Research Article

Enhancing Operations for Sustainability in Indonesian SMEs through Climate Change Awareness and Business Orientation

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ABSTRACT

This study aims to identify the level of climate change awareness among small-medium scale entrepreneurs (SMEs) and to investigate its impact on future business orientation, with individual self-perception acting as a mediating variable. Addressing a significant gap in the literature, this research explores the reciprocal influence between SMEs and climate change—an area previously underexplored. Conducted in West Sumatra, Indonesia, this study employs a quantitative causal analysis approach using Structural Equation Modelling-Partial Least Squares (SEM-PLS) for robust analysis. The findings indicate that while awareness and self-perception of climate change among SMEs are low, they significantly influence potential changes in business orientation. The study reveals that although many SMEs possess a high level of educational attainment, this does not necessarily translate into heightened awareness or self-perception regarding climate change. This disconnect underscores the critical role of tailored educational initiatives and support systems to bridge the gap between knowledge and action. Additionally, the study finds that SMEs often prioritize immediate financial stability over long-term environmental sustainability, driven by the necessity to meet daily operational demands. These results underscore the urgent need for pre-emptive government policies to guide SMEs toward sustainable practices. Effective interventions should include financial incentives, technical assistance, and educational programs designed to enhance climate change awareness and capabilities among SMEs. Furthermore, this study contributes to the field of industrial engineering by identifying opportunities to optimize SME operations. By integrating environmental sustainability into business strategies, SMEs can enhance their resilience and competitiveness while contributing to broader environmental goals. This research advances the understanding of the dynamic interplay between SMEs and climate change, providing a foundation for future studies aimed at promoting sustainable industrial practices.

Keywords: climate change, small-medium entrepreneurs, self-perception, business orientation

INTRODUCTION

Climate change has emerged as a critical global challenge that demands urgent attention from every nation. Its impacts, predicted in the past, are now manifesting across all sectors of life, bringing severe consequences to countries, societies, and ecosystems worldwide. According to Heshmati [1], [2], climate change affects not only plants and animals but also has significant repercussions for human beings, including water and food insecurity, increased morbidity and mortality, and population displacement. Beniston [3] elaborates on these effects, highlighting the threats to human well-being resulting from deteriorating environmental conditions and changing social dynamics, such as the rapid urbanization of developing countries and ecological disruptions.

Hsiang and Kopp [4] describe climate change as the long-term variation in the joint probability distributions of atmospheric, oceanic, and freshwater states, including ice. This environmental phenomenon, characterized by changes in temperature, precipitation patterns, sea levels, and the frequency of extreme weather events, inevitably affects human activities. These changes disrupt natural ecosystems, influence agricultural productivity, alter water supply, and impact human health, demonstrating the far-reaching consequences of climate change on daily life. From

an economic and business perspective, de Juan et al. [5] discuss the complex causality between climate change and economic activities. Economic activities, such as industrial production, transportation, and energy consumption, can directly or indirectly influence climate change through greenhouse gas emissions and other environmental impacts. In turn, climate change can affect the operations of entrepreneurs and other economic actors by disrupting supply chains, increasing operational costs, and creating uncertainties in the market. This reciprocal relationship underscores the significant impact of climate change on business operations.

Small and medium enterprises (SMEs), by their vast numbers, have the potential to influence climate change through their business activities. Representing approximately 90% of business entities in both developed and developing nations, SMEs significantly contribute to economic performance by fostering innovation, creating jobs, and driving GDP growth. Despite their economic significance, their operations often result in environmental challenges due to inefficiencies and a lack of awareness regarding sustainable practices. These businesses frequently face constraints in resources and expertise, making it difficult for them to implement and maintain eco-friendly measures. Pinner [6] highlights that SMEs, which dominate global value chains, are central to the climate change discourse. Their widespread presence and integral role in supply chains mean that their collective environmental impact is substantial. Simultaneously, they are also significantly affected by climate change impacts. International Trade Center (ITC) forum reports that only 38% of SMEs are capable of investing in climate change mitigation and environmental risk reduction [7]. This statistic underscores the limited capacity of SMEs to implement environmentally sustainable practices, highlighting the urgent need for heightened awareness and proactive measures within this sector. The combination of these operational shortcomings and the absence of eco-friendly processes positions SMEs as both contributors to and victims of climate change.

Empirical evidence supports the relationship between climate change and human and economic activities, particularly those of SMEs. Alam et al. [8] note that climate change can significantly enhance SMEs' innovation performance by necessitating more socially and environmentally friendly business operations. However, the negative impacts of climate change on SMEs are multifaceted, affecting supply chains, production, resource acquisition, infrastructure, and regulatory environments [9]. These challenges may compel SMEs to adapt their production and operational patterns.

In Indonesia, climate change profoundly affects social and environmental scenarios, impacting freshwater availability, sea-level rise, biodiversity, ecosystem services, human health, and vulnerability [10]. Recognizing these threats, the Indonesian government and other stakeholders advocate for measures to mitigate climate change impacts. Despite the significant presence of SMEs in Indonesia's private sector, there remains a lack of empirical research on the knowledge and awareness of Indonesian SME entrepreneurs regarding climate change and its direct and indirect effects on their businesses. This research gap is the primary focus of this study.

Scholars have explored various indicators to measure the impact of climate change on human and economic activities. Aufhammer et al. [11] and Dell et al. [12] identify weather variables, such as temperature and precipitation, as key indicators of climate change's impact on human activities. The Intergovernmental Panel on Climate Change (IPCC) [13] also highlights global warming, defined as the evolving distribution of temperature, as a critical measure. Additional indicators include humidity, solar radiation, wind speed, direction, and atmospheric pressure [5]. These indicators collectively provide a comprehensive understanding of how climate change influences human and economic systems.

Building on this understanding, the theory of awareness, initially proposed by Mansell [14], suggests that awareness is generated from perceptual or experiential data resulting from certain stimuli. This awareness shapes individuals' self-perception, influencing how they interpret and respond to their experiences. Self-perception theory, introduced by Bem [15], posits that individuals understand their beliefs, attitudes, and perceptions by observing their behavior and the underlying reasons. If individuals lack full awareness of their behavior, they analyze it as an outsider would, deducing their inner characteristics. This process of self-analysis and awareness is crucial in how individuals respond to environmental changes, including those brought about by climate change. Bem [15] further explains that self-perception evolves continuously with new experiences. Robak [16] and Santos-Álvarez et al. [17] support this view, describing self-perception as the cognitive process through which individuals form an image of their surrounding

reality. This perception drives actions, as individuals process sensory information and relate it to past experiences, creating a sociocultural filter through which they view the world [18]. As climate change alters environmental conditions, the way individuals perceive and respond to these changes is significantly influenced by their self-perception.

Personality theory, as discussed by Bandura [19], focuses on the interaction between behavior, personal factors, and environmental influences, a concept known as reciprocal determinism. This theory highlights how an individual's self-orientation is shaped by both internal and external factors, determining their behavioral patterns and worldview. Understanding these dynamics is essential for comprehending how individuals and societies adapt to and mitigate the impacts of climate change. By considering the interplay between personal perception, awareness, and environmental influences, we gain a more holistic view of the human response to climate change.

Theoretically, this study aims to explore the relationship between environmental phenomena, specifically climate change, and the awareness and self-perception of SME entrepreneurs. Understanding this relationship is crucial as it can influence changes in business orientation towards more sustainable business practices. This research investigates the level of knowledge about climate change among SME entrepreneurs in West Sumatra Province, Indonesia, and assesses how this knowledge can enhance awareness and influence business orientation to anticipate and mitigate the negative impacts of climate change. We posit that the knowledge SMEs entrepreneurs possess about climate change will influence their awareness and self-perception, potentially leading to changes in their business orientation. This relationship represents the primary research gap this study aims to address.

By focusing on SMEs in Indonesia, this study offers valuable insights into the level of climate change awareness within this sector and proposes ways to improve it. The findings contribute to the field of industrial engineering by identifying opportunities for optimizing SME operations to mitigate climate impacts. This study thus provides a foundation for pre-emptive government policies and strategic interventions aimed at fostering sustainable business practices among SMEs, aligning with the broader goals of environmental sustainability and industrial optimization.

METHODS

This explanatory study employs a quantitative methodology to investigate the relationship and influence of SME entrepreneurs' knowledge about climate change on potential changes in their business orientation. Causal analysis is used to explore how SMEs' knowledge may shape their self-perception regarding climate change, with descriptive statistics supporting the analysis. Initially, the study assesses the level of climate change knowledge among SME entrepreneurs to understand the construct of self-perception in this context. This construct is then linked to potential changes in business orientation planned by the SME entrepreneurs. These constructs form the major variables of the study. Data were collected using a cross-sectional cohort design with a questionnaire as the primary research instrument. The questionnaire was prepared using a 4-point Likert scale, which aims to measure perception, action, and experience from the samples regarding the topic of study. The use of a 4-point Likert scale is based on the intention to avoid neutral answers from the samples, which could result in normative and formal statements only. In measuring the awareness of the samples regarding climate change, the 4-point Likert scale of the study is interpreted as follows: 1 = fully aware; 2 = simply aware; 3 = not really aware; and 4 = not aware at all. Meanwhile, to measure changes in orientation and individual perception of the samples, the 4-point Likert scale used in the study is interpreted as 1 = totally agree; 2 = agree; 3 = not fully agree; and 4 = do not agree at all.

A simple random sampling method was employed to distribute the questionnaire to SME entrepreneurs across various business sectors in multiple municipalities in West Sumatra Province, Indonesia. The study aimed to collect data from at least 100 respondents, preparing and distributing 300 questionnaires to prospective participants. Out of these, 137 questionnaires (45.67%) were completed and returned, providing the final sample size for analysis. The sample was considered gender-neutral, with no gender-based sampling criteria or specific business branches considered.

The questionnaire was disseminated offline, with the authors directly distributing it to the respondents. A pilot study was first conducted with at least thirty respondents to validate the questionnaire. Following the pilot study, the

Table 1. Operational Definition of Variables

No.	Variables and Definition	Dimension	Indicators
1.	**Awareness** Awareness is defined provisionally as the generation of certain data (perceptual or other experiences), due to the occurrence of certain objects of experience (cortical states) [21]	• Perceptual view of data • Experience • Cortical state [21]	• Level of knowledge about facts and data (A10) • Understanding the impact (A11) • Need to undertake individual campaign (A12) • Constructive and productive actions (A13) • Level of impact (A5) • Level of bad experiences from the impact (A6) • Need to undertake action (A7) • Changing mindset (A8) • Level of financial performance (A9)
2.	**Business Orientation** A visual representation for the connections between preconditions, long-term outcome, indicators, and interventions, and of the underlying context [22]	• Precondition • Long-term outcome • Indicators • Interventions [22]	• Changing business orientation needs to consider current business situation (BC10) • Level of orientation changing from massive business operation (BC11) • Changing in business orientation needs government's intervention (BC12) • Need for supportive pre-condition to change orientation (BC13) • New performance indicator in business (BC14) • New orientation means new performance (BC16) • Level of intervention needed as the owner (BC18) • Other stakeholders need also to intervene (BC19) • Social environment and public need to be stimulated (BC20) • Need for company's internal and external interventions (BC21) • Changing in business orientation can be seen in long-term (BC5) • Anticipating means investment (BC6)
3.	**Individual perception** Perception is the process by which the individual forms an image of the surrounding reality. In other words, it is the cognitive representation resulting from the individual interpretation process [20]	• Recognition of stimuli • Subsequent interpretation [20] • Sensory awareness or cognition of the experience. • Personal experience. • Comprehension can lead to a response. [23]	• Find and apply business solution (IP10) • Impact will soon influence business (IP11) • Learning valuable things from impact (IP12) • Know how to anticipate impacts (IP13) • Experience to impact should change us (IP15) • Personal experience to the impact (IP16) • Know and understand about the impact from partners' experiences (IP17) • Can feel the impact within the company (IP3) • Following news about the impact (IP4) • Personal respond in terms of positive actions (IP6) • Willingness to campaign about the impact (IP8) • Changing personal behavior when understand the impact (IP9)

Source: conception of the authors, adopted from [20]-[22].

remaining questionnaires were distributed, with the authors accompanying respondents to assist in accurately completing the questions, thereby minimizing potential bias and misunderstandings. The operation of variables in this study uses the guidelines in Table 1.

This study employs Structural Equation Modelling (SEM) with Partial Least Squares (PLS) as its primary data analysis method. SEM-PLS is particularly suitable for this research as it allows testing of complex models and analysis of latent variables, such as awareness of climate change and individual perception, which cannot be directly measured. Additionally, SEM-PLS is adept at handling variables with multiple dimensions, making it an appropriate choice for this study.

The SEM-PLS procedure in this study includes both outer model and inner model tests. The outer model test comprises validity and reliability assessments. The validity test involves evaluating both convergent and discriminant validity to ensure that the measurement model accurately reflects the constructs it is intended to measure. In contrast, the reliability test is conducted to confirm the consistency and stability of the measurement model over time. In the inner model test, R-square values are examined to determine the proportion of variance in the dependent variables that can be explained by the independent variables. Following this, path coefficients are analyzed to evaluate the strength and significance of the relationships between constructs in the model.

By following these procedures, SEM-PLS facilitates a comprehensive analysis of the data, enabling the exploration of complex relationships and providing robust insights into the constructs under study.

RESULT AND DISCUSSION

By using cross-tabulation to the respondents' profile, the first finding of the study revealed that the majority of respondents is medium scale business entrepreneurs, who have undergraduate/bachelor degree as their educational background. The percentage of this respondents is as much as 56,3% from all respondents. This is followed by medium scale business entrepreneurs, who has junior high school background (50%). Those are in the age between 31 and 35 years (67%) dominated the respondent profile. These figures imply that from educational background, respondents of this study can be categorized as young people who are having medium to high level of education, which are believed can equip and inspire them to understand about climate change matters. Ideally, the circumstance possessed by respondents can be used as to argue that they should have sufficient level of knowledge as the basis for awareness regarding climate change. The knowledge can be gathered from various resources, such as online and offline media, data-information released by the government or other institutions and raising awareness activities undertaken by stakeholders of climate change.

However, the study has found contradictory fact about this. The study found that the level of self-perception regarding climate change among small and medium scale enterprises in the study context is relatively low. This finding was clearly revealed by respondents – who mostly ticked the answer as 'not really know' in six items of the questionnaire, which measures the level of personal knowledge regarding: 1) overall/general understanding about climate change, 2) the impact and danger of climate change, 3) whether or not business operation should respond to climate change, 4) stakeholders' responsibility to climate change, 5) changing individual mindset about climate change, and 6) the dissemination of climate change and its negative impact to others. From all of six concerns, the majority of respondents revealed that they do not really know about the matters mentioned. The percentage of respondents was as much as eighty-five percent and this is a clear indication that the level of knowledge as the basis to create self-perception regarding climate change among the study context is considerably low.

Analyzing this finding and relate it with the real situation of small and medium scale enterprises in the study context, the study then understands why the finding has stipulated that. As in other developing worlds, small and medium scale enterprises in the context of the study suffer from limited capacities and competencies in their business operation, cannot reach updated world's business dynamics and global concerns, should survive in a dynamic but harsh competition, and lack of resources (fund/capital, business infrastructures and facilities, qualified human resources, information, etc.) [23]. These circumstances have resulted that small and medium scale entrepreneurs solely concentrate their business operation to survive and grow rather than considering, and further, applying environmental and global issues surrounding their business.

The finding of this study also proved a similar opinion by Schaper [24] who mentioned the low level of knowledge & awareness regarding climate change possessed by small-medium scale entrepreneurs, with relevant cynical

Table 2. Differences between Small-Medium Scale Enterprises & Large Enterprises Dealing with Climate Change

No.	Concerns	SMEs	Large Enterprises
1.	Level of emissions	Low	High
2.	Ability to measure GHGs (Greenhouse Gas Measurements)	Low	High
3.	Compliance cost burden	Proportionately high	Proportionately low
4.	Knowledge of, and to access to, relevant information	Limited, and ad-hoc	Sophisticated, and extensive
5.	Access to technical experts and training capabilities	Limited	High
6.	Financial capacity to fund climate initiatives	Typically small and limited	Substantial
7.	Use of external carbon advisers	Limited, and ad-hoc	Systematic, and structured

Source: adopted from [23]

question whether small and medium scale enterprises truly think that climate change is really an important issue for them and whether they truly intend to undertake something positive to reduce emissions from their business operation. Schaper [24] has robustly mapped the differences between small-medium scale enterprises and large enterprises when dealing with the effects of climate change, where small-medium scale enterprises have experienced circumstances (as in the Table 2) compare with larger enterprises. From table 2, the finding regarding the low level of knowledge towards climate change in the study context is relevant/similar to what Schaper [24] mentioned about the limited knowledge and limited access to relevant information regarding climate change possessed by small-medium scale entrepreneurs (point no. 4). This is totally different to the situation in large enterprises [25], which usually have sophisticated knowledge and broader access to various information about climate change. The condition faced by small-medium scale entrepreneurs is viewed as the result of lack and incapability in providing sufficient fund/capital, business facilities, qualified human resources, etc. to be used as respond growing concerns towards climate change.

As in Figure 1. The convergent validity of the study shows that the value of each indicator in the variables of Awareness, Individual perception, and Business orientation, has loading factor between 0.5 and 0.7. As in the exploratory research, this value means that every indicator in research variables is valid.
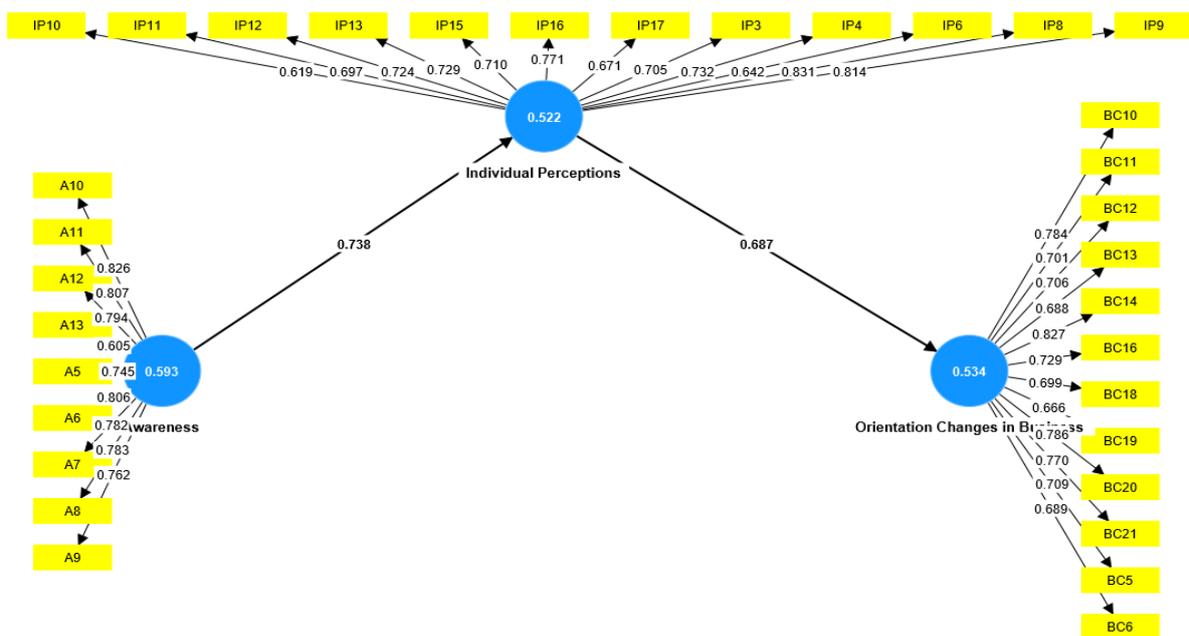

Figure 1. Convergent Validity of the Study

Table 3. Discriminant Validity of the Research Variables

Indicators	Variables (Constructs)			Indicators	Variables (Constructs)		
	Awareness	Individual Perceptions	Business Orientation		Awareness	Individual Perceptions	Business Orientation
A10	0.826	0.532	0.375	BC20	0.436	0.539	0.786
A11	0.807	0.575	0.449	BC21	0.464	0.564	0.770
A12	0.794	0.654	0.369	BC5	0.379	0.530	0.709
A13	0.605	0.511	0.211	BC6	0.228	0.497	0.689
A5	0.745	0.439	0.382	IP10	0.321	0.619	0.455
A6	0.806	0.550	0.364	IP11	0.542	0.697	0.391
A7	0.782	0.633	0.514	IP12	0.591	0.724	0.374
A8	0.783	0.647	0.498	IP13	0.679	0.729	0.422
A9	0.762	0.501	0.359	IP15	0.452	0.710	0.513
BC10	0.383	0.532	0.784	IP16	0.541	0.771	0.533
BC11	0.388	0.515	0.701	IP17	0.395	0.671	0.504
BC12	0.272	0.396	0.706	IP3	0.480	0.705	0.530
BC13	0.438	0.540	0.688	IP4	0.490	0.732	0.625
BC14	0.338	0.520	0.827	IP6	0.573	0.642	0.514
BC16	0.461	0.499	0.729	IP8	0.647	0.831	0.562
BC18	0.349	0.452	0.699	IP9	0.604	0.814	0.510
BC19	0.341	0.374	0.666				

Table 3 shows discriminant validity among the variables of Awareness, Individual Perceptions, and Business Orientation. Specifically, indicators A10 to A13 and A5 to A9 exhibit the highest loadings on the Awareness construct, demonstrating their effectiveness as measures of this variable compared to others. Similarly, indicators IP10 to IP13, IP15 to IP17, IP3, IP4, IP6, IP8, and IP9 show the highest associations with Individual Perceptions, indicating they are most strongly related to this construct. For Orientation Changes in Business, indicators BC10 to BC14, BC16, BC18 to BC21, and BC5 to BC6 stand out with the highest loadings, underscoring their relevance. Overall, the consistent higher loadings of each item on its respective construct, rather than on other constructs, validate the distinctiveness of each construct and confirm the validity of the measurement model.

The data in Table 4 indicates high construct reliability for the research variables Awareness, Individual Perceptions, and Orientation Changes in Business. The Cronbach's alpha values for all three constructs exceed 0.9, with Awareness at 0.913, Individual Perceptions at 0.916, and Orientation Changes in Business at 0.920, suggesting excellent internal consistency. Additionally, the composite reliability values (rho_a and rho_c) for each construct also surpass 0.9, further demonstrating strong reliability and consistency in the measurement model. The Average Variance Extracted (AVE) values are all above 0.5—Awareness at 0.593, Individual Perceptions at 0.522, and Orientation Changes in Business at 0.534—indicating that more than 50% of the variance in the indicators is explained by the constructs. This underscores good convergent validity, showing that the constructs are well-represented by their items. Overall, the high values across Cronbach's alpha, composite reliability, and AVE affirm that the constructs in the study are both reliable and valid measures of their respective concepts.

The data in Table 5 indicates the R-square and adjusted R-square values for the research variables Individual Perceptions and Orientation Changes in Business. For Individual Perceptions, the R-square value is 0.545, and the

Table 4. Construct Reliability of the Research Variables

The Variables	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Awareness	0.913	0.918	0.929	0.593
Individual Perceptions	0.916	0.920	0.929	0.522
Business Orientation	0.920	0.923	0.932	0.534

Table 5. R-Square of the Research Variables

Variables	R-square	R-square adjusted
Individual Perceptions	0.545	0.542
Orientation Business	0.471	0.468

Table 6. Path-Coefficient of the Research Variables

Variables Relationship	Original sample (O)	Sample mean (M)	Std. deviation (STDEV)	T statistics (|O/STDEV|)	P value
Awareness → Individual Perceptions	0.738	0.742	0.042	17.662	0.000
Individual Perceptions → Business Orientation	0.687	0.695	P.051	13.343	0.000

adjusted R-square value is 0.542. This implies that approximately 54.5% of the variance in Individual Perceptions can be explained by the independent variables in the model. The small difference between the R-square and adjusted R-square values suggests that the model has a good fit with a minimal number of predictors. For Business Orientation, the R-square value is 0.471, and the adjusted R-square value is 0.468. This means that around 47.1% of the variance in Orientation Changes in Business is explained by the independent variables in the model. Similarly, the close values of R-square and adjusted R-square indicate a reasonable model fit with a balanced number of predictors. Overall, the R-square values signify that the independent variables have a substantial influence on the dependent variables, Individual Perceptions and Orientation Changes in Business, explaining nearly half or more of the variance in these constructs.

The path coefficient values in Table 6 offer insights into the relationships between the research variables Awareness, Individual Perceptions, and Business Orientation. The path coefficient from Awareness to Individual Perceptions is 0.738, with a sample mean of 0.742 and a standard deviation of 0.042. The T-statistic is 17.662, and the P-value is 0.000. These results imply a strong, positive, and statistically significant relationship between Awareness and Individual Perceptions. The high T-statistic and low P-value indicate that this relationship is highly significant, suggesting that increases in Awareness are strongly associated with increases in Individual Perceptions. Similarly, the path coefficient from Individual Perceptions to Orientation Changes in Business is 0.687, with a sample mean of 0.695 and a standard deviation of 0.051. The T-statistic is 13.343, and the P-value is 0.000. These results also indicate a strong, positive, and statistically significant relationship between Individual Perceptions and Orientation Changes in Business. The high T-statistic and low P-value here further confirm the significance of this relationship, indicating that higher Individual Perceptions are strongly associated with more substantial Business Orientation.

Despite the finding that individual self-perception regarding climate change among SMEs in the study context is low, this awareness still acts as a predictor that can significantly impact self-perception creation. The results indicate that while the majority of the sample possesses considerable knowledge about climate change, as evidenced by their educational levels, their self-perception remains low. This discrepancy highlights a critical issue: knowledge alone does not necessarily translate into heightened self-perception or changes in business orientation.

One key finding is that despite good knowledge levels, there is a lower likelihood of SMEs shifting their business orientation towards more environmentally focused practices. The primary reason for this appears to be the prioritization of immediate income over long-term environmental considerations. For many SMEs in the study, income is crucial for meeting daily life expenses rather than for achieving financial growth or sustainability. This necessity drives SMEs to focus on survival and growth in a competitive market, often at the expense of integrating environmental concerns into their business operations.

This study suggests that the limited capacities and competencies of SMEs in the study context, similar to those in other developing regions, hinder their ability to keep pace with global business dynamics and environmental concerns. These enterprises face challenges such as limited access to capital, inadequate business infrastructure, a lack of qualified human resources, and insufficient information. Consequently, SMEs prioritize short-term operational survival over long-term environmental strategies.

Table 7. Differences between Small-Medium Scale Enterprises and Large Enterprises Dealing with Climate Change

No.	Concerns	Small-Medium Enterprises	Large Enterprises
1	Level of emissions	Low	High
2	Ability to measure GHGs (Greenhouse Gas Measurements)	Low	High
3	Compliance cost burden	Proportionately high	Proportionately low
4	Knowledge of, and to access to, relevant information	Limited, and ad-hoc	Sophisticated, and extensive
5	Access to technical experts and training capabilities	Limited	High
6	Financial capacity to fund climate initiatives	Typically small and limited	Substantial
7	Use of external carbon advisers	Limited, and ad-hoc	Systematic, and structured

Supporting findings of Schaper [24], this study confirms that the low level of awareness regarding climate change among SMEs is largely due to a perceived lack of relevance. SMEs often view climate change as a non-critical issue, resulting in minimal efforts to reduce emissions or adopt environmentally friendly practices. This perception is further compounded by the harsh competitive environment and resource constraints that SMEs face, making it difficult for them to implement proactive environmental measures.

Schaper [24] also highlights significant differences between SMEs and large enterprises in dealing with climate change effects (see Table 7). While large enterprises have sophisticated knowledge, extensive access to information, and substantial financial resources to tackle environmental challenges, SMEs typically operate with limited knowledge and resources. This disparity underscores the need for tailored strategies and policies to enhance climate change awareness and facilitate the adoption of sustainable practices among SMEs.

CONCLUSION

This study explicate a significant positive relationship between individual awareness of climate change and perceptions, which subsequently influences future business orientation changes among small-medium scale entrepreneurs (SMEs). Despite high educational levels, SMEs' knowledge about climate change does not necessarily lead to a positive self-perception or an environmentally friendly business orientation. The primary reasons for this include the necessity to prioritize immediate income, the inherent characteristics of SMEs, and a general ignorance regarding the importance of climate change. The study highlights the critical role of awareness as a predictor of self-perception, which in turn affects business orientation. However, the limited capabilities and resources of SMEs in the context of the study hinder their ability to adopt sustainable practices. This underscores the need for tailored interventions that address these limitations.

In the context of industrial engineering and systems optimization, the findings suggest that there is an urgent need to develop frameworks capable of optimizing SME operations in a way that integrates environmental sustainability without compromising financial stability. By creating such frameworks, SMEs can effectively balance the demands of economic viability and environmental responsibility. Moreover, the study emphasizes the importance of interdisciplinary approaches. By combining insights from environmental science, business management, and industrial engineering, it is possible to devise comprehensive strategies that SMEs can adopt to mitigate the impacts of climate change. This interdisciplinary collaboration can lead to more robust and effective solutions that address the multifaceted challenges faced by SMEs. Government policies also play a crucial role in this context. Effective interventions should include constructive law enforcement and supportive policies that facilitate the adoption of sustainable practices among SMEs. This could involve providing financial incentives, technical assistance, and educational programs to enhance awareness and capabilities. By supporting SMEs in this manner, governments can

help them transition towards more sustainable business practices, contributing to broader environmental goals and the optimization of industrial systems.

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CONFLICT OF INTEREST

The author declares that there are no conflicts of interest regarding the authorship or publication of this research.

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