These emissions are easy to identify because they happen within the company's operations. Reducing direct emissions often involves changes in equipment or fuel used in the business. The *second type* of emissions comes from energy use. These are called indirect emissions from electricity or other forms of energy bought by the company. Even if the company does not produce the electricity itself, it still uses energy in daily operations like lighting, air conditioning, or machinery. This use causes emissions at the power plant. To lower this kind of emission, businesses can use energy-saving devices or buy electricity from clean

energy sources such as solar or wind. The *third type* of emissions comes from the entire supply chain. These include emissions from the production of raw materials, transport of goods, and waste disposal. This category is often the largest and most difficult to control. It involves many outside partners such as suppliers and delivery services. Reducing these emissions requires cooperation across the supply chain. Businesses can choose suppliers with low emissions and design products that create less waste. This broad approach helps businesses manage environmental risks and improve sustainability in the long term.

Measuring the carbon footprint helps businesses understand their environmental impact. Carbon footprint means the total amount of greenhouse gases released into the air because of business activities (Mancini et.al, 2016). These gases include carbon dioxide, methane, and other harmful emissions. The carbon footprint can come from many sources such as using fuel, electricity, and transporting goods. By calculating the carbon footprint, businesses can know how much they contribute to climate change. This information helps them find ways to reduce emissions and make better choices for the environment. To measure and manage carbon footprints, businesses use tools and standards. Two common standards are ISO 14064 and the Greenhouse Gas Protocol. ISO 14064 gives clear steps to measure and report emissions (Chen, Zhang & Han, 2021). It helps companies collect and report data in the same way. The Greenhouse Gas Protocol also provides a framework for measuring emissions. It is widely used by businesses around the world. These tools help SMEs understand their emissions in a simple and structured way. When they follow these standards, they can compare their data with others and find ways to improve. This supports better risk management and helps them follow global environmental goals.

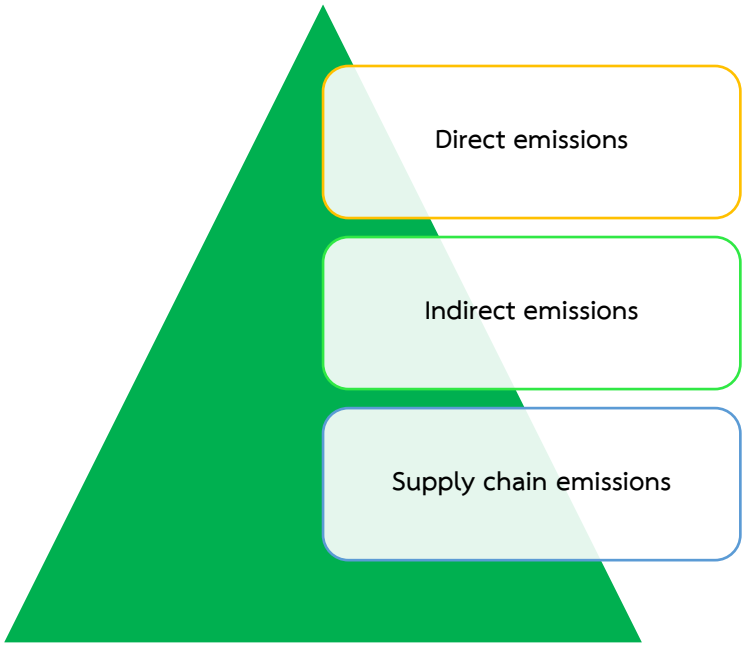

Figure 1 Emission Types

For small and medium-sized enterprises (SMEs), knowing their carbon footprint is the first step toward becoming more sustainable (Eleftheriadis & Anagnostopoulou, 2024). It shows which parts of their business create the most emissions. This can include machines, lighting, packaging, or delivery processes. When businesses know where their emissions come from, they can plan how to reduce them. This process also helps them follow environmental laws and meet customer expectations for green products. Measuring the carbon footprint is not only about the environment. It also helps reduce costs and manage business risks (Munkongtum, Thriyawanich & Ayasanond, 2024).

In conclusion of this section, understanding the carbon footprint helps businesses, especially SMEs, see how their activities affect the environment. It shows where emissions come from and guides actions to reduce them. By using clear tools and standards, businesses can measure their emissions, improve

operations, and support sustainable goals. This is an important step toward protecting the environment and building long-term success.

Risk Management and Carbon Footprint

Risk management helps SMEs find and reduce problems that can affect their business (de Araújo Lima, Crema & Verbano, 2020). One important problem today is the carbon footprint, which links to climate change and environmental damage. Managing this risk means understanding emissions, following new laws, and protecting the business from rising costs and public concerns. By using carbon footprint data, SMEs can plan better, reduce harm, and grow in a more sustainable way (Kamkankaew, 2025). Risk management means identifying and reducing possible problems that may affect a business (Thorniley-Walker, 2011). It helps small and medium enterprises (SMEs) prepare for events that can cause harm. These problems may come from inside or outside the business. Good risk management allows businesses to find threats early and make plans to reduce or stop those threats (Raja, 2021). This process is important for staying stable and competitive. In today's world, one of the major problems that needs risk management is the environmental impact, especially the carbon footprint.

Climate change brings new risks to business operations. Changes in weather patterns, rising temperatures, and extreme weather events can damage property and reduce productivity (Singh et.al, 2023). For example, floods can close factories, and heatwaves can affect employee health. These environmental problems can raise costs and interrupt business activities. SMEs that depend on agriculture, tourism, and local transport are more at risk. Climate change can also change the demand for certain products, which affects income (Caby, Ziane & Lamarque, 2022). Managing these risks is important for long-term business success.

Carbon regulations can create legal and financial risks. Governments are starting to set rules to limit carbon emissions (Lu & Sun, 2021). These rules may require companies to report their emissions or pay extra taxes. Businesses that do not follow the rules may face fines or legal action. New laws can also increase the cost of energy and transport. SMEs that are not prepared may have to spend more money to change their systems or update their equipment (Abbass et.al, 2022). This can be difficult, especially for small businesses with limited budgets. Understanding carbon rules helps businesses plan and avoid legal problems.

High emissions can harm a company's image. Today, customers, investors, and partners care more about the environment (Schleich et.al, 2024). They prefer businesses that reduce pollution and act responsibly. A company with high emissions may be seen as careless or outdated. This can reduce customer trust and hurt sales. It can also make it harder to find new partners or enter international markets. SMEs need to protect their reputation by showing that they care about the environment. A good image helps build strong relationships and attract new opportunities.

Using carbon footprint data helps avoid these risks. Carbon footprint data shows how much greenhouse gas a business produces (Bui, 2017). When SMEs know their emissions, they can take action to reduce them. This includes using cleaner energy, saving electricity, and improving transport. With this data, businesses can also follow government rules and show their efforts to the public. It becomes easier to join green programs and get support from banks or partners. Measuring carbon footprints is a smart way to manage risks and move toward sustainability.

It supports better planning and decision-making. When SMEs have clear data about their carbon emissions, they can make better business choices (Caby, Ziane & Lamarque, 2022). For example, they can decide which machines use less energy or which suppliers offer eco-friendly options. They can also plan for future rules or climate changes. With this information, businesses can set goals and

check their progress. This helps them stay competitive and responsible. In the long run, using carbon data leads to better results, lower costs, and more trust from society.

In conclusion of this section, linking carbon footprint to risk management helps Thai SMEs prepare for environmental and business challenges. It allows them to understand their emissions, follow laws, protect their image, and make better decisions. Using carbon data is a simple but powerful way to reduce risks, save costs, and build a stronger and more sustainable future.

The Role of Carbon Footprint in Business Strategy

The carbon footprint is now an important part of business strategy. It helps companies see how their actions affect the environment. By using carbon data, businesses can set clear goals, make better decisions, and reduce waste (Olekanma et.al, 2024). This helps them save money, improve their image, and meet new environmental rules. For small and medium-sized enterprises, it also opens new market opportunities. Including carbon goals in business planning supports long-term growth and builds trust with customers and partners.

Carbon data can help companies set clear environmental goals. It shows how much carbon emissions are produced in different parts of the business (Penz & Polsa, 2018). By looking at this data, companies can understand their environmental impact. They can then make goals to reduce emissions step by step. These goals can be small at first and grow over time. For example, a company may aim to lower emissions from transportation or reduce energy use in production. Setting goals based on real data makes progress easier to track and more meaningful for both the company and its stakeholders (Kamkankaew et.al, 2024). Carbon data also supports decisions about how to use energy, what materials to buy, and how to design products (Raja, 2021). Companies can choose energy sources that produce less carbon, such as solar or wind power. They can

also select raw materials that are more eco-friendly. In product design, they can think about making items that last longer, use fewer materials, or are easier to recycle. These choices not only help the environment but can also reduce costs and meet customer demand for sustainable products. Using carbon data makes these decisions smarter and more responsible.

Understanding a company's carbon footprint helps identify areas where waste can be reduced (Müller et.al, 2020). For example, if a business uses more electricity than needed or produces a lot of packaging waste, carbon data can reveal these problems. Once waste is found, the company can take steps to fix it. Reducing waste saves money, improves efficiency, and helps the environment (Sutton-Parker, 2022). It also prepares the business to meet future regulations or industry standards that focus on sustainability. When a company takes steps to reduce its carbon footprint, it can build more trust with customers and business partners. People today care more about the environment. They want to support businesses that take action. Showing clear efforts to reduce carbon emissions sends a strong message. It shows the company is responsible and forward-thinking. This kind of image helps build long-term relationships and improves the company's reputation in the market.

The financial impact of carbon reduction practices in business strategy can be seen through improved financial performance. When businesses reduce their carbon emissions, they can lower energy costs, manage waste better, and increase efficiency (Issa, 2024). These actions help the business save money in the long term. Companies that follow strong carbon reduction strategies also build better reputations, which can attract more customers and investors. As a result, their market value and profit levels may rise. Domingo & Le (2025) indicated that this positive impact becomes even stronger when businesses also have good governance and responsible social practices. Therefore, investing in carbon reduction is not just good for the environment but also brings financial benefits to the company

Small and medium-sized enterprises (SMEs) can also use carbon data to become part of green supply chains (Munkongtum & Moryadee, 2023). Many larger companies want suppliers who follow green practices. If SMEs can show their carbon reduction efforts, they may get more contracts and grow their business. Joining a green supply chain can also help SMEs learn new ways to work more efficiently. It connects them with partners who share the same values. This gives SMEs more chances to compete and succeed in a changing market. A business strategy that includes carbon goals can help the company grow in a sustainable way (Sutton-Parker, 2022). It prepares the company for the future. As more rules about carbon emissions appear, companies with carbon strategies will be ready. They can avoid fines, meet customer needs, and stand out from competitors. Carbon goals also encourage innovation. They push companies to find new ways to work better and cleaner. This kind of long-term thinking leads to steady growth and stronger business results.

In conclusion of this section, using carbon footprint data in business strategy helps companies grow in a smart and sustainable way. It supports better planning, improves efficiency, and builds trust with customers. By setting clear carbon goals, businesses can reduce waste, lower costs, and prepare for future changes. This makes the company stronger and more ready for long-term success.

Table 1 The Role of Carbon Footprint in Business Strategy

Key Role	Description
Environmental Impact Awareness	Helps businesses see how their actions affect the environment and make informed decisions.
Goal Setting and Progress Tracking	Enables setting step-by-step carbon reduction goals based on actual emission data.

Smarter Business Decisions	Supports better choices in energy use, material selection, and product design.
Waste Reduction and Cost Savings	Identifies areas of waste and helps improve efficiency and reduce costs.
Enhanced Reputation and Customer Trust	Builds trust with stakeholders by showing commitment to sustainability.
Access to Green Supply Chains	Opens opportunities for SMEs to join green supply networks and gain more contracts.
Long-Term Growth and Innovation	Encourages sustainable growth, readiness for regulations, and innovation in business practices.

The Role of Thai SMEs in Sustainable Management

Small and medium enterprises (SMEs) play an important role in Thailand's economy (Office of Small and Medium Enterprises Promotion, 2024). Most of these businesses operate in the service, manufacturing, and trade sectors, which are closely linked to environmental impacts. Because there are so many SMEs and they are active in many areas, their actions have a big effect on the environment. This makes them a key part of sustainable development. If SMEs manage their carbon footprint, they can help lower the country's greenhouse gas emissions (Kantabutra, 2019). At the same time, sustainable practices can make these businesses stronger and more competitive. Since SMEs form the majority of businesses in Thailand, their support and participation in green efforts are necessary for the country to reach its environmental goals.

Many small and medium enterprises (SMEs) in Thailand do not have enough knowledge or resources to manage their carbon footprint (Chaiyaboot et.al, 2021). Most of them are focused on day-to-day operations and do not have staff trained in environmental issues. They may not understand what a carbon footprint is or why it is important. Many SMEs also do not have access to tools

or systems that help measure emissions. In addition, they often lack the money to invest in cleaner technology or energy-saving equipment. This makes it hard for them to follow new environmental rules or join green business networks. Without support and training, these SMEs may fall behind in the move toward sustainable business (Munkongtum & Moryadee, 2023). Helping SMEs learn how to manage their carbon footprint is important for both business success and environmental protection.

Thai SMEs have great potential to lead in green practices (Sutthiphapa & Thongtho, 2022). They are flexible and can adapt to new ideas quickly. Many SMEs are close to their local communities, so they understand local needs and problems. This helps them find simple and smart ways to reduce environmental harm. Some SMEs have already started using eco-friendly products, reducing waste, or saving energy (Munkongtum & Moryadee, 2022). Their smaller size allows them to make changes faster than large companies. If more SMEs act in this way, they can help create a strong movement for green business across the country. This will not only protect the environment but also increase their chances to join green markets and supply chains.

To help Thai SMEs move toward green practices, support from the government and business networks is important. Many SMEs do not have enough money, tools, or knowledge to start these changes by themselves. The government can help by giving training, tax support, or easier rules for green actions (Meejaisueb et.al, 2023). Networks such as business groups, trade associations, and universities can also play a big role. They can share ideas, offer advice, and help SMEs work together on projects. When public and private sectors work as a team, SMEs can grow in a sustainable way and help protect the environment for the future.

In conclusion of this section, Thai SMEs are a key part of the country’s move toward sustainable management. Although many face challenges like

limited resources and knowledge, their large number and flexibility give them strong potential to lead in green practices. With the right support from the government and networks, SMEs can take meaningful steps to manage their carbon footprint, protect the environment, and build a stronger, more sustainable economy.

Table 2 The Current Role and Potential Role of Thai SMEs in sustainable management

Aspect	Current Role of Thai SMEs	Potential Role of Thai SMEs
Economic Importance	Major contributors to Thailand's economy, especially in service, manufacturing, and trade sectors.	Continue to drive economic growth while integrating sustainability into core operations.
Environmental Impact	Significant due to large numbers and diverse activities, but often unmanaged.	Can collectively reduce national greenhouse gas emissions through sustainable practices.
Knowledge & Resources	Often lack awareness, training, and tools to manage carbon footprints.	With support, can become knowledgeable and equipped to implement green practices.
Operational Focus	Primarily focused on daily survival and short-term goals.	Can shift toward long-term sustainability and resilience.

Flexibility & Innovation	Limited by lack of support, but inherently adaptable.	High potential to innovate and adopt eco-friendly solutions quickly.
Community Connection	Close ties to local communities but underutilized in sustainability efforts.	Can leverage local knowledge to implement context-specific green solutions.

Table 2 The Current Role and Potential Role of Thai SMEs in sustainable management *(Cont.)*

Aspect	Current Role of Thai SMEs	Potential Role of Thai SMEs
Examples of Green Action	Few SMEs have adopted eco-friendly practices.	Many more can follow suit, creating a nationwide green business movement.
Support Needs	Require external help (training, funding, tools).	With government and network support, can lead in sustainable development.

Carbon Footprint into Risk Management: Challenges for Thai SMEs

This section synthesizes the challenges of integrating carbon footprint into risk management for Thai SMEs as follows (Chaiyaboot et.al, 2021; Munkongtum & Moryadee, 2022; Meejaisueb et.al, 2023; Leenoi, 2025; Saethep, Kiratiphumtam & Detkawinlerd, 2025):

1. Many Thai SMEs may face problems in tracking their carbon emissions because they do not have the right tools or trained staff. Measuring a carbon footprint needs special equipment, software, and knowledge. Most SMEs do not have experts in this area or enough budget to hire outside help. Without the right tools, it is hard to collect and understand data about greenhouse gases. This makes it difficult for SMEs to know how much they are emitting and where the emissions come from. As a result, they cannot plan well to reduce emissions or follow environmental rules. This challenge slows down their progress in becoming more sustainable and makes it harder to include carbon footprint in risk management.

2. Thai SMEs in managing carbon footprint is that carbon data can be hard to find or measure. Many small businesses do not have clear systems to collect or track information on their carbon emissions. The data may be scattered across different parts of the business or may not exist at all. Some emission sources are hard to measure, especially in the supply chain. For example, it is not easy to calculate emissions from transportation, raw materials, or energy use without proper tools. SMEs may not know which data they need or how to record it correctly. Also, there is often a lack of guidance on what standards to follow or how to use the results. This makes it difficult for SMEs to understand their environmental impact or set clear carbon goals. As a result, efforts to reduce emissions or improve sustainability are often limited or delayed.

3. Thai SMEs in managing their carbon footprint is the lack of awareness about sustainability. Many business owners do not fully understand what sustainability means or how it relates to their daily operations. They may not see the link between their activities and environmental problems such as climate change. As a result, they often do not consider the carbon footprint of their business when making decisions. This lack of awareness leads to low interest in reducing emissions or using eco-friendly practices. Without basic knowledge, it is hard for SMEs to see the value of sustainability or how it can benefit their

business in the long term. This makes it difficult for them to take the first steps in measuring, tracking, or managing carbon-related risks. Therefore, raising awareness is a key step in helping Thai SMEs move toward a more sustainable and responsible way of doing business.

4. While there are some policies and programs to promote sustainability, they are often limited in scope or reach. Many SMEs do not receive enough help in the form of funding, technical assistance, or training. As a result, they struggle to adopt low-carbon practices or invest in green technologies. Some support programs are also hard to access due to complex procedures or lack of clear information. This makes it difficult for SMEs to start or continue their efforts in reducing emissions. Without strong and ongoing support from the government, it is hard for small businesses to include carbon footprint management in their business plans. This situation creates a gap between policy goals and what SMEs can do in practice, which slows down progress toward sustainable development.

5. Many SME owners and staff do not have enough knowledge or skills to understand carbon footprint and how to reduce it. They may not know how to start or what steps to take. Without basic training, it is hard for them to take action. In addition, many available tools are too complex or expensive for small businesses. These businesses need easy-to-use tools that can help them measure, track, and manage their carbon emissions. Simple guidelines and step-by-step support are also needed. Providing training and basic tools can help SMEs take the first step toward low-carbon practices and improve their long-term sustainability.

In conclusion, Thai SMEs face many challenges in managing their carbon footprint, such as limited budgets, lack of tools, hard-to-find data, and low awareness of sustainability. Without enough support, knowledge, or simple tools, it is difficult for them to measure and reduce emissions. These problems make it

hard for SMEs to include carbon footprint in risk management and to move toward sustainable practices.

Table 3 Challenges of Carbon Footprint into Risk Management for Thai SMEs

Challenge	Description
Lack of Tools and Expertise	SMEs often lack the equipment, software, and trained staff needed to measure and manage carbon emissions effectively.
Limited Access to Carbon Data	Carbon data is often hard to collect, scattered, or unavailable, especially in supply chains and energy use, due to lack of systems and standards.
Low Awareness of Sustainability	Many SMEs are unaware of how sustainability and carbon footprint relate to their business operations, leading to low engagement.
Insufficient Government Support	Policies and support programs exist but are often hard to access or not tailored to SME needs, limiting their impact.
Lack of Training and Simple Tools	Business owners and staff lack the knowledge and user-friendly tools needed to begin carbon footprint tracking and reduction.

Practical Recommendations

Based on the presentation above, the following recommendations can be proposed as:

1. To help Thai SMEs manage their carbon footprint, the government should provide strong support through training and funding. Training programs can help SME owners and staff learn about carbon emissions, measurement

methods, and low-carbon practices. These programs should use simple language and examples that relate to small businesses. In addition, the government should offer funding to help SMEs buy tools, upgrade equipment, or invest in cleaner technology. Many SMEs do not have enough money to do this on their own. With financial support, they can take action faster and more effectively. Together, training and funding will help Thai SMEs build knowledge, improve operations, and become part of the country's sustainable growth.

2. Universities can play a key role in helping Thai SMEs manage their carbon footprint by developing simple tools and easy-to-follow guides. These tools should help businesses understand how to measure and reduce their greenhouse gas emissions. Universities can work with SMEs to make sure the tools fit their needs and are not too difficult to use. They can also create step-by-step guides that explain the process in a clear and practical way. By doing this, universities can support SMEs in making better decisions, reducing environmental risks, and joining sustainable supply chains. These efforts can also help build stronger links between academic knowledge and real business practice, leading to more innovation in green management.

3. Industry groups can play an important role in helping Thai SMEs manage their carbon footprint. They can create networks where businesses share best practices and learn from each other. These groups can collect and spread useful examples of how to reduce emissions in simple and cost-effective ways. By working together, SMEs can find solutions that match their needs and limits. Industry groups can also invite experts to give advice and help companies understand carbon footprint tools. This kind of support can reduce the time and cost needed for each SME to act alone. Sharing knowledge in this way can make it easier for more SMEs to start using sustainable practices and include carbon management in their business plans.

4. SMEs should begin by using simple methods to track their carbon footprint. This first step can help them understand how much greenhouse gas their activities produce. Basic tools, such as spreadsheets or online calculators, can be used to collect and record data on energy use, fuel, and materials. Starting with easy tracking can also build awareness among business owners and staff about the importance of reducing emissions. It does not require large investments and can fit with daily operations. Over time, as businesses learn more, they can improve their systems and include carbon tracking in broader risk management plans. This simple start can lead to better decisions, cost savings, and a stronger position in green supply chains.

5. Thai SMEs should include carbon goals in their business plans to support sustainable growth. By setting clear carbon reduction targets, SMEs can better manage risks related to climate change and environmental regulations. These goals can guide choices about energy use, raw materials, and production methods. Including carbon goals in business planning also helps companies improve efficiency and reduce waste. It makes it easier to track progress and report results to customers and partners. This can build trust and attract green investors or clients who value sustainability. Setting carbon goals from the start also prepares SMEs to join green supply chains and follow new rules. This approach can support long-term success while helping the environment.

6. Thai SMEs should work together in networks to reduce costs and share knowledge about carbon footprint management. When businesses join networks, they can learn from each other and use shared resources. This can help them understand how to measure and reduce emissions in simple and low-cost ways. For example, they can share tools, data, or training programs instead of paying for them alone. Networks also create a space for new ideas and best practices to spread faster. This support makes it easier for SMEs to manage risks linked to climate change. In the long term, strong networks can help small firms grow in a green and sustainable direction.

Table 3 Practical Recommendations

Stakeholder	Key Recommendation	Expected Impact
Government	Provide training programs (using simple language and SME-related examples) and funding to help SMEs adopt low-carbon tools and cleaner technologies.	Builds SME capacity and accelerates the adoption of sustainable practices through enhanced skills and resources.
Universities	Develop simple tools and step-by-step guides for measuring and reducing GHG emissions, ensuring these resources are tailored to SME needs.	Facilitates informed decision-making for SMEs and bridges academic knowledge with practical business applications.
Industry Groups	Create networks for sharing best practices, cost-effective emission reduction examples, and expert advice on using carbon footprint tools.	Reduces individual costs, speeds up the adoption of sustainable practices, and supports collaborative innovation.
	Start with basic tracking methods (e.g., spreadsheets or online calculators) to monitor carbon footprints, building awareness without heavy investment.	Generates initial insights into emissions, fosters gradual improvements, and integrates carbon tracking into routine operations.

SMEs	Integrate carbon reduction targets into business plans, influencing decisions on energy, materials, and production methods.	Enhances efficiency, reduces waste, and positions SMEs as attractive partners for green investors and sustainable supply chains.

Table 3 Practical Recommendations *(Cont.)*

Stakeholder	Key Recommendation	Expected Impact
SMEs	Collaborate in networks to share tools, data, and training resources for managing carbon footprints and reducing costs collectively.	Encourages cost-sharing, innovation, and faster spread of sustainable practices within the SME community.

Future Research Directions

Based on the presentation above, the following future research directions can be proposed as:

1. Future research should focus on studying SMEs in different sectors because each sector has its own challenges and opportunities when managing carbon footprints. For example, manufacturing, agriculture, tourism, and retail businesses have different types of emissions and different ways of reducing them. By looking at these differences, researchers can develop better tools and strategies that match each sector's needs. It is also important to study how sector-specific policies and technologies can support carbon management. Future studies should also look at how customer behavior, market demand, and supply chain practices affect carbon emissions in each sector. This will help create a clear picture of how carbon footprint and risk management work in real

business settings. More research will give a deeper understanding of what works best and what still needs improvement for each type of SME.

2. Future research should explore how digital tools can help Thai SMEs track their carbon footprint. These tools can include mobile apps, online platforms, or smart devices that make it easier to collect and analyze emissions data. Many SMEs may not have the staff or skills to do manual tracking, so digital solutions can save time and reduce errors. Researchers should also study which tools are most useful for different types of SMEs, such as those in food, manufacturing, or retail. It is also important to test how easy the tools are to use and how they fit into daily business operations. Research can look at the costs, benefits, and challenges of using these digital tools in real business settings. This will help provide practical advice to SMEs, developers, and policymakers who want to support low-carbon business growth in Thailand.

3. Future research should focus on case studies of Thai SMEs that have successfully included carbon footprint management in their business practices. These case studies can show practical steps that other SMEs can follow. They can help explain how small businesses overcome challenges and apply simple tools. By studying real examples, researchers can learn what works best in the Thai context. These case studies can also give useful insights into the costs, benefits, and support systems that help SMEs become more sustainable. This kind of research can help build a clear path for other small businesses to reduce emissions and improve their long-term success.

4. Future research should focus on studying how government policies affect the way Thai SMEs manage their carbon footprint. These studies can help show what kinds of policies work well and which ones do not. By understanding the results of past and current policies, researchers can suggest better ways for the government to support SMEs in becoming more sustainable. This can include financial help, training programs, or laws that encourage green practices. Research

can also compare different policy approaches and look at how they affect different sectors. Clear evidence from policy impact studies can help the government design programs that match the real needs of SMEs and support long-term environmental goals.

5. Future research should focus on how consumer behavior relates to green products and sustainable business practices. Understanding what customers think and how they choose eco-friendly products can help Thai SMEs make better decisions. Studies can look at what makes people buy green products, such as their values, habits, or knowledge about the environment. Researchers can also explore how marketing messages about carbon reduction influence consumer choices. This knowledge can support SMEs in creating products that match customer demand and promote low-carbon goals. More studies in this area will help connect business strategies with customer expectations, which is important for long-term success in a green economy.

Conclusion

This review article highlights that managing carbon footprint is a key part of sustainable business practices for Thai SMEs. Climate change brings serious risks, and carbon footprint data helps businesses understand their role in this issue. Thai SMEs can use this data to reduce emissions, improve efficiency, and meet environmental regulations. However, many face challenges such as lack of tools, limited knowledge, and budget constraints. Risk management that includes carbon footprint tracking helps SMEs prepare for environmental changes and new laws. By setting carbon goals and using simple tracking methods, SMEs can make progress toward sustainability. Support from the government, universities, and business networks is also important. These partners can offer training, tools, and advice. With the right help, SMEs can become more competitive, reduce costs, and build trust with customers. In this way, managing carbon footprint is not only

good for the environment but also supports the long-term success of small businesses in Thailand.

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