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Review article

Towards smart sustainable development through value stream mapping – a systematic literature review

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ABSTRACT

Value Stream Mapping (VSM) is a standard Lean tool for identifying and reducing waste. It is used to create value and improve the performance of any industry. The value of the VSM has greatly expanded from conventional to smart over time; hence, researchers and practitioners in this sector are paying more emphasis. Comprehensive review research is needed to understand VSM-based smart, sustainable development from a triple-bottom-line perspective. The primary goal of this research is to look at various insights from the historical literature that can help with the adoption of smart, sustainable development through VSM. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) with a fifteen-year time range (2008–2022) is being considered to study various insights and gaps in value stream mapping. Analysis of the significant outcomes presents an eight-point study agenda: year, national context, research method, sector, wastes, VSM type, applied tools, and analysis indicators. The critical finding implies that empirical qualitative research dominates the research sector. Effective VSM implementation requires balancing the three sustainable dimensions of economic, environmental, and social through digitalization. The circular economy should also bolster research on the intersection of sustainability applications and new digital paradigms such as industry revolution 4.0.

1. Introduction

Lean manufacturing is a vital management subject that emphasizes cutting waste in production, managing reduced inventories, avoiding wasteful expenditure, and enhancing the overall business by cutting non-value-adding activities [1]. The idea of Lean Manufacturing came into existence at Toyota Production System in Japan 1980s. Lean tools support manufacturers and help them eliminate waste. Five steps can define lean application: identifying the value of the process, identifying the process value stream, focusing on process flow, configuring of pull factor & work towards process perfection [2]. There are several tools to achieve lean orientation, and famous examples include poka-yoke, standardized work, 5S, VSM, etc. [3].

Value Stream Mapping is essential among the various lean tools as it showcases an organization's current and future scenario. The application of value stream mapping is not only restricted to any single industry. It finds usage in Manufacturing [4], healthcare [5], the auto-ancillary industry [6], the textile industry [7], pharmaceutical company [8], the food industry [9], the telecommunications industry [10], Oil and gas industry [11], and so on. Concerning process ratio, TAKT time, process inventory level, overall lead time, and bottleneck time, VSM highlights the favorable effects. The suggested modification also contributed to greater customer satisfaction

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in terms of better quality, lower costs and on-time delivery [6]. According to Ref. [12], VSM is a useful, effective, and adaptable method for redesigning production systems with different flow lines. This is evident from the redesign outcomes and the implementation teams satisfaction. In a worldwide economic crisis, a company ability to adapt to changes in customer preferences, governmental rules, technology, and rivals in the marketplace determines whether it will survive and remain competitive.

Value stream mapping serves as a fundamental methodology for the assessment process and can uncover significant opportunities to enhance production speed, cost reduction, save time, and causes minimum degradation to the environment [13]. Now that the concept of integrating Lean with the Green narrative has found its place and importance in the industries, VSM comes as the handiest and most easily accessible lean tool that can be modified to include the criteria of green production. It is known as either Green VSM [14] or Sustainable VSM [15,16]. Various other models that aim at overcoming the shortcomings of traditional VSM that overlook the environmental impact of the processes are also coming up, namely, Energy-VSM, which looks at the energy aspect of the model and aims at saving energy as well as the cost associated with its consumption for the manufacturer [17]. In addition to using environmentally friendly raw materials and ecologically friendly product design, green manufacturing also comprises environmentally friendly product packaging, distribution, and disposal or reuse after the product's useful life [15]. Nowadays, industries seek agile, digitalized, and practical approaches to lean manufacturing. A digital twin-enabled VSM solution was presented by internet of things (IoT) technology [18]. design an agile system to sustain productivity benefits utilizing a methodology and value stream mapping in industry 4.0. Lean-based value stream mapping is a technique for enhancing productivity by reducing non-value-added processes. According to Ref. [19] "Industry 5.0" may look like and how it may make our industries more future-proof, resilient, sustainable, and human-cantered.

Based on a systematic approach, this study covers the literature published in reputed journals providing valuable information about the application of VSM in various industries. The contribution of the current research is emphasized in several subcategories as listed the article outlines described in section 1 and the prelude to the literature review included in Section 2. The research methodology is in Section 3, and the descriptive analysis is in Section 4. Section 5 examines the present study significant findings, gap areas, future scope, and limitations are discussed to give context to the current research. Finally, the concluding remarks are represented in section 6.

2. Prelude to literature review

Studying contemporary review articles is critical to analysing the literature better. A careful review of the literature identifies significant gaps and potential research directions.

2.1. Existing literature reviews on VSM

The examination of existing review papers reveals the work done in the field of VSM, and identified gaps justify the need for a follow-up study. The SCOPUS database was used to find reviews on available value stream mapping. The search yielded eight publications that attempted to provide a VSM review. These eight publications were thoroughly examined to assess the work done in the VSM field. Table 1 shows the results of previous VSM review studies.

3. Methodology

3.1. PRISMA

"A systematic literature review (SLR) is a strategy for locating, analysing, and summarising the body of finished and documented work created by researchers, scholars, and practitioners that is systematic, explicit, thorough, and reproducible" [27]. The SLR method permits an evidence-based approach to selecting, identifying, and analysing secondary data. SLR is different from other methods of writing a review because of its principles, i.e., inclusivity, transparency, heuristic, and explanatory nature. These leave room for an impartial overview of the search results and eliminate discrepancies or errors [28]. The current research uses the "Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)" method for analysing the quality of systematic reviews in VSM in a more comprehensive fashion, paying particular attention to the specific guidelines followed in this method, its use across a number of disciplines like tourism [29], and Agriculture [30], and many other fields.

In this study, a systematic literature review was done to map the development and application of VSM in various industries. Scopus's academic database searches relevant publications and is credited to be the largest multidisciplinary dataset of peer-reviewed scientific publications worldwide. For paper retrieval, three search criteria were created. Firstly, only scholarly journals were chosen for assessment to maintain quality, and papers from conferences, book reviews, and editorials were removed. Second, the search timeframe for publications was shortened to 2008–2022. This phase was chosen because it is when growth is most pronounced. Third, only consider articles written in the English language. PRISMA narrowed the search to gain a deeper comprehension of VSM-related research. The flow chart for PRISMA is shown in Table 1.

We obtained our primary source materials reviewed for this study from Scopus and it was implemented using 'keywords/title/abstract'. We constructed two search phrases (SP) for our preliminary source material search, and selection was used in the retrieval process. These keywords can be used to find pertinent word variations.

SP-1 ('lean manufacturing' OR 'Value steam mapping') AND ('VSM' OR 'value stream management' OR 'value stream analysis' OR 'value stream process') These keywords can be used to capture relevant variations of a word.

SP-2 ('green VSM' OR 'sustainable VSM' OR 'digital VSM' OR 'quality VSM' OR 'energy VSM')

Table 1
Earlier review studies.

Author	Year	Time Span	Article Type	Country	Publications Considered for study	Title	Focus Area	Methodology	Outcomes	Source
Lee et al., 2021	2021	2008–2019	Journal	Malaysia	57	Sustainability-Oriented Application of Value Stream Mapping: A Review and Classification	This review aims to identify the most relevant papers that present VSM implementation from a triple bottom line (TBL) perspective and classify and define the sustainability indicator set.	The following stages were taken during the article literature review: 1. Data mining took place in March and April 2020 and used an academic database. 2. A categorization framework was developed after identifying and screening articles to correctly classify and codify the 57 articles found. 3. Finally, using defined coding and classification, identify the major gaps in the literature.	The paper findings are as follows: 1. It could strengthen sustainability- oriented VSM studies to evaluate and enhance organizational sustainability performance, notably in sustainable manufacturing processes. 2. The sustainability indicator collection contains concrete indicators (metrics) successfully employed in state-of-the-art research. It could aid practitioners in better understanding the indicator selection process when implementing VSM with a sustainability focus.	[20]
Dominguez-Alfaro et al., 2021	2021		Journal	Mexico	26	Ergo VSM: A New Tool that Integrates Ergonomics and Productivity	Identifying potential ergonomic concerns imposed on by Lean Manufacturing deployment in companies	The approach and tools employed for its implementation, the results attained, and the difficulties encountered are all included in this literature review.	The Ergo VSM is primarily based on the Rother & Shook VSM approach, which is mostly used in the healthcare industry with ergonomic analysis tools that concentrate on the physical and psychosocial elements of the workers.	[21]
Pagliosa et al., 2021	2019	2000–2018	Journal	Brazil	93	Industry 4.0 and Lean Manufacturing	Identifying the connections between Industry 4.0 (I4.0) technologies and Lean Manufacturing (LM) methods is the goal of this article	Four databases were used to find the papers for the literature review: Scopus, Web of Science, ProQuest, and Emerald. There was no publishing deadline, and the search was conducted in 2018. Nine I4.0 technologies and 14 Lean practices were found and grouped into various levels of value stream application and synergy.	They emphasized the traits and uses of I4.0 technologies and lean practices at various value stream stages and highlighted their connections. The lean manufacturing manufacturers who want to take advantage of I4.0 should put more effort into implementing IoT and Cyber-Physical Systems. These I4.0 technologies are the most likely to produce results sooner since they have the most significant number of high-synergy linkages with Lean practices.	[22]

(*continued on next page*)

Table 1 (*continued*)

Author	Year	Time Span	Article Type	Country	Publications Considered for study	Title	Focus Area	Methodology	Outcomes	Source
Vasconcelos Ferreira Lobo et al., 2020	2018	2012–2017	Journal	Brazil	42	Evaluation of value stream mapping (VSM) applicability to the oil and gas chain processes	The primary purpose of this research is to undertake a systematic review of the current literature on the use of the VSM in oil and gas operations to establish whether it is suitable, as well as the challenges and reasons for its slow acceptance. The second purpose is to confirm the framework companies in this industry use to map their processes, identify wastes, and create future state maps with improved information and material flows.	The articles for the literature review were found using the Scopus databases. This database was chosen because it houses the world's largest abstract and citation database for peer-reviewed literature, including scientific journals, books, and conference proceedings.	Researchers and practitioners use the VSM methodology/ framework in the oil and gas industry. The VSM was utilized in all empirical investigations on this SLR, according to the book "Learning to See".	[11]
Shou et al., 2017	2017	1999–2016	Journal	South Korea	131	A cross-sector review on the use of value stream mapping	The purpose of this article is to examine the VSM implementation in the manufacturing, health care, construction, product development, and service sectors, as well as the differences across the five sectors and the reasons for the discrepancies. It identifies potential future directions for facility and VSM deployments.	VSM implementation was evaluated and contrasted based on four aspects: (1) current state analysis metrics, (2) future state improvement methodologies, (3) VSM implementation advantages, and (4) key success factors (CSFs) for effective VSM implementation in specific circumstances.	The most often discussed idea in the literature is the application of VSM theory to increase lean thinking implementation in real scenarios. VSM should concentrate on the sorts of lean measurements and methodologies that should be used, as well as how the recommended lean solutions should be implemented precisely while taking into account the features of the production value streams and flows.	[23]
De Steur et al., 2016	2016	1990 to 2015	Journal	Belgium	24	Applying Value Stream Mapping to reduce food losses and wastes in supply chains: A systematic review	The state of the art of applying lean manufacturing principles in the agrion business is presented in this study, which identifies lead time as the most suitable VSM performance measure.	This article's technique is based on categorizing articles into several forms, such as time period, VSM tools, performance indicator, and quality score.	These findings have broader implications for efforts to improve food and nutrition security in the context of minimising FLW (Food losses and wastes) ii. lean practises inherently improve production efficiency, and by lowering production costs, prices of nutritious foods may fall in favour of the vulnerable and hungry.	[24]
Forno et al., 2014	2014	2000–2014	Journal	Brazil	57	Value Stream Mapping: a study about the problems	The purpose of this study is to look at the major challenges and constraints faced during	The study looked at peer-reviewed journals in electronic databases (Emerald	This research aimed to identify issues with VSM implementation, examine	[25]

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Table 1 (*continued*)

Author	Year	Time Span	Article Type	Country	Publications Considered for study	Title	Focus Area	Methodology	Outcomes	Source
						and challenges found in the literature from the past 15 years about application of Lean tools	the creation of current state maps, analyse the underlying causes, and suggest some guidelines to make the usage of VSM to map processes easier.	Insight and Springer link databases). The authors attempt to evaluate the key challenges and constraints in creating a VSM current state map, as well as the major causes and guidelines for its use. By doing a bibliographic search using the terms VSM and lean system, a theoretical-conceptual approach was adopted.	possible reasons, and develop suggestions to make the process less complicated and more likely to succeed. It identified future VSM implementation prospects, particularly in terms of increased productivity and reliability of this lean tool. The most difficult aspect of problem identification was understanding and characterising problems identified in the investigations	
B. Singh et al., 2011	2011	1990–2010	Journal	India	49	Value stream mapping: literature review and implications for Indian industry	A case study of a small manufacturing Indian industry is described in the article, with reductions in lead time, processing time, work-in-process inventory, and staffing requirements.	The literature is divided into four categories: conceptual work, empirical/modelling work, case studies, and survey papers. A large body of work on value stream mapping and its expanding adoption in developed and emerging nations indicates that researchers and practitioners are interested in this field.	VSM is a very successful technique for identifying and reducing various forms of wastes, according to the findings of conducted case study. Work in process inventory was reduced by 80.09%, finished goods inventory was reduced by 50%, product lead time was reduced by 82.12%, station cycle time was reduced by 3.75%, change over time was reduced by 6.75%, and manpower was reduced by 16.66%.	[26]

Four research questions were developed to direct the search, selection, and inclusion of our primary source materials.

1) RQ1: What is the role of VSM in sustainable production growth?
2) RQ2: Classify and codify the various VSM metrics and analysis indicators under the triple bottom line (TBL) point of view.
3) RQ3: What lean, green, and digital tools and techniques can ensure comprehensive sustainability in industries despite the existing threats?

We adopted a two-pronged methodology approach in this study. First, we performed a systematic literature review (SLR) on the growth of digital-sustainable orientated VSM using the "Preferred Reporting Item for Systematic Reviews and Meta-Analysis (PRISMA)". Next, we proposed a framework for implementing Smart-Sustainable VSM using our SLR.

Table 2
Selection criteria.

S.No	Criteria	Coding
1	National Context	A- Developed Countries B- Emerging Countries
2.	Year	A- 2008-2012 B- 2013-2017 C- 2018-2022
3.	Research Method	A- Empirical qualitative B- Empirical quantitative C- Desk qualitative D- Desk quantitative Empirical triangulation E– Review
4.	Sector	A- Construction B- Health Professions C- Manufacturing/Production D- Business, Management, and Accounting E– Agricultural and Biological Sciences Architecture F- Computer Science G- Decision Sciences H- Environmental Science I- Materials Science J- Economics, Econometrics, and Finance K- Energy L- Multidisciplinary
5.	Waste	A- Overproduction B- Over-processing C- Transport D- Inventory E– Waiting F- Defects G- Motion H- Human Potential I- Information J- Others
6.	Types of VSM	A- Traditional VSM B- Green VSM C- Energy VSM D- Quality VSM E– Sustainable VSM F- Digital VSM G- Other
7.	Tools applied	A- Lean Tool B- Green Tool C- Digital Tool D- Others
8.	Analysis indicators	A- Value Added Time (VAT) B- Material consumption C- Energy consumption D- Steam % E– Carbon emission F- Green House Gas (GHG) emission G- Cost Analysis H- Employee satisfaction assessment I- Digitalization Rate J- Other

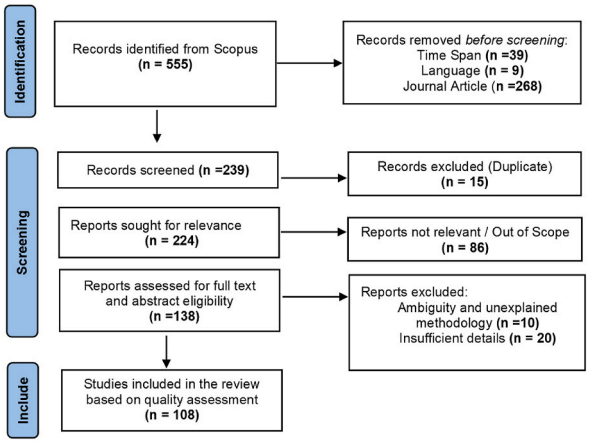

Fig. 1. PRISMA flow chart.

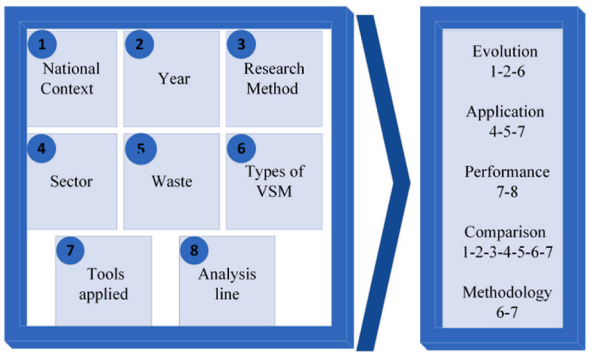

Fig. 2. Selection Criteria for Literature review.

3.2. Literature review selection criteria

A Categorization system was established to correctly classify and codify discovered articles after locating and screening the published studies on VSM. This classification system consists of eight key themes (National Context, Year, Research Method, Sectors, Wastes, Types of VSM, and Analysis indicators), numbered 1 through 8, following the established aims and leading investigations. Each eight main topic sub-categorized in different ways (see Fig. 1).

Alphabetical letters (A, B, C, etc.) were used to code each sub-classification. Hence, this classification uses both numbers and letters. The frameworks are shown in Table 2 in this manner, classification 1 is related to the national context of the studies and is coded on a scale A and B. Classification 2 deals with the year and is categorized on a scale from A to C under a five-year time frame, where A represents (2008–2012), B (2013–2017), and C is the most recent year (2018–2022). Classification 3 is graded on a scale from A to E and pertains to the research methodology. Classification 4 is associated with the investigated sectors: Construction, Health, Manufacturing/Production, or other areas. Classification 5 identifies the types of waste reduced by the VSM implementation; this part is coded on a scale from A–J. Classification 6 relates to adopting various VSM approaches, including traditional and new ones, and is coded from A-G. Classification 7 explores the tools integrated with VSM implementation and new paradigms such as smart, sustainable manufacturing. This classification is coded on a scale from A-D. Classification 8 outlines the various analysis methods used to apply VSM under the triple-bottom-line principles of the economy, environment, and society (scale A-J). Fig. 2 depicts the frameworks evolution, performance, applicability, etc., as represented in Table 2.

4. Detailed analysis

The descriptive analysis of the selected articles is presented in this section by classifying them into several groups (discussed in Table 2) and defining them in charts and tables for better graphical representation. For ease of comprehension, the categories outlined in the current paper are summarized as follows in Table 3.

Table 3
Summarized literature review.

Year	Source	National Context	Research Method	Sector	Waste	Types of VSM	Tools applied	Analysis Indicators
2022	[31]	A	D	C	A, B, C, D, E, F, G	A	A	A
2022	[32]	B	A	J	A, B, C, D, E, F, G	A	A	A
2021	[33]	B	A	F	A, B, C, D, E, F, G, H. I	A, F	A, C	A, J
2021	[34]	A	A	C	A, B, C, D, E, F,G,H	A	A	A
2021	[35]	A	B	L	A, B, C, D, E,F,G	A, G	A	A, D
2021	[36]	B	C	C	A, B, C, D, E, F. H	A, B	A	A, C
2021	[37]	B	D	C	A, B, C, D, E, F, G	A	A	A
2021	[38]	B	A	C	A, B, C, D, E, F, H	A	A	A
2021	[18]	B	A	C	A, B, C, D, E, F, G	A	A	A
2021	[39]	B	C	L	C, D, F, J	A	A	A
2021	[40]	B	A	B	A, B,C,D,E,F,G	G	A	A,G,J
2021	[16]	A	A	L	A, B, C,D,E,F,G	A,B,E	A, B	A,C,G.H,J
2021	[41]	B	A	C	A, B, C,D,E,F,G	A	A	A
2021	[42]	A	D	L	A, B,C,D,E,F,G	G	A,D	A
2021	[43]	A	A	G	A, B,C,D,E,F,H	A,B	A,B	A,F,J
2021	[44]	B	A	C	A, B,C,D,E,F,H	A	A	A
2020	[6]	B	A	C	A,B,D,F	A	A	A
2020	[45]	B	C	C	D,G	F	C	A
2020	[46]	A	B	C	I	G	A,D	A
2020	[47]	B	A	C	A,B,C,D,E,F,G	G	A	A
2020	[48]	A	A	E	A,B,C,D,E,F,G	A	A	A
2020	[49]	B	A	C	A, B,C,D,E,F,G	A	A	A
2020	[50]	B	D	C	A,B,C,D,E,F,G	A	A	A
2020	[51]	B	D	G	A,B,C,D,E,F,G	A	A	A
2020	[14]	B	A	C	A,B,C,D,E,F,G	B	A,B	A,B,C,D,E,J
2020	[3]	B	D	C	A,B,C,D,E,F,G	E	A,B	A,B,C
2020	[52]	B	A	C	A,B,C,D,E,F,G	A	A	A,G
2020	[53]	B	A	C	A,B,C,D,E,F,G	A	A	A
2020	[54]	B	D	L	A,B,C,D,E,F,G	G	A	A
2020	[55]	B	A	D	A, B,C,D,E,F,G	A	A	A
2020	[56]	B	D	E	A, B,C,D,E,F,G	A	A	A
2020	[57]	A	C	K	A, B,C,D,E,F,G	A	A	A
2019	[58]	B	A	C	A,B,C,D,E,F,G	D	D	H,J
2019	[59]	B	A	C	A,B,C,D,E,F,G	A	A	A
2019	[60]	B	A	C	A,B,C,D,E,F,G	A	A	A
2019	[61]	B	A	C	A,B,C,D,E,F,G	A	A	A
2019	[62]	B	A	C	A,B,C,D,E,F,G	A	A	A
2019	[63]	B	A	C	A,B,C,D,E,F,G	A	A	A
2019	[9]	B	A	E	A,B,C,D,E,F,G	A	A	A
2018	[64]	B	A	C	A, B,C,D,E,F,G	A	A	A
2018	[65]	B	A	C	A, B,C,D,E,F,G	A,B	A,B	A,C
2018	[66]	B	C	C	A, B,C,D,E,F,G	A	A	A
2018	[67]	B	C	C	A, B,C,D,E,F,G	A	A	A
2018	[68]	B	C	G	A, B,C,D,E,F,G	A	A	A
2018	[69]	B	D	C		A	A	
2018	[70]	B	A	C	A, B,C,D,E,F,G	A	A	A
2018	[71]	B	A	C	A, B,C,D,E,F,G	A	A	A
2018	[72]	B	A	C	A, B,C,D,E,F,G	A	A	A
2018	[73]	B	A	C	A,B,C,D,E,F,G	A	A	A
2018	[74]	A	B	C	A,B,C,G	F	C	
2018	[75]	B	A	C	A,B,C,D,E,F,G	A	A	A,G
2018	[76]	B	A	C	A, B,C,D,E,F,G	A	A	A
2017	[77]	A	A	D	A, B,C,D,E,F,G	A,G	A,B	A,J
2017	[10]	B	A	J	A, B,C,D,E,F,G	A	A	A
2017	[2]	A	C	L	A, B,C,D,E,F,G	A	A	
2017	[78]	B	C	L	A, B,C,D,E,F,G	A	A	A
2017	[79]	B	A	C	A, B,C,D,E,F,G	A	A	A
2017	[80]	B	A	C	A, B,C,D,E,F,G	A	A	A
2016	[81]	A	A	C	A,B,C,D,E,F,G,I	A,E	A,B	A,B
2016	[5]	B	C	B	A, B,C,D,E,F,G	A	A	A
2016	[17]	A	C	C	J	C	B	C
2016	[82]	B	A	C	A, B,C,D,E,F,G	A,B	A,B	A,C
2016	[83]	A	C	C	A, B,C,D,E,F,G	A,B, E	A, B	A, C,F,E
2016	[84]	B	A	C	I	F	C	I
2016	[85]	B	A	C	A, B,C,D,E,F,G	G	D	J
2016	[86]	B	A	L	A, B,C,D,E,F,G	A	A	A
2016	[71]	B	A	L	A, B,C,D,E,F,G	A	A	A
2016	[87]	A	D	A	A, B,C,D,E,F,G	A	A	A

(*continued on next page*)

Table 3 (*continued*)

Year	Source	National Context	Research Method	Sector	Waste	Types of VSM	Tools applied	Analysis Indicators
2015	[88]	B	A	C	A, B,C,D,E,F,G	A	A	A
2015	[89]	B	D	L	A, B,C,D,E,F,G	A	A	A
2015	[90]	A	A	C	A, B,C,D,E,F,G	A	A	A
2014	[91]	A	A	C	A, B,C,D,E,F,G	E	B	A,B,C,J
2014	[15]	A	A	C	A,B,C,D,E,F,G	E	B	A,B,C,J
2014	[92]	A	C	C				
2014	[93]	A	A	D	A,B,C,D,E,F,G	A	A	A
2014	[94]	A	A	L	A,B,C,D,E,F,G	A	A	A
2013	[95]	B	C	E	A,B,C,D,E,F,G	A	A	A
2013	[96]	A	A	C	A,B,C,D,E,F,G	A	A	A
2013	[97]	B	A	C	A,B,C,D,E,F,G	A	A	A
2013	[98]	B	A	C	A,B,C,D,E,F,G	A	A	A
2013	[99]	B	A	C	A,B,C,D,E,F,G	A	A	A
2013	[85]	B	A	C	A,B,F	A	A	A
2012	[100]	A	C	B	A,B,C,D,E,F,G	A	A	A
2012	[101]	A	C	F	A,B,C,D,E,F,G	A	A	A
2012	[8]	B	A	B	A,B,C,D,E,F,G	A	A	A
2011	[102]	B	A	C	A,B,C,D,E,F,G	A	A	A
2011	[103]	B	D	C	A,B,C,D,E,F,G	A	A	A
2011	[104]	B	A	C	A, B,C,D,E,F,G	A	A	A
2011	[105]	B	D	G	A, B,C,D,E,F,G	A	A	A
2011	[7]	A	A	L	A, B,C,D,E,F,G	A	A	A
2009	[106]	A	C	L	A, B,C,D,E,F,G	A	A	A
2009	[107]	A	A	L	A, B, C,D,E,F,G	G	A	A
2008	[12]	A	A	C	A, B,C,D,E,F,G	A	A	A

4.1. Categorization based on the national context

This categorization depicts information about the countries represented by the authors of the selected studies. According to the content analysis, India is at the top of the list, with 91 articles (38.07%). This suggests that the research issue is significant for developing countries like India. Most multinational corporations (MNCs) focus on developing and undeveloped countries to deploy VSM to deliver supplies and information while efficiently reducing waste. As a result of the importance of sustainability principles in their supply chains, developing countries like India will have a major impact in the next few years. The United States is the second country on the list, with a contribution of 23 (9.6%). Other countries have evidence of VSM studies after the US, as shown in Fig. 3. Based on the released report [108], the list of countries was further divided into two categories: developed countries and emerging countries. The classifications used to categorise the national contexts are A - "Developed Country" and B - "Developing Country". According to this classification, developed countries account for 31.18% of publications while developing countries account for 68.8%.

4.2. Categorization based on year

The frequency analysis of the final sample (239 articles), based on the articles released year by year, is displayed in Fig. 4. The trend indicates that research growth on VSM was low between 2008 and 2012 (14.64%). The articles were published on VSM at a moderate rate (39.33%) between 2013 and 2017. From 2018 to 2022, there has been a significant increase in the number of articles produced (46.02%). In the last ten years (2013–2022), research publications on VSM have increased dramatically, with 204 papers accounting for 85.35% of all articles published. These rising research papers demonstrate that academics and practitioners have recognized the importance of establishing sustainable practices to ensure a better future. This is because the value of steam mapping growing social

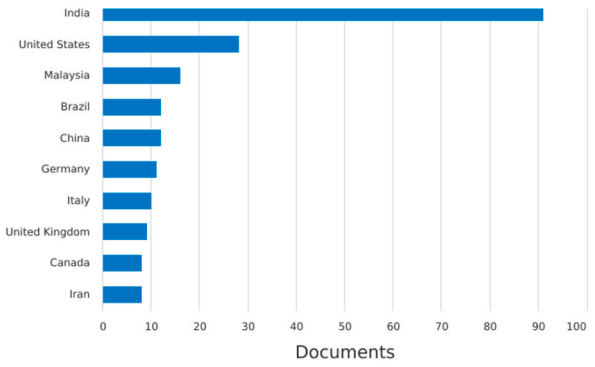

Fig. 3. Categorization based on the national context (Source - SCOPUS database).

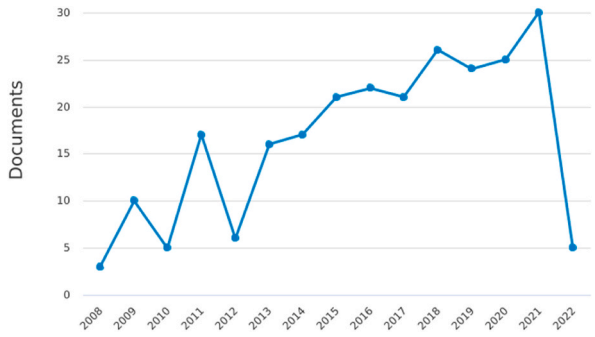

Fig. 4. Distribution of the reviewed papers by year of publication (Source - SCOPUS database).

Table 4
Categorization based on research method.

Research Design	Description	No of paper	Percentage
Empirical qualitative	Case study based on practical implementation or interview-based research design	70	64.82
Empirical quantitative	This is a survey-based research method.	4	3.70
Desk qualitative	A conceptual model, theoretical concepts, and future research exploration	19	17.59
Desk quantitative Empirical triangulation	Research design based on mathematical modelling and simulation	15	13.89

and environmental concerns have put pressure on it to find a long-term solution. Nowadays, industries are moving away from traditional production techniques and toward more efficient lean and green procedures in response to increased customer demands for affordable quality products. Academics and practitioners stepped forward to address VSM for supply material and information's social, environmental, and economic concerns.

4.3. Categorization based on research method

The literature review is divided into two categories based on whether empirical research or desk research was used. The four types of empirical and desk research are empirical qualitative, empirical quantitative, desk qualitative, and desk quantitative. The type of research design reported in the examined publications is shown in Table 4. The table also shows the percentage of each ingredient. The frequency of empirical qualitative with 70 articles (64.82%), Empirical quantitative with 4 articles (3.70%), desk qualitative with 19 articles (17.59%) and desk quantitative Empirical triangulation with 15 articles (13.89%). Case studies or interviews type research design are more common in VSM. As a result of the analysis, research in the VSM field is more likely to take a qualitative approach than a quantitative one. Quantitative research accounts for 17.59% of all papers assessed, while qualitative research accounts for 82.41%.

4.4. Categorization based on sector

The research in VSM has considered a variety of sectors. Because sustainable practices vital for one industry may not be as significant for another, classifying and evaluating the study by industrial sector will better bring out the applicability of VSM research sector by sector. Fig. 5 summarises the industry in which our sample concentrated in the field of VSM. The manufacturing/production sector consumes a significant number of non-renewable resources and generates waste, raising concerns about the sector's ability to respond to sustainability issues. Most articles reporting VSM concepts focus on the manufacturing industry, with 174 articles (35.3%). It is suggested that the application of sustainability concepts by manufacturing businesses is related to two factors. Traditionally, it has focused on production and manufacturing issues; and historically, environmental rules have focused on manufacturing plants. By examining the cases presented in the selected literature, the current study aimed to determine the level of sustainability adoption in various manufacturing businesses. The second most important sector is Business, Management, and Accounting, contributing 118 articles (23.1%).

4.5. Categorization based on waste

The Toyota production system has defined seven types of Muda (waste) generally: overproduction, waiting, transportation, motion, over-processing, inventory, and defect. Adaptation of the 'seven wastes' to the clinical setting of interventional radiology by Ref. [100]. Human Potential is also the new type of waste coming from the philosophy of Toyota's production. The content analysis of the selected articles reveals that mostly seven types of waste generally focused on traditional VSM. Still, VSM can be used to identify waste in maintaining information management procedures through mapping and quantifying different kinds of information waste [48].

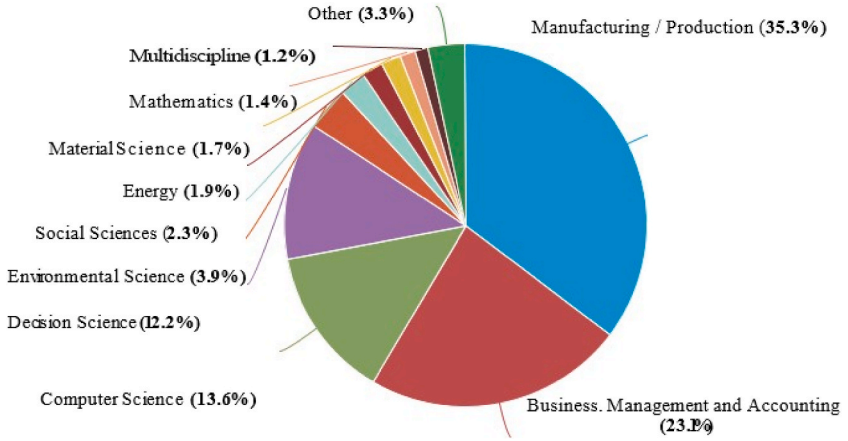

Fig. 5. Categorization based on sector (Source - SCOPUS database).

4.6. Categorization based on types of VSM

To explore knowledge of various types of VSM, the selected articles were categorized based on Traditional VSM, Green VSM, Energy VSM, Quality VSM, Sustainable VSM, and Digital VSM. The applications have undergone extraordinary numbers of changes, from the 'traditional VSM', which is employed to improve organizational performance, to the environmentally related aspects, known as 'Green VSM' [14], 'Energy VSM' [17], 'Environmental VSM'. The content analysis depicts (79.56%) researchers using mostly traditional VSM while another VSM has less consideration. The current categorization highlights the considered smart, and sustainable dimensions are chosen to emphasize the focus on distinct forms of VSM. Table 5 displays recent developments in VSM growth strategies (see Table 6).

4.7. Categorization based on tools applied

Various tools and techniques used to eliminate waste and improve the process in VSM are classified into four categories: lean tool, green tool, digital tool, and others related to management. In lean techniques, takt time, single-minute exchange of die, poka-yoke, total productive maintenance, kanban pull system, 5S, and kaizen, are the most popular techniques that have been employed. The mixed approaches entailing lean tools with other green tools such as Life Cycle Analysis (LCA), life cycle cost analysis (LCCA) [104], Lean Six Sigma (LSS), Quality function deployment (QFD) [49] and other green approaches have been used to identify environmental issues in the production process. Lean tools (86 articles) are most used compared to mixed integer lean and green tools (12 articles) in value stream approaches. The application of digital tools in the reviewed papers has been reported in 6 papers. Digital tools have been introduced to support the Industry 4.0 concept, such as RFID [23] and virtual reality [74], to support waste identification and elimination in a dynamic environment. The successful implementation of VSM may require management assistance, including early involvement and training.

4.8. Categorization based on analysis indicators

This categorization aims to create awareness about the analysis indicators, which actively use in current & future state mapping. The following scale is employed for analysis indicators A-value-added time (VAT), B- material consumption, C- energy consumption, D-Steam flow, E−carbon emission, F- GHG emission, G-cost analysis, H- employee satisfaction assessment, I- digitization rate, J-others. According to the analysis, the VAT used 87.17%, 6.41% material consumption, 8.97% Energy consumption, 2.56% Carbon emission, 2.56% GHG emission, 6.41% cost analysis, and few amount to employee satisfaction and digitization rate. It can be helpful in the indicators selection process and its implementation in any industry.

5. Outcomes of study

Significant findings and discussion are presented with potential future research directions to highlight the present study contribution.

5.1. Significant findings and discussion

This section describes the major significant conclusions drawn from the descriptive analysis of the chosen literature. Analysing the data makes it possible to identify the literature's advantages and disadvantages, which opens the possibility of conducting VSM-related research that is smart and sustainability-oriented. It also discusses the potential causes of the outcomes that were found. A comparison of the discovered study results with the body of literature already in existence has also been made. The current part also discusses

Table 5
Categorization based on types of VSM.

Types of VSM	Objective	Key Performance Indicators	Motivation	References
Sustainable VSM	To visualize and evaluate the environmental impact, a sustainability metric set is integrated with the conventional VSM.	Energy consumption, water use, raw material use, material utilisation rate, carbon emissions, greenhouse gas emissions, etc.	Traditional VSM only focuses on economic factors like value-added time and lacks consideration for environmental factors.	[3,15,16, 81,91]
Social value stream mapping (Socio-VSM)	To visualize and evaluate the societal sustainability performance in the context of manufacturing.	Rapid Entire Body Assessment (REBA), Noise Level.	The sociocultural components of research have generally been neglected in favour of environmental challenges.	[58]
Scrap Value Stream Mapping (S-VSM)	To minimize the identified wastes and enhance the Supply Scrap Management Process (SSMP).	Total lead time, Value-added time, Storage Space costs, and Inventory Risk costs.	VSM is one of the most acceptable methods for mapping processes and removing their significant concerns. Still, it might be unsuccessful in management processes, such as the Supply Scrap Management Process (SSMP).	[77]
Cost Value Stream Mapping (CVSM)	The time domain of traditional value-stream mapping must be extended to include the cost of production.	Total cost investment, Total Activity Cost, Total lead time, Value-added time.	Value stream mapping (VSM) is a lean tool that addresses time-based non-value-added activities. However, it does not deal with it in terms of costs.	[40]
Ergo VSM	Determine any ergonomic concerns that may result from adopting lean manufacturing in businesses. Evidence that process analysis needs to incorporate ergonomics and productivity indicators.	Rapid Entire Body Assessment (REBA), Job Safety Analysis, 10 Beats, NIOSH Method, MAC Method, ERGO/IBV Software.	Lean manufacturing does not consider the effects of process modifications on the workforce. The impact of the strict application of lean manufacturing is not felt, nor are ergonomic risks.	[21,85].
VSM with HS (Hybrid Simulation)	Establish Industry 4.0 roadmaps and identify changes in materials, equipment, processes, and information flows related to Industry 4.0 application scenarios.	Value-added time (VAT), Production lead time (LT) days, Production output per day.	VSM construction by hand is highly labour-intensive and time-consuming. Hence simulation should be employed at every stage of the procedure to speed up the process.	[31].
Energy VSM	The use of EVSM reduces non-value-added energy consumption.	VAT Energy consumption	Build an energy-efficient machine or decrease the amount of energy used in processes currently in use	[17]
Procurement value stream mapping (P-VSM)	To increase the effectiveness of procurement while reducing waste and delays.	Cycles for creating plans, billing, information, logistics, and procurement.	To consistently raise quality, promptly satisfy client requests, and boost competitiveness, procurement management will take place throughout the entire value-added process of manufacturing firms. However, studies on how to enhance procurement management tasks from a value flow perspective are uncommon.	[47]
Lean-Energy-Six Sigma Value Stream Mapping (LESSVSM)	The LESSVSM approach reduces waste and contributes to sustainability. Also devised is an energy equation based on entropy.	VAT Energy consumption	Focus only on sustainable energy business practices to balance environmental and economic objectives.	[36]
Dynamic value stream mapping	To make clear how IIoT could improve the VSM as a tactical differentiator for better decision-making.	Overall plant efficiency Mean time to repair (MTTR) in hours.	Value stream mapping (VSM) is frequently static and specialized. VSM does not offer continuous or real-time visibility of lean-related transformation.	[45]
Fuzzy VSM	To consider variability in a manufacturing setting, fuzzy set theory was used in VSM analysis.	Total lead time Value-added time.	Lean production systems should take unpredictability and uncertainty into account.	[54]
Economic and environmental value stream maps (E^2VSM)	It simulated dynamic material, energy, and information flows in multi-product manufacturing systems to create value stream maps for the economy and environment.	Time, electricity, CO2 Emission, Gas emissions.	Extending the traditional VSM technique to the dynamic assessment of economic and environmental goals for multiple product manufacturing systems.	[83]
QFD integrated value stream mapping	To integrate the QFD technique into the VSM framework for scientific waste prioritization and method identification.	VAT	Using subjective human judgment in lean processes introduces ambiguity and bias because the evaluator's knowledge and expertise can vary.	[54,75]
VSM integrated with Fuzzy QFD	Implement a framework for value stream mapping (VSM) combined with fuzzy quality function deployment (QFD) to optimize improvement ideas based on science to increase leanness.	VAT	Fuzzy QFD involves intricate and time-consuming processing. Additionally, a computational error may result in incorrectly prioritizing enhancement recommendations.	[109]

(*continued on next page*)

Table 5 (*continued*)

Types of VSM	Objective	Key Performance Indicators	Motivation	References
Digital VSM	To change the "conventional" production environment through Internet-based real-time networking of infrastructure and operations.	Digital information flow Process KPC Detection Key Performance Characteristic.	To continuously measure and subsequently enhance the management of data and process information along the product value stream, VSM exists at no step.	[110]

Table 6
Categorization based on tools applied.

Applied Tools	Sub Tools	No of articles	Percentage
Lean Tool	✓ TAKT time [53,64,66,86,95] ✓ Pull system (Kanban) [64,89,93,96] ✓ Supermarket [51] ✓ 5S [8,53,60,70,70,97] ✓ Kaizen [6,18] ✓ Single minute exchange of die (SMED) [16] ✓ Poka-yoke [104] ✓ Cellular manufacturing [8,61,86] ✓ Total productive maintenance [92] ✓ Just in time [56] ✓ 5 Whys [8,60] ✓ Continuous improvement [88,110] ✓ Heijunka box [41]	86	79.63
Green Tool	✓ Life Cycle Assessment (LCA) [43] ✓ life cycle cost analysis (LCCA) [104] ✓ Quality function deployment (QFD) [49,104,104]	12	11.11
Digital Tool	✓ Information technology [84,111] ✓ Visual aid ✓ Autonomous Robots [112] ✓ Simulation [3,37,113] ✓ Industrial IoT [45] ✓ Cyber security ✓ Cloud ✓ Augmented Reality (AR) ✓ Big data and analytic	6	5.56
Others Tool	✓ Training ✓ Early involvement ✓ Involvement of stakeholders ✓ Change management ✓ Risk evaluation ✓ Stage inspection	4	3.70

numerous issues that need to be resolved for better knowledge of VSM and upcoming chances. The following noteworthy results, along with a discussion of them, have been highlighted in this section:

- ➢ The state of a country's context most likely influences the application of lean tools and the ensuing effects on sustainability performance. Therefore, it is essential to identify scenarios for additional research on how the lean approach might improve sustainability. The current analysis showed that VSM had been used more in developing countries (68.8%) than in developed countries (31.18%). Many multinational corporations (MNCs) have recently expanded their operations or sourced raw materials from emerging nations. By working with developed countries in this situation, developing nations can significantly contribute to the penetration of VSM. This scenario supports the importance and applicability of VSM for developing nations like Malaysia, China, and India. The ranking of developing countries like India, Malaysia, and China (Fig. 3) is particularly intriguing and inspiring because India comes in first after the two developed nations, followed by Malaysia and China in that order, respectively. By providing financial support and a precise path for developing countries to implement VSM, cooperation with wealthier nations can help to improve the process. The government of India's "Make in India" campaign may inspire businesses in developed countries to support this endeavour.
- ➢ According to the category of selected papers based on the year of publication (Fig. 4), the number of publications throughout the previous ten years (2012–2021) has shown an upward tendency. Every year, a significant number of papers show that scholars and practitioners are becoming more interested in adopting VSM. One of the leading causes of the increase in interest may be the strict government laws and regulations that prevent businesses from using conventional techniques. As people become more aware of

sustainable practices, they realize how important it is to include social and environmental concerns in business plans to minimize or completely eradicate their adverse effects on society and the environment.

- The bulk of research reported in the literature is qualitative (82.4%), mainly to the use of two qualitative research designs, namely the desk qualitative research design (18.2%) and the empirical qualitative (64.2%). This suggests that the contributors primary areas of interest were the conceptual model, theoretical ideas, desk-based qualitative research inquiry, and case studies or interview-based research (empirical qualitative). The difficulty in gathering secondary data may be the reason for the increased acceptance of case studies or interview-based research. When doing survey-based research, the acquired data must be validated and subjected to reliability testing; otherwise, the investigation would be useless or ineffective at uncovering relevant insights. The least adopted research design is empirical quantitative and Empirical desk triangulation with (3.2%) of articles which indicates that the authors have not utilized the quantitative method.
- Most articles (35.5%) are published in the manufacturing/production sector of the chosen literature. The increased demand for automobiles, pressure from non-governmental organizations (NGOs) for green products, and stringent governmental regulations may all be factors in the manufacturing industry's decision to adopt VSM to the greatest extent possible, particularly in the automobile sector. VSM research is not limited to manufacturing but is also broad in scope business management and accounting with 23.1% and low applications in decision science (12.2%), computer science (13.6%), environmental science (3.9%), Social science (2.3%), energy, and other fields. Some examples of applications of VSM like the textile industry [7,37], pharmaceutical companies [56], and Food industries [9], telecommunications industry [10]. Now a time, the application of value stream mapping (VSM)extends to the supply chain of an e-commerce retailer on Amazon [32] and is used in also education system [39].
- VSM helps locate waste or operational inefficiencies across the board in a mapped process. Current and future state mapping are the two types of mapping of VSM. All of the value-added and non-value-added activities engaged in a sequence of actions that make up a process are described in the present state VSM. After some detected wastes have been eliminated or minimized, the future state is designed [72]. The Waste Identification Diagram (WID) is a brand-new, highly-promising visual representational tool for manufacturing units, particularly in trash identification and quantification [73]. People from academia and industry evaluated the tool both quantitatively and qualitatively.
- Since evaluators have different knowledge and skills, applying subjective human judgment to lean procedures creates ambiguity and bias. To address this weakness, present the fuzzy VSM [54,75]. Fuzzy numbers are used to simulate the ambiguity of subjective human judgment on the level of application of lean practices, together with a further factor connected to the duration of the implementation of lean practices and the use of multi-evaluators. Benchmarking is not essential because value stream mapping is utilized to evaluate the level of lean performance [114].
- Value stream mapping (VSM) is often static and skill-reliant. It is the most harmful component of VSM's static behaviour. The Industrial Internet of Things (IIoT) enables the conversion of the VSM into a dynamic model, boosting many additional factors measured concurrently in real-time, and increasing the visibility of the cause-and-effect relationship. The factory execution system real-time data can be combined with geodata acquired by an RFID system to display the current value stream forever and identify bottlenecks and potential enhancements. VSM would transform in this fashion from a static tool to a dynamic one [74]. RFID allows for quick data collection and accurate, line-of-sight-free object identification. So it can be used to identify, find, track, and keep an eye on actual objects. The term "dynamic value stream mapping" (DVSM) refers to this system, which is a real-time computer-based VSM [45]. The real-time manufacturing cost tracking system (RT-MCT), one of DVSM's lean-based modules, can track the development or accumulation of actual product costs during the flow of products along a value stream [115]. Additionally, VSM lacks any cost analysis or cost tracking mechanisms. The typical static VSM can be changed into a dynamic VSM using computer-based simulations to increase managers analytical decision-making capacity [42].
- Value stream mapping has traditionally considered the relationship between the amount of time spent on a process and the amount of time that adds value [97]. This would reveal the steps that would take too long without offering anything in the way of value. This timeline would provide a visual comparison between the two, but it ignored the resources used or trash produced during the process. Bringing harmony between the three sustainable dimensions of economic, environmental, and social with digitalization is crucial for implementing VSM to be effective. Some essential aspects related to smart, sustainable dimensions were highly ignored. Here are some vital suggestions for the analysis metrics for SS-VSM.

- Consumption and responsibility are two aspects of the environment. Material lines can be formed for any resource under consumption (like energy, water, exhaustible resources, raw materials, etc.). Additionally, the accountability area criteria include wasteful energy use, hazardous gas emissions, effects on global warming, ozone depletion, ecotoxicity, and carbon emissions [14,83].
- In standard VSM, the time spent on different processes is mapped without keeping track of the growth in direct and indirect costs. This methodology divides the economic pillar into cost management and operational efficiency. Cost of energy use, inventory needed to maintain production while setup is taking place, cost of inventory waste, and cost of operator waste during setup time [40].
- In the social pillar, employee happiness and human resources are the two key components. The significant factors for measuring staff satisfaction in this area revolve around absenteeism, teamwork, and motivation finally, the skillful operator in human resources [58].
- The I4.0 methodology sums up these digital solutions. Its foundation is the digitalization of production with a focus on Internet technology, automation, and close integration of clients in a networked production web. This digital analysis line includes the digitization rate, process key performance characteristic detection and digital information flow [84].

➢ A combination of lean, green, and digital tools and techniques is essential for the quick overall growth of industries. It can take advantage of these synergies and invest in Industry 4.0 technologies that enable cutting-edge digital production methods. This strategy employs resource optimization, innovation, internationalization, and flexible manufacturing to sustain competitiveness in the global markets [116].

As a result, another aspect of this study's is creating a set of indicators for using smart, sustainability-focused VSM. The concrete indicators (metrics) in this set of smart indicators have been successfully used in recent studies. It can help choose the indicators and put them into practice because many references can be used well.

5.2. Future research direction

Future study directions have been highlighted based on the findings and discussion of the current review.

- Globalization demand has prompted industries to adopt eco-friendly data-connected lean manufacturing technology and optimize their information and supply chain flow. The country obtains resources from around the world, making the procedure more environmentally friendly. Since MNCs are investing in expanding their companies in emerging nations, such nations must start and strengthen the adoption of VSM. Following developing countries like India and China, with promising results from VSM research, further in depth studies can be launched in those nations.
- Since the focus of most of the study has been primarily on environmental and economic issues, the societal components have largely been neglected. Lean manufacturing does not consider the effects of process modifications on the workforce. The impact of the strict application of lean manufacturing is not felt, nor are ergonomic risks the initiative to encourage researchers and practitioners to adopt different social aspects of VSM. The performance of societal sustainability in manufacturing should be considered in future studies.
- Future research is also required to assess VSM applicability to diverse industrial sectors. Future studies using the simulation platform can investigate the integration of artificial intelligence techniques and machine learning models to process input data for the simulation model or to depict the behaviour of Industry 4.0 components in the simulated system. The appropriate approach is used to protect the privacy and security of the network and data.
- To consistently raise quality, promptly satisfy client requests, and boost competitiveness, procurement management will play a vital role entire value stream process. However, it is uncommon to find a study that examines how to improve procurement management operations from the standpoint of value flow. Additional analysis in multi-angle or multi-case studies is required to provide better procurement management.

5.3. Limitations of the current study

- The SCOPUS database is the only one used for the literature search in this study. Even though SCOPUS has a sizable number of publications, the current research does not include all pertinent articles available outside the SCOPUS database. By expanding the sample size of the articles and considering papers from various databases, a future study that is more thorough can be conducted.
- Since only English language papers were included in this study, VSM-related literature written in other languages was not considered when concluding decisions. The study findings and conclusion could change if articles in other languages were considered.

6. Conclusion

Over the past ten years, value stream mapping research has exploded. This study conducts a thorough literature evaluation of 117 articles published on VSM in the previous 1.5 decades to advance understanding in the research field. It is possible to list and analyse fruitful discoveries by categorizing the chosen articles for assessment along various aspects and the table content. The current study has shown how the VSM approach has strengthened over the last 15 years. The purpose of this paper is to provide a framework for SS-VSM applications that is focused on sustainability. This application has attracted significant attention from practitioners and academics and is slowly being adopted to evaluate sustainability performance. This review can significantly contribute to the body of current information because there is a lack of study on the integration and systematization of the actual knowledge on smart sustainable VSM. The following are the effects of the conclusions:

- Academic implications – Developing the Value stream approach in new and better ways by synthesizing the literature under the triple bottom line with a digitalization perspective. Several performances and analysis metrics have been proposed for traditional and smart sustainable VSM. The findings of this review have broader implications concerning the efforts employed to improve the visibility of the entire value stream and adequate sharing of information in the context of digitalization and further engage the application in new paradigms like circular economy & Industry 4.0.
- Practical implications – Putting up a set of various indicators that have not previously been examined in the literature. The tangible indicators (metrics) included in this set of smart sustainability indicators have been successfully used in state of the art investigations. The analysis covers the complete information on the growth of VSM over time, including metrics of the current state map, improvement technique for future state map, and finally, suggests critical elements & enabling techniques for SS-VSM

implementation. This review offers innovative insights for future scientific research to extend the application of smart, sustainable VSM in different sectors. It might aid practitioners in better comprehending the method used to choose the indicators when putting smart sustainability focused VSM into practice. Additionally, this page contains many references that can be used effectively.

Author contribution statement

All authors listed have significantly contributed to the development and the writing of this article.

Data availability statement

Data will be made available on request.

Declaration of competing interest

Conflict of Interest and Authorship Confirmation Form.
Please check the following as appropriate:

✓ All authors have participated in (a) conception and design, analysis, and interpretation of the data; (b) drafting the article or revising it critically for important intellectual content; and (c) approval of the final version.
✓ This manuscript has not been submitted to, nor is it under review at, another journal or other publishing venue.
✓ The authors have no affiliation with any organization with a direct or indirect financial interest in the subject matter discussed in the manuscript

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