Available online at : http://josi.ft.unand.ac.id/

Jurnal Optimasi Sistem Industri

| ISSN (Print) 2088-4842 | ISSN (Online) 2442-8795 |

Conceptual Paper

Digitalization and Sustainability Indicators for SMIs Resilience in Developing Economies: A Conceptual Model from Padang City of Indonesia

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DOI: 10.25077/josi.v24.n2.p367-391.2025 **Submitted:** February 12, 2025 **Accepted:** October 29, 2025 **Published:** December 30, 2025

ABSTRACT

The application of digital technology increases productivity, expands market reach, helps small and medium industries (SMIs) adapt to various changes, and provides a great contribution to sustainability. Sustainability emphasizes the importance of maintaining economic, environmental, and social balance in the long term, while resilience describes the ability of SMIs to confront and recover from various disruptions. However, the SMIs in Padang are less aware of the importance of implementing digitalization sustainably to achieve SMI resilience. Several indicators remain unmet by SMIs. This study aims to compile and validate digitalization and sustainability indicators appropriate to the context of local SMIs. These indicators were collected from various literature sources that include digital literacy, digital marketing, economic, environmental, and social sustainability, and resilience aspects. The validation process involved five experts from academia, government, and industry practitioners selected based on their expertise in the fields of the aforementioned aspects. Experts assessed the relevance and clarity of each indicator using the Likert scale, then the results were analyzed with the Aiken index and tested for reliability between assessors using SPSS to ensure consistency of assessments. The results of the study show that these indicators are aligned with the dimensions measured, particularly those that affirm the importance of digital literacy, digital marketing, and social aspects of sustainability in strengthening the resilience of SMIs. These validated indicators were then used to develop a conceptual model that can be a strategic reference for stakeholders and policymakers to increase the competitiveness, resilience, and sustainability of SMIs in Padang.

Keywords: digitalization, sustainability, resilience, small and medium industries (SMIs), indicator validation

INTRODUCTION

Digitalization has become a key driver for SMIs, increasing competitiveness, productivity and adaptability in dynamic markets. It covers a wide range of areas, including digital learning, strategy, processes and business [1]. By adopting digital technologies, SMIs can optimise their operations, increase the efficiency of their resources and simplify their workflows. In addition, digitalization enables companies to design and deliver innovative products and services, enhancing the competitiveness of the market [2]. Evidence shows that digital adoption increases market reach, efficiency and profitability through processes such as digital business processes, e-commerce marketing and e-commerce platforms [3]. In Padang, where SMIs make a significant contribution to the regional economy, digitalization is essential not only for productivity but also for resilience and sustainability in the face of the changing challenges.

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Digital technologies also promote long-term environmental sustainability in manufacturing. Industry 4.0 uses advances in information and communication technologies and data storage to monitor energy consumption in real time, enabling optimization and energy savings [4]. Companies with deeper digital integration report a reduction in carbon emissions of up to 35.1% per production unit compared with companies without digitalization [5]. These findings highlight that digitalization increases efficiency while at the same time promoting resource conservation and in line with global sustainability objectives.

In addition to the environmental benefits, digitalization brings significant economic benefits to SMIs. It reduces operating costs, increases productivity and reinforces competitiveness [5]. Effective procedures and faster decision-making improve the quality of products, strengthen economic resilience and promote regional growth [3]. However, challenges remain, which require careful assessment to ensure that digitalization does not create new risks to economic and environmental sustainability [4], [5].

The main obstacles are the limited digital skills of workers and limited access to infrastructure [6], [7]. This problem is exacerbated by low digital literacy in education, with only half of the workforce having basic skills and less than 1% having advanced skills [7]. The gap between the needs of industry and the skills of graduates, combined with funding constraints and lack of qualified staff, is limiting innovation, especially among Padang SMIs [7]. Surveys show that the food industry is the leader in digital adoption, using platforms such as WhatsApp and Instagram to market itself, while traditional sectors such as textiles and handicrafts (songket) rely on direct sales because of a lack of literacy and infrastructure. Songket artisans face difficulties in integrating with e-commerce, with a lack of digital catalogues, brand strategies and familiarity with online payment systems. Sustainability practices also vary: some food businesses use recyclable packaging, while the furniture and textile sectors are lagging behind due to lack of awareness, limited guidelines and financial constraints. The findings from 2024 show uneven progress in digitalization and sustainability and highlight the need for targeted support to specific sectors.

From 2018 to 2022, the manufacturing sector accounted for the top five contribution to GDP in Padang, underlining the role of SMIs as a catalyst for regional economic growth [8]. Ensuring their resilience is essential to maintain this contribution and to allow them to adapt and to remain resilient to economic and environmental pressures. However, many SMIs still face capital, technology and knowledge challenges [6]. The COVID-19 pandemic has accelerated digitalization in Indonesia and its benefits for SMIs - such as increased resilience and operational continuity - are becoming increasingly clear. Digital transformation is therefore crucial to enable Padang's SMIs to recover from past disruption and remain competitive in the fast-changing business environment.

Under the Decree of the Minister of Industry of Indonesia No.64 For 2016, SMIs are classified on the basis of investment value and workforce size, except for real estate and buildings. Small industries employ 19 workers with investment of up to 1 billion rupiah, while medium-sized industries employ 20 to 99 workers with investment of up to 15 billion rupiah [9]. This study focuses on SMIs, which face particular challenges in maintaining their resilience within these parameters.

Recent data show a decrease in the resilience of SMIs in Padang on three financial indicators. First, their contribution to the GDP of Padang has decreased from 11.77% in 2021 to 11.26% in 2022. Second, the GDP growth of SMIs has slowed down from 1.06% to 0.66% over the same period. Thirdly, total revenues of micro and small enterprises fell by 12.3% [8]. Interestingly, the number of SMIs in 2022 increased by 12.8% compared to 2021, suggesting a recovery in terms of number of enterprises, but revealing a disconnect between the growth in numbers and the resilience of the economy.

In 2022, there were 2,336 SMIs in Padang. However, a 2020 survey by the Central Statistics Agency (BPS) found that only 17.78% of these businesses used the internet. Internet use is a key indicator of digitalization in the economy

 DOI: 10.25077/josi.v24.n2.p367-391.2025

[10] and the ability to use digital tools is now a key competitiveness factor. A significant digital divide remains, which limits access to e-commerce, online platforms and data-driven technologies, owing to low internet penetration, insufficient infrastructure, high technology costs and limited awareness of the benefits of digitalization [11]. To address these gaps, targeted measures such as improving network quality, subsidizing digital devices, and providing digital skills training are necessary to ensure an inclusive digital transformation for SMIs.

Recognising these challenges, the Government is continuing to support technology transfer and digital access expansion to help SMIs adapt and remain competitive [12]. Initiatives such as "IKM Go Digital" program provide training in digital marketing, support for the adoption of e-commerce and help with the development of websites and e-commerce shops. In addition, the integration of smart city principles into local policies through digital literacy programmes and cluster development will ensure that SMIs have the capacity to grow in a digitally connected and sustainable economic ecosystem.

Despite these efforts, a preliminary study indicates that most SMIs in Padang have yet to fully embrace sustainable digitalization in business management. Several indicators remain unmet in both digitalization and sustainability dimensions, which are critical for achieving resilience. Although Padang's internet usage rate is higher than other districts in West Sumatra, resource limitations and unfavorable perceptions among business actors hinder progress toward sustainable digitalization and resilience.

Previous studies have provided valuable insights on digitalization and sustainability, but their relevance for the SMIs in Padang remains limited. For instance, Denicolai et al. [14] examined digitalization indicators and sustainability in Italian SMIs, focusing on the footwear sector, which is structurally different from the Padua context. Similarly, Brenner and Hartl [15] analysed the impact of digitalization on sustainability in economic, social and environmental dimensions, without taking a regional approach. Gao et al. [16] examined how e-commerce and digital platforms affect the performance of the Bangladeshi SMI, while Khalil et al. [17] highlighted the role of digital technologies in enhancing resilience in several developing countries during the crisis. These international studies confirm that digitalization promotes sustainability and resilience, particularly in challenging times, but lack a contextualization for SMIs in Padang.

Regional studies offer a closer look at the context in Indonesia. Bidasari et al. [18] found that digital literacy improves the performance of the MSEs in Northern Luwu, while Isnaeny and Susilowati [19] found no direct link between digital literacy and the sustainability of the business sector in Purbalingga, indicating that digitalization requires strategic integration and environmental support. Muafi et al. [20] has shown that digital entrepreneurship increases sustainable performance when mediated by factors such as job satisfaction, which highlights the need for a wider framework. Similarly, Jaish et al. [21] highlighted internal readiness as a key determinant for successful digitalization, reflecting the challenges facing Indonesian SMIs.

Despite these contributions, gaps remain in integrating resilience into the digitalization-sustainability nexus. Khalil et al. [17] addressed resilience at macro level, but failed to explain how digitalization promotes micro resilience in developing countries. Indonesian studies often treat digitalization and sustainability as separate issues, neglecting resilience as a link in time of uncertainty and disruption. This study addresses these gaps by (1) placing resilience as a result and a structural element of the process and (2) by placing these links in the operational reality of SMIs in regions undergoing digital transformation, such as Padang.

Existing models have explored the links between digitalization, sustainability and resilience, but rarely as an integrated system, especially in the case of SMIs in Padang. For example, Khalil et al. [17] focused on resilience during the pandemic without covering sustainability, while Robertson et al. [22] studies on digitally advanced SMIs have been conducted without considering the role of sustainability. Conversely, Ahmić [23] analyzed the strategic

orientation for sustainability and resilience, but excluded digitalization and did not adapt to the specific challenges of SMI. Moreover, many proposed indicators for digitalization and sustainability are overly complex and impractical for SMIs in Indonesia. As a result, manufacturing activities often do not comply with these principles, as companies struggle to use indicators that do not reflect their needs or conditions [24]. This emphasizes the need for simpler, relevant and easy to use indicators, adapted to the characteristics and challenges of SMIs in Padang.

These limitations underscore the need for a model that effectively integrates digitalization, sustainability, and resilience for SMIs in Padang. While indicators for these concepts have been widely discussed, a significant gap remains because no study has developed an integrated conceptual model assessing their combined influence. Moreover, existing research largely targets large enterprises and overlooks the unique conditions and challenges faced by SMIs in Padang. To address this gap, a locally adapted approach is essential.

The aim of this study is to identify digitalization and sustainability indicators that will increase the resilience of Padang's SMIs. It also aims to develop and validate a conceptual model that links these indicators to assess and strengthen the resilience of local SMIs. The proposed model will provide a framework to explain the link between digitalization, sustainability and resilience, thus promoting the adaptability and long-term competitiveness of Padang's SMIs.

METHODS

Phase 1: Determining the relevant indicators

The first phase of the study involved collecting and adapting digitalization, sustainability and resilience indicators from various academic publications. This involved the removal of indicators which are not relevant to the research objectives. Tan (2025) argues that the indicators chosen must meet three basic requirements: be easy to understand, meaning that they can be understood by non-specialists; be applicable, meaning that meaning they align with and reflect issues faced by SMIs within the local context; and be relevant, meaning that they actually support continuous improvement initiatives.

The following are the criteria in the selection of indicators:

1. Indicators are adapted from scientific articles from various academic sources such as ScienceDirect, Emerald, Taylor & Francis Group, ResearchGate, and other scientific journals
2. To remain in line with the research objectives, the year of publication of the adapted article is limited to a maximum of 10 years
3. The selection of indicators is adjusted to the scale of the SMI business in Padang
4. The selected indicators are also in line with the criteria used in the West Sumatra BPS report on the profile of SMIs in Padang in 2020–2023.
5. Indicators that have similar meanings or definitions are combined into one to make them clearer and not overlap

The complete process of determining the indicator is shown in Figure 1.

The next stage is indicator validation, carried out by five experts using an indicator validation questionnaire. Hendriyadi [26] states that the minimum number of experts recommended in research is three. In line with Puspitasari and Febrinita [27] who also emphasize that the minimum number of experts is 3 people and not to exceed 10 people. Experts are people who have knowledge and expertise that is relevant to the research topic. The expert validation process is carried out by visiting the expert directly, explaining the procedure for filling out the questionnaire. At this stage, each expert received a printed version of the questionnaire and completed it manually during the meeting. They were asked to rate each indicator solely based on its perceived importance. The

 DOI: 10.25077/josi.v24.n2.p367-391.2025

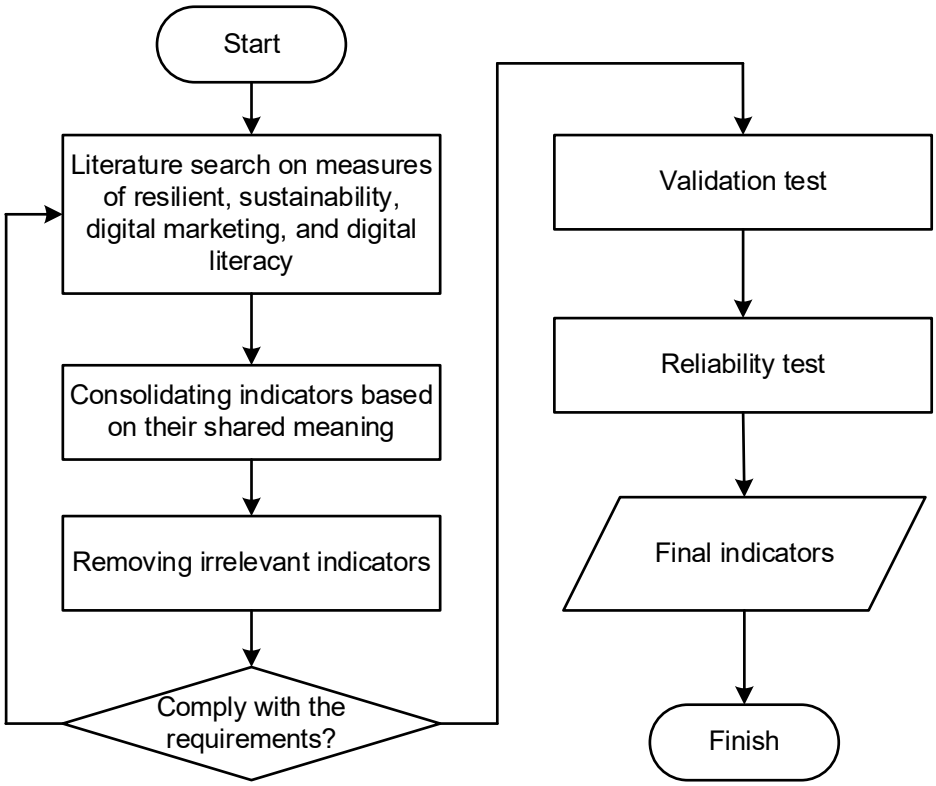

Figure 1. Steps in determining the relevant indicators

questionnaire did not provide for the addition of new items or qualitative feedback, thereby focusing exclusively on evaluating the existing indicators.

Experts assessed the importance of each indicator using a five-point Likert scale, where 1 indicated "very unimportant" and 5 indicated "very important." A total of five experts participated, representing government, academia, and industry. Selection criteria included holding a relevant position—such as lecturer for academia, manager or business owner for practitioners, and analyst or expert staff for government—along with a minimum of five years of work experience and expertise aligned with the research topic.

The selection of experts was conducted purposively to ensure alignment with the research focus on digitalization, sustainability, and resilience. The panel comprised representatives from academia, government, and industry to provide a comprehensive perspective in validating the proposed indicators. Academic experts were chosen based on their relevant expertise and experience in fields related to the research topic. Government experts were selected for their roles in managing and promoting industrial development at the regional level, bringing extensive experience in supervising small and medium industries (SMIs). Industry representation came from SMI owners with several years of operational experience, ensuring that the validated indicators reflect both theoretical and policy considerations as well as practical realities faced by businesses in the field.

The objective of this process is to integrate assessments from experts representing academia, government, and industry to ensure that the validation reflects diverse perspectives relevant to model development. Academic insights, policy considerations from government, and practical viewpoints from industry practitioners are expected to produce indicators that align with the current needs, challenges, and opportunities of small and medium industries (SMIs). To determine whether an indicator should be retained or removed based on its perceived importance, content validity was assessed using Aiken's formula (1985), which calculates the degree to which an item represents the intended construct according to expert judgment. When n experts rate an item on a scale (r) from 1

(very unimportant) to 5 (very important), with the highest value (c) = 5 and the lowest value (l) = 1, the Aiken index is applied as follows [28]:

$$V = \frac{\sum_{i=1}^{n} S}{n(c-1)} \quad (1)$$

$$S = r - I_0 \quad (2)$$

where

V : Aiken indeks
S : the number given by the expert minus the lowest score in the category
r : the number of judgements given by the expert
I_0 : lowest validity assessment number
c : highest validity assessment number
n : number of experts

The classification of Aiken validity values (V) is shown in Table 2. The value of V is in the range of 0 to 1 and indicates how strong the validity of the content of each indicator is. Although the table provides its interpretation categories, Suseno [29] adds the explanation that a certain threshold is required to determine whether an indicator is worth using. According to Suseno [29] an indicator is considered valid if it has a V value of at least 0.50. This limit is used so that only indicators that get an adequate level of expert agreement are maintained for the next stage of analysis.

The use of the Aiken Index in this study is supported by several advantages. First, this index provides an easy-to-understand numerical value so that researchers can see how strong the validity of each item is. Second, this method is quite flexible because it can be used in quantitative and qualitative research, and is suitable for various types of items and instruments. Third, the assessment is carried out by several experts who have competence in their fields, so that the results are more reliable. In addition, the Aiken Index helps researchers find items that have low validity so that they can be corrected or removed from the instrument. Thus, the final instrument becomes more powerful and accurate in describing the construct to be measured [30].The Aiken validity classification can be seen in the Table 1 [28].

To ensure that the experts' assessments are consistent, a reliability test was carried out between assessors using SPSS version 26.0. Inter-evaluator reliability (IRR) indicates how consistent the assessment is given by two or more evaluators, and is an important part of the validity of the instrument. The results of the reliability test in SPSS are usually seen through Cronbach's alpha value, which is in the range of 0 to 1.00. Closer to 1.00 means the higher the level of agreement between the raters, while a value closer to 0 indicates low agreement. Cronbach's alpha values between 0.41–0.60 indicate moderate reliability. The instrument is considered fairly stable if the value is above 0.50, and very stable if the value is more than 0.80 [31].

Table 1. Aiken Criteria Validity [28]

Validation Results	**Criteria**
$0.81 \leq V \leq 1.00$	Very High
$0.61 \leq V < 0.80$	High
$0.41 \leq V < 0.60$	Fair
$0.21 \leq V < 0.40$	Low
$0.00 \leq V < 0.20$	Very Low

 DOI: 10.25077/josi.v24.n2.p367-391.2025

The digitalization indicator includes 16 items, consisting of eight digital literacy indicators and eight digital marketing indicators. Meanwhile, sustainability indicators amount to 27 items and are divided into three main dimensions: seven economic indicators, eleven environmental indicators, and nine social indicators. This division refers to the Triple Bottom Line (TBL) framework introduced by Elkington in 1997, which views sustainability as a combination of economic, environmental, and social aspects [32]. Each indicator is placed according to the most relevant dimensions, following previous research as well as international sustainability assessment standards, including guidance from the United Nations Sustainable Development Goals (SDGs). The grouping process is carried out based on literature review and expert input to ensure that each indicator truly reflects the dimensions in question. In addition, there are four indicators related to resilience. In total, 47 initial indicators were successfully identified. Through the V Aiken index method, indicators that do not meet the validity limits as described in Table 2 will be eliminated. Thus, the indicators used in this research instrument are indicators that have been validated and considered appropriate to describe the variables of digital literacy, digital marketing, sustainability, and resilience in the context of SMIs.

Phase 2: Design the Model

The conceptual model shows the relationship between the variables that have been determined at the previous stage. The preparation refers to the discussion of theories and correlation results from various previous studies published in scientific journals. In the process, model design is carried out through three steps: compiling an internal model (structural model), an external model (measurement model), and drawing the entire path diagram.

Structural Model Design (Inner Model)

Inner models are designed to describe predictive or explanatory relationships between latent variables, i.e. variables that cannot be directly measured [33]. In this study, the latent variables used include resilience, sustainability, economy, environment, social, digital literacy, and digital marketing. Based on literature reviews, digital literacy and digital marketing have an effect on resilience, as well as also affect sustainability. Additionally, studies have shown that the sustainability variable affects the resilience variable. Consequently, the exogenous latent variables in this study are digital literacy, digital marketing, and sustainability. Endogenous latent variables, on the other hand, are variables influenced by exogenous variables. In this study, the latent variable for sustainability is multidimensional, as it is categorized into three dimensions: economic, social, and environmental. Therefore, the endogenous latent variables in this study consist of the economic, social, and environmental dimensions, as well as the resilience variable.

Measurement Model Design

The measurement model (outer model) is designed to demonstrate how each manifest variable, also referred to as an indicator, is associated with its respective latent variable (construct). Manifest variables (indicators) serve to explain the latent variables [33]. In this study, the latent variables for resilience, digital marketing, and digital literacy are unidimensional, so each construct is formed directly by its indicators. Meanwhile, the sustainability variable has a multidimensional.

Path Diagram Design

The path diagram is compiled to illustrate the overall relationship between the inner model and outer model. The model forms the Hierarchical Component Model (HCM), which is multidimensional because there are latent variables with several interconnected dimensions.

RESULT AND DISCUSSION

Selection of suitable indicators

There have been many Indicator frameworks that previous research has produced, but most of them are difficult to apply to small and medium-sized industries. Therefore, Therefore, SMIs urgently need a simple but still relevant and comprehensive framework [25]. Indicators in the context of local businesses make it easier for business actors to adopt them in encouraging efforts to implement digitalization, sustainability and resilience. Therefore, it is necessary to design indicators that are easy to apply by SMIs in Padang.

This study identifies 16 digitalization indicators which are divided into two aspects, namely digital literacy and digital marketing indicators. Each aspect consists of eight indicators (Table 2). According to Robertson et al. [22] businesses that implement digital marketing effectively and business actors who have good digital literacy can adapt and be more responsible in dealing with market changes. Implementing the right digital marketing strategy can help businesses face innovation and survive in the midst of increasingly rapid digital growth. Digital literacy includes the ability of business actors to understand and use information sourced from the internet, as well as in computer-based use. These skills consist of cognitive, emotional and social aspects in a digital environment. Digital literacy consists of five main competencies, namely information literacy, digital content creation, collaboration and interaction, security, and problem-solving skills [34].

Online communication with customers is one of the important factors that strengthen the resilience of SMIs in Padang. Where business people can still communicate with customers, can respond to market changes and ensure that businesses continue to run with the use of digital platforms. Interactions with customers can also continue even

Table 2. Identification of Digital Literacy Indicators

No	Digitalization Aspect	No	Indicator	Reference
1	Digital Literacy	1	Information processing: search	[34], [37]
		2	Data collection	[38], [37], [34],
		3	Data evaluation	[38], [37], [34],
		4	Interaction through digital technology	[39], [37], [34],
		5	Digital technology-based cooperation	[39], [37], [36],
		6	Digital content creation	[34], [37]
		7	Data security	[34], [37]
		8	Technical problem-solving skills	[38], [34], [37]
2	Digital Marketing	1	Online promotions	[40], [41]
		2	Social media aptitude	[42], [43], [41]
		3	Website proprietorship	[41], [43],
		4	Product search ease	[44], [40].
		5	Online correspondence with clients	[43] [42]
		6	Quality of information	[44], [43], [42]
		7	Enhanced customer support	[45], [46]
		8	Internet-based sales	[42], [44]
	Total	**16**	**Indicators**	

 DOI: 10.25077/josi.v24.n2.p367-391.2025

in the midst of uncertain situations in order to build trust and loyalty with customers. SMEs can still get to make sales online, read changes in customer needs, and develop products that are more suitable in the middle. Therefore, maintained communication with customers that can create trust and familiarity in the eyes of customers is one of the long-term successes for business actors [35].

In this study, digital marketing is understood as the ability of businesses to use digital tools and technology through digital platforms in order to continue to exchange information with business partners. This activity also includes online marketing on social media, data analysis, e-commerce, digital content creation, to search engine optimization (SEO). Thus, business people can produce content that is in accordance with the target market, build interaction with customers on social media, increase visibility on search engines, and facilitate transactions with customers in the buying and selling process [36].

The sustainability indicators in this study include 7 economic indicators, 11 environmental indicators, and 9 social indicators compiled based on various scientific journal sources. Some indicators were then eliminated because they were considered inconsistent with the real conditions of SMIs in Padang. This screening stage is carried out so that the indicators used are really relevant and reflect the characteristics and needs of the local industry.

1) Renewable energy use
   In Padang, SMIs generally use a smaller amount of energy than large industries or commercial companies. Consequently, investing in renewable energy technology may yield substantially less potential cost savings or advantages, thereby decreasing the attractiveness of the return on investment.
2) Research & Development expenditure
   Funding for R&D projects must compete with other urgent demands, such as ongoing operations, business growth, or marketing initiatives. As a result, Padang SMIs can place a higher priority on short-term financial stability than on long-term R&D expenditures.
3) Recycled water use
   The concept of recycled water and its potential application in their particular business or operations could be foreign to SMIs in Padang.
4) Sustainability awards
   SMIs in Padang are not well-informed about sustainability activities and prizes due to gaps in knowledge or resource limitations.
5) Sustainability reports p`ublishing
   The external demand on SMIs in Padang to disclose their environmental, social, and governance (ESG) performance is not as significant. Sustainability report release is not seen as valuable by SMIs unless there is a demonstrable demand or incentive from stakeholders.

Total sustainability indicators for the three aspects are 27 indicators (Table 3). The improvement targets for achieving sustainability, as outlined in Table 10, are adapted based on the study conducted by Tan et al. [25], an upward arrow (↓) signifies that a higher value for the indicator is desirable as it reflects an improvement in performance or sustainability outcomes. On the other hand, the down arrow indicates that the lower the indicator value, the better the performance achieved. This is because the value of the indicator is related to costs, negative impacts, or reduced resource use. Operational costs, consumption of energy sources, and emissions are components that must be reduced. Reductions in this indicator can not only reduce the cost aspect but can also reduce the impact on the environment. Meanwhile, product quality, profitability, energy efficiency and wage provision are components that must be improved to encourage economic, environmental and social progress. This approach aims to define clear priorities to achieve the sustainability and resilience of SMIs.

Table 3. Identification of Sustainability Indicators

No.	Sustainability Aspect	No	Indicator	References
1	Economy	1	Profit	[47], [25], [48], [49]
		2	Sales growth	[47], [48], [49]
		3	Material cost	[47], [49], [25]
		4	Labor cost	[47], [49], [50]
		5	Energy cost	[47], [25]
		6	Inventory cost	[47], [49], [25]
		7	Product quality	[47], [49]
2	Environment	1	Water consumption	[47], [49], [25]
		2	Energy consumption	[47], [25], [48], [49]
		3	Energy efficiency	[47], [25], [48], [49]
		4	Energy intensity	[47], [25], [48], [49]
		5	Material Consumption	[47], [49], [25]
		6	Recycled material use	[47], [25]
		7	Packaging material consumption	[47], [49], [25]
		8	Greenhouse gasses emissions	[47], [49], [25]
		9	Waste water discharge	[47], [25]
		10	Solid waste disposal	[47], [25], [48], [49]
		11	Recyclable waste	[47], [25]
3	Social	1	Fair salary	[47], [51], [49]
		2	Employee turnover	[47], [51], [25], [48], [49]
		3	Employee satisfaction	[47], [49]
		4	Occupational health and safety	[47], [51], [25], [48], [49]
		5	Employee training and development	[47], [51], [25], [48], [49]
		6	Lost productive days	[47], [25]
		7	Safety and health of customers	[47], [25], [49]
		8	Customer satisfaction	[47], [49], [25],
		9	Corruption	[47], [48]

Table 4 contains four indicators of resilience. In this study, the concept of resilience is not only seen from managerial aspects such as perception, integration, coordination, reorganization, or recovery. On the other hand, resilience indicators are compiled based on measurable aspects and in accordance with the real conditions faced by SMIs. The indicator is adapted from previous research that discussed the influence of digitalization on resilience, emphasizing both the financial and non-financial aspects of a business's ability to survive.

Table 4. Identification of Resilience Indicators

No	Variable	No	Indicator	References
1	Resilience	1	Sales	[52], [53], [54], [55], [36]
		2	Profit	[56], [54], [55]
		3	Customer Satisfaction	[57], [54], [58], [59], [60]
		4	Delivery Lead time	[58], [57], [59]

 DOI: 10.25077/josi.v24.n2.p367-391.2025

Validity and Reliability of the Indicators

The next step, after all indicators have been determined, is the validation process. The experts were selected based on their diverse expertise and substantial professional experience. They include senior academics, such as a professor in industrial engineering with 25 years of experience and a department head in informatics engineering with 9 years of experience, ensuring strong theoretical and technical perspectives. From the government sector, two officials from the local industry and labor department contributed practical insights on policy and industrial development—one serving as head of the industrial sector with 20 years of experience and another as an expert functional staff member with 17 years of experience. Additionally, an industry practitioner, the owner of a food and beverage enterprise with 8 years of experience, provided real-world viewpoints on operational challenges and indicator applicability. This combination of academic, governmental, and industrial expertise ensures a comprehensive and contextually relevant validation process for SMIs in Padang.

Each of the indicators is assessed by the experts as to whether they are all worth using at a later stage of the research. Based on the minimum validity limit established by Suseno[29], indicators with a low validity score will be immediately excluded from the model. In this regard, only those indicators that get adequate levels of agreement among experts retain their positions, while less approved ones are eliminated for relevance and reliability.

From the results in Appendix A.1 and A.2, we can observe the overall validity assessments for indicators of digitalization, resilience, and sustainability based on Aiken's index. Most indicators across the three variables (digital literacy, digital marketing, and resilience) scored very high (Aiken's $V \geq 0.8$), indicating strong expert consensus about their relevance. These include indicators such as data collection, data evaluation, and data security under digital literacy. Online advertising, social media capability, and information quality under digital marketing. Sales, profit, and customer satisfaction under resilience. Meanwhile for sustainable indicators, profit, sales growth, and product quality under the economy aspect. Fair salary, employee satisfaction, and customer satisfaction under the social aspect.

Some indicators received slightly lower scores (Aiken's $V \geq 0.6$), such as interaction through digital technology and technical problem-solving skills under digital literacy. Website ownership under digital marketing. Some indicators within the economy and environment aspects, such as material cost and energy efficiency, scored in the range of 0.61 to less than 0.80. These indicators are valid but less robustly supported than the very high category. These scores suggest they are still valid but may require further refinement or additional context for stronger validation. However, several sustainability indicators, particularly in the environmental dimension such as water consumption, wastewater discharge, solid waste disposal, and recyclable waste fell into the "fair" category, with Aiken's V index values ranging from 0.4 to less than 0.6. However, according to Suseno [29], A system is considered valid when it achieves an Aiken's V value of 0.5 or higher. Indicators with values below 0.5 are therefore deemed invalid and excluded from the model. Consequently, the indicators for recyclable waste and water consumption, both of which had Aiken's V values of 0.45, were removed.

There are several possible reasons why these indicators received relatively low Aiken's V scores. The water consumption is considered very unimportant to be reduced by considering the unlimited water resources in Padang. In addition, according to experts from business actors, the level of pollution caused by water consumption by SMIs in Padang is considered quite low. This can be seen from the percentage of SMIs that use water as the main raw material in making products is less than SMIs that do not use water. While the waste recycling indicator is considered less important because the average SMIs in Padang does not recycle waste from their operational activities. For instance, to calculate the V value for the waste recycling indicator, the process begins with determining the S value

Table 6. Comparison of total indicators before and after validation

No	Variable	Before Validation	After Validation
1	Digital Literacy	8	8
2	Digital Marketing	8	8
3	Resilience	4	4
4	Economy	7	7
5	Environment	11	9
6	Social	9	9
	Total	47	45

for each expert. The S value is derived using the formula (2) where r represents the rank assigned by an expert and I_0 is the ideal rank. For the first expert, the assigned rank (r) is 1, and the ideal rank (I_0) is also 1. This results in $S_1 = r - I_0 = 1\text{-}1 = 0$, clearly indicating the final value as 0. For the second expert, the rank is $r = 3$ while the ideal rank remains I_0=1, giving $S_2 = r - I_0 = 3\text{-}1 = 2$. Repeat the same steps to calculate the values of S_3, S_4, and S_5, resulting in values of 4, 2, and 1, respectively. Next, the total S value is then calculated as the sum of all S values. From the summation results, the total S value is obtained as 9. Finally, the V value is computed using the formula (1). n is the number of experts (5 in this case) and c is the maximum rank assigned by any expert (5 in this case). Thus, the calculated V value for the waste recycling indicator is 0.45. The final results to determine whether the indicator is valid or not can be seen in the last column.

Following the validation of 45 indicators in Table 6, an inter-rater reliability analysis was conducted to assess the consistency of evaluations provided by five experts. This analysis was performed using SPSS version 26.0. The results of the inter-rater reliability test are presented based on the Cronbach's Alpha coefficient. Based on the inter-rater reliability test using SPSS software version 26.0, a Cronbach's Alpha coefficient value of 0.599 was obtained, as shown in Figure 3. This value is in the medium category for reliability levels involving five experts. Thus, it can be concluded that the 45 indicators that have been tested not only meet the criteria of validity but also have good reliability among experts. So that this model can be used for the development of instruments at the next stage of research.

Digitalization and sustainability indicators for small and medium industries

A total of 45 indicators were identified, consisting of eight indicators for digital literacy, eight for digital marketing, four for resilience, seven for economic aspects, nine for social aspects, and nine for environmental aspects. Each indicator is specified in detail through several additional elements. These elements are assigned an identification (ID) number, along with the name of the aspect, factor, and indicator, as well as an improvement target, as presented in Table 7, 8, and 9, respectively. The improvement targets serve as general guidelines for using the indicators by either increasing (↑) or decreasing (↓) their values.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.599	.584	5

Figure 3. Inter-Rater Reliability

 DOI: 10.25077/josi.v24.n2.p367-391.2025

Table 7. Improvement Target of Digital Literacy dan Digital Marketing Indicators

No	Digitalization Aspect	Code	Indicator	Improvement Target
1	Digital Literacy	LD1	Information processing : search	↑
		LD2	Data Collection	↑
		LD3	Data Evaluation	↑
		LD4	Interaction through digital technology	↑
		LD5	Collaboration through digital technology	↑
		LD6	Digital content creation	↑
		LD7	Data security	↑
		LD8	Technical problem-solving skills	↑
2	Digital Marketing	PD1	Online advertising	↑
		PD2	Social media capability	↑
		PD3	Website ownership	↑
		PD4	Ease of product search	↑
		PD5	Online communication with customer	↑
		PD6	Information quality	↑
		PD7	Improved customer service	↑
		PD8	Online sales	↑

Table 8. Improvement Target of Sustainability Indicators

No	Sustainability Aspect	Code	Indicator	Improvement Target
1	Economy	EK1	Profit	↑
		EK2	Sales growth	↑
		EK3	Material Cost	↓
		EK4	Labor cost	↓
		EK5	Energy Cost	↓
		EK6	Inventory Cost	↓
		EK7	Product Quality	↑
2	Environment	LI1	Energy consumption	↓
		LI2	Energy efficiency	↑
		LI3	Energy intensity	↓
		LI4	Material Consumption	↓
		LI5	Recycled material use	↑
		LI6	Packaging material consumption	↓
		LI7	Greenhouse gasses emissions	↓
		LI8	Wastewater discharge	↓
		LI9	Solid waste disposal	↓
3	Social	SO1	Fair salary	↑
		SO2	Employee turnover	↓
		SO3	Employee satisfaction	↑
		SO4	Occupational health and safety	↑
		SO5	Employee training and development	↑
		SO6	Lost working days	↓
		SO7	Customer health and safety	↑
		SO8	Customer satisfaction	↑
		SO9	Corruption	↓

Table 9. Improvement Target of Resilience Indicators

No	Variable	Code	Indicator	Improvement Target
1	Resilience	KE1	Sales	↑
		KE2	Profit	↑
		KE3	Customer Satisfaction	↑
		KE4	Delivery Lead time	↑

Conceptual model of the digitalisation and sustainability effect to the resilience of SMIs

The validated indicators of digital literacy, digital marketing, and sustainability are utilized to develop a conceptual model that examines the impact of digitalization and sustainability on the resilience of small and medium industries (SMIs) in Padang. The development of the conceptual model follows three key steps, as outlined below:

Structural Model (Inner Model)

The direction of the arrows between endogenous and exogenous latent variables in this structural model is determined based on findings from previous research, as shown in Appendix A.3. Resilience and sustainability serve as endogenous latent variables as they are influenced by the variables of digital marketing and digital literacy. The exogenous latent variables in this study are digital literacy and digital marketing, as they affect both resilience and sustainability variables. Furthermore, sustainability also acts as an exogenous latent variable due to the reflective directional arrows pointing toward the economic, social, and environmental variables. The structural model in this study can be seen in Figure 4.

Measurement Model (Outer Model) and Path Diagram

The indicators for each latent variable in this study are reflective in nature. According to Ghozali [33] the development of constructs in various studies generally recommends the use of reflective constructs. Reflective

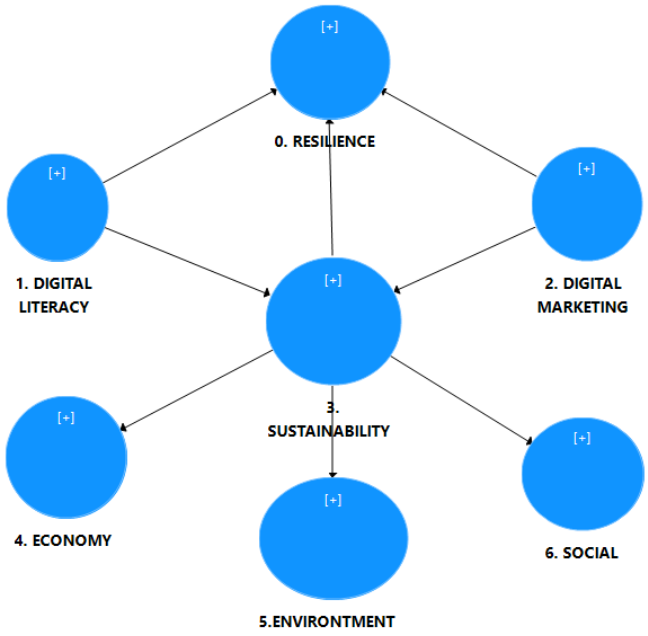

Figure 4. Structural Model

 DOI: 10.25077/josi.v24.n2.p367-391.2025

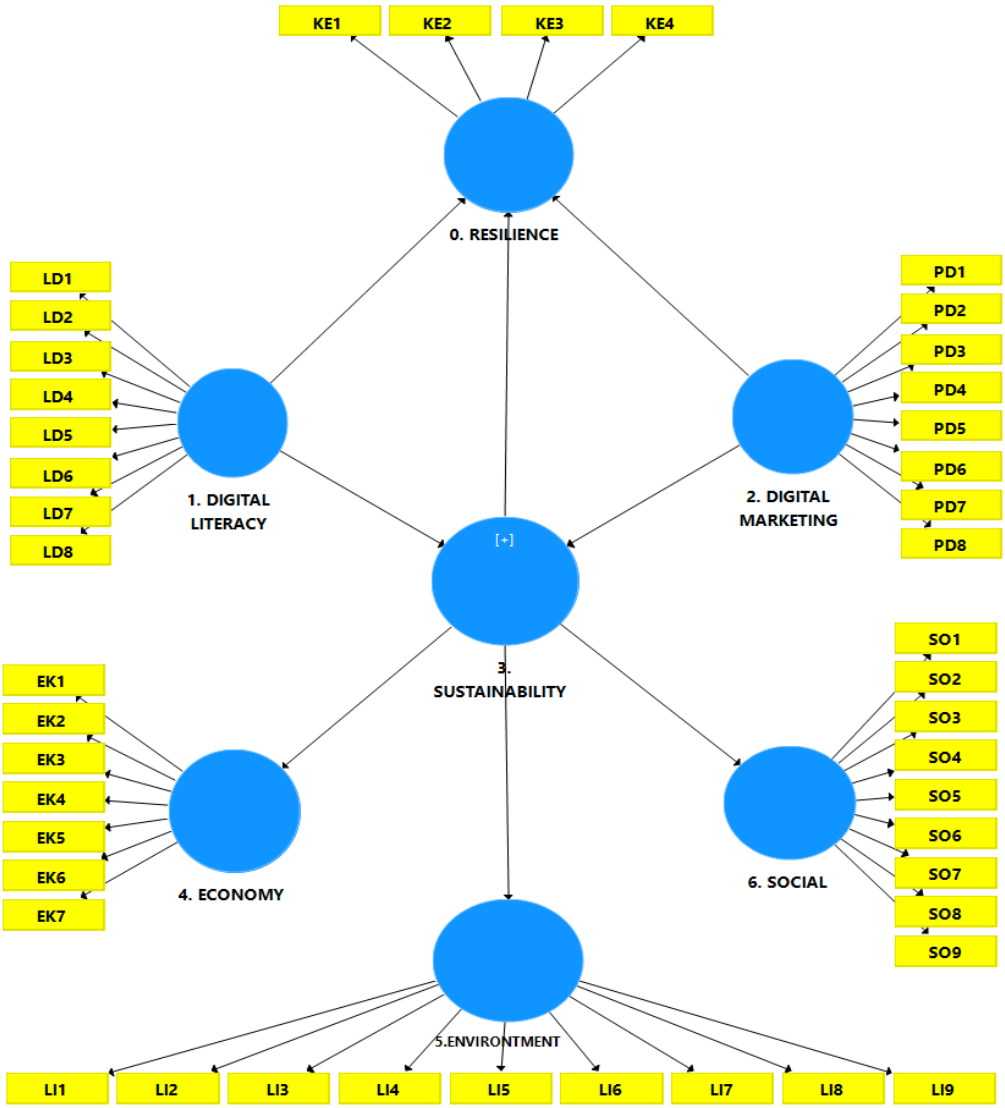

Figure 5. Conceptual Model of the Impact of Sustainability and Digitalization on Resilience

indicators are defined by the following criteria: a change in one indicator does not cause a change in the construct (latent variable), the removal of one indicator does not alter the meaning of the construct, and changes in one indicator are not correlated with changes in other indicators.

The final stage is the design of a path diagram to visualize the relationship between the inner model and outer model paths as a whole. This model will form a multidimensional hierarchical component model (HCM) because there are latent variables that have more than one interrelated dimension. Figure 5 shows the designed path diagram of the relationship between digital literacy, digital marketing, sustainability, and resilience. Latent variables consisting of digital literacy and digital marketing are directly represented by their indicators. Meanwhile, the latent variable of sustainability is constructed by three dimensions of sustainability, namely the economic dimension, the social dimension, and the environmental dimension.

Although the model designed in this study is a structural foundation, it is still necessary to evaluate the model empirically. For the next stage, the researcher needs to use quantitative methods such as Structural Equation Modeling or Partial Least Squares using survey data collected directly from SMIs in Padang. So that the researcher can assess the validity of the model and test the predictive relationship between each construct variable in the model.

In addition, by evaluating the model using SEM or PLS, the researcher can also test the analysis of paths between latent variables in the model based on the value of the resulting path coefficient. So that researchers can find out which aspects have the most significant influence on the resilience of SMIs. Is it the digitalization aspect that has the greatest impact, or is it the application of sustainability aspects in achieving the resilience of SMIs.

Furthermore, although this model has a framework that can be an instrument in evaluating the current performance of SMIs. However, with empirical testing, the model can also be refined to better suit economic conditions and the maturity level of digital technology use in Padang. In addition, in order for the model to be evaluated specifically according to the level of complexity in the real world, it is necessary to conduct trials of the application of the model to a specific business. So that the theoretical foundations built on the model can be useful in encouraging the sustainability and resilience of SMIs.

CONCLUSION

This research developed a comprehensive framework comprising four resilience indicators, 16 digitalization indicators—split evenly between digital marketing and digital literacy—and 27 sustainability indicators derived from literature spanning 2015 to 2023. The sustainability dimension includes seven economic, eleven environmental, and nine social indicators. To ensure relevance for SMIs in Padang, these indicators were validated by experts from academia, government, and industry, resulting in the removal of two sustainability indicators and leaving 25, while digitalization indicators remained unchanged. Each indicator is accompanied by clear guidance to facilitate understanding and adoption by SMIs. The resulting conceptual model enables businesses to measure resilience and sustainability, assess current capabilities, and formulate strategies to strengthen competitiveness. It also provides a foundation for policymakers and organizations to design targeted interventions that support adaptability and long-term sustainability. However, the model has limitations: it is conceptual and lacks empirical validation, relies on expert judgment that may introduce bias, does not account for sectoral or regional variations, and its implementation depends on organizational readiness and stakeholder alignment. Future research should empirically test the model using methods such as SEM or PLS, integrate it into organizational processes for resilience assessment, and adapt components for training, audits, and digital monitoring. Expanding the scope of digitalization beyond literacy and marketing to include digital transformation—such as advanced technologies, data-driven decision-making, and Industry 4.0 adoption—will further clarify how digitalization drives sustainability and resilience in uncertain environments.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to the experts from academia, government, and industry who contributed their time and insights to validate the indicators used in this research. Appreciation is also extended to the institutions and organizations that supported this study, as well as to all individuals who provided valuable feedback and assistance throughout the research process.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this research. All procedures, analyses, and interpretations were conducted objectively and independently, without any financial, personal, or professional relationships that could influence the outcomes of this study.

 DOI: 10.25077/josi.v24.n2.p367-391.2025

FUNDING

The author received no financial support for the research, authorship, and publication of this article

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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APPENDIX

A.1. Calculation of Index Aiken Validity for Digitalization and Resilience Indicators

No	Variable	No	Indicator	Expert					S					$\sum_{i=1}^{n} S$	n(c-1)	V	Criteria	Valid
				1	2	3	4	5	S_1	S_2	S_3	S_4	S_5					
1	Digital Literacy	1	Information processing : search	3	5	5	5	4	2	4	4	4	3	17	20	0.85	Very High	Valid
		2	Data Collection	5	5	5	5	5	4	4	4	4	4	20	20	1.00	Very High	Valid
		3	Data Evaluation	5	5	5	5	5	4	4	4	4	4	20	20	1.00	Very High	Valid
		4	Interaction through digital technology	3	5	4	3	4	2	4	3	2	3	14	20	0.70	High	Valid
		5	Collaboration through digital technology	5	5	4	3	4	4	4	3	2	3	16	20	0.80	Very High	Valid
		6	Digital content creation	4	4	4	4	5	3	3	3	3	4	16	20	0.80	Very High	Valid
		7	Data security	5	5	5	4	5	4	4	4	3	4	19	20	0.95	Very High	Valid
		8	Technical problem-solving skills	3	4	4	4	5	2	3	3	3	4	15	20	0.75	High	Valid
2	Digital Marketing	1	Online advertising	5	3	4	4	5	4	2	3	3	4	16	20	0.80	Very High	Valid
		2	Social media capability	5	5	4	4	5	4	4	3	3	4	18	20	0.90	Very High	Valid
		3	Website ownership	5	2	4	3	5	4	1	3	2	4	14	20	0.70	High	Valid
		4	Ease of product search	5	5	4	4	5	4	4	3	3	4	18	20	0.90	Very High	Valid
		5	Online communication with customer	5	5	4	5	5	4	4	3	4	4	19	20	0.95	Very High	Valid
		6	Information quality	5	5	4	5	5	4	4	3	4	4	19	20	0.95	Very High	Valid
		7	Improved customer service	5	5	4	5	5	4	4	3	4	4	19	20	0.95	Very High	Valid
		8	Online sales	5	5	4	4	5	4	4	3	3	4	18	20	0.90	Very High	Valid
3	Resilience	1	Sales	5	5	4	4	5	4	4	3	3	4	18	20	0.90	Very High	Valid
		2	Profit	5	5	4	4	5	4	4	3	3	4	18	20	0.90	Very High	Valid
		3	Customer Satisfaction	5	5	5	5	5	4	4	4	4	4	20	20	1.00	Very High	Valid
		4	Delivery Lead time	5	4	5	4	5	4	3	4	3	4	18	20	0.90	Very High	Valid

DOI: 10.25077/josi.v24.n2.p367-391.2025

A.2. Calculation of Index Aiken Validity for Sustainability Indicators

No	Sustainability Aspect	No	Indicator	Pakar Ke-					S ke-					$\sum_{i=1}^{n} S$	n(c-1)	V	Criteria	Valid
				1	2	3	4	5	S_1	S_2	S_3	S_4	S_5					
1	Economy	1	Profit	5	5	4	5	5	4	4	3	4	4	19	20	0.95	Very High	Valid
		2	Sales growth	5	5	4	5	5	4	4	3	4	4	19	20	0.95	Very High	Valid
		3	Material cost	4	4	3	4	5	3	3	2	3	4	15	20	0.75	High	Valid
		4	Labor cost	4	4	3	4	4	3	3	2	3	3	14	20	0.70	High	Valid
		5	Energy cost	3	4	3	4	3	2	3	2	3	2	12	20	0.60	High	Valid
		6	Inventory cost	5	4	4	4	4	4	3	3	3	3	16	20	0.80	Very High	Valid
		7	Product quality	5	5	5	5	5	4	4	4	4	4	20	20	1.00	Very High	Valid
2	Environment	1	Water consumption	1	4	4	3	2	0	3	3	2	1	9	20	0.45	Fair	No
		2	Energy consumption	4	3	4	4	4	3	2	3	3	3	14	20	0.70	High	Valid
		3	Energy efficiency	4	3	4	4	4	3	2	3	3	3	14	20	0.70	High	Valid
		4	Energy intensity	4	3	4	4	4	3	2	3	3	3	14	20	0.70	High	Valid
		5	Material consumption	4	3	4	4	5	3	2	3	3	4	15	20	0.75	High	Valid
		6	Recycled material use	5	3	4	3	5	4	2	3	2	4	15	20	0.75	High	Valid
		7	Packaging material consumption	5	3	5	3	5	4	2	4	2	4	16	20	0.80	Very High	Valid
		8	Greenhouse gasses emissions	1	4	5	4	3	0	3	4	3	2	12	20	0.60	High	Valid
		9	Wastewater discharge	1	3	5	3	3	0	2	4	2	2	10	20	0.50	Fair	Valid
		10	Solid waste disposal	1	4	5	3	3	0	3	4	2	2	11	20	0.55	Fair	Valid
		11	Recyclable waste	1	3	5	3	2	0	2	4	2	1	9	20	0.45	Fair	No
3	Social	1	Fair salary	5	4	4	4	5	4	3	3	3	4	17	20	0.85	Very High	Valid
		2	Employee turnover	5	4	4	4	3	4	3	3	3	2	15	20	0.75	High	Valid
		3	Employee satisfaction	5	5	4	4	4	4	4	3	3	3	17	20	0.85	Very High	Valid
		4	Occupational health and safety	4	4	4	5	4	3	3	3	4	3	16	20	0.80	Very High	Valid
		5	Employee training and development	5	4	4	4	5	4	3	3	3	4	17	20	0.85	Very High	Valid
		6	Lost working days	5	4	4	4	3	4	3	3	3	2	15	20	0.75	High	Valid
		7	Customer health and safety	5	4	5	3	4	4	3	4	2	3	16	20	0.80	Very High	Valid
		8	Customer satisfaction	5	5	5	4	5	4	4	4	3	4	19	20	0.95	Very High	Valid
		9	Corruption	5	5	4	3	4	4	4	3	2	3	16	20	0.80	Very High	Valid

A.3. Conceptual Framework Model and Research Variables Derived from Previous Studies

No	Reference	Research Goals		Digitalization		Sustainability			Resilience			
		Identification Indicators	Correlation Analysis	Digital Literacy	Digital Marketing	Economy	Social	Environment	Sales	Profit	Delivery Lead time	Customer Satisfaction
1	Gao et al. [16]	√	√		√	√	√	√	√	√		
2	Zahara et al. [61]	√	√		√				√			√
3	Al Asheq et al. [62]		√		√				√	√		
4	Sambowo dan Hidayatno [58]	√									√	√
5	Heredia et al. [63]		√	√					√	√		
6	Sulistyo et al. [64]		√	√		√	√	√				
7	Sharma et al. [65]		√	√		√	√	√				
8	Jaish et al. [21]		√	√	√	√	√	√				
9	Chinakidzwa dan Phiri [66]		√		√				√	√		
10	Rahman et al. [67]		√			√	√	√	√	√		
11	Broccardo et al. [68]		√			√	√	√	√	√		
12	Abidi et al. [69]		√	√					√			
13	Sardana et al. [70]		√			√			√	√		
14	Rosario et al. [71]		√		√	√	√	√				
15	Gu et al. [72]	√	√	√							√	√
16	Kawira et al. [73]	√	√		√				√	√		√
17	Werner et al. [74]	√									√	√
18	Muafi et al. [20]		√	√					√	√		√

DOI: 10.25077/josi.v24.n2.p367-391.2025

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