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SURVEY

Revealing the State of the Art in Managing IT Infrastructure Within Enterprises: A Systematic Mapping Study

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ABSTRACT Effective management of information technology infrastructure (ITI) is key to success for any enterprise offering IT services in this contemporary digital era. Considering the importance of the topic both for research and practice, a Systematic Mapping Study (SMS) was conducted (with the following research questions) to present state-of-the-art concerning the management of ITI, (i) what focus areas related to the management of IT Infrastructure have been considered in the extant literature?, (ii) what are the publication trends and characteristics of existing research on IT Infrastructure Management?, (iii) what are the main challenges in the context of managing IT Infrastructure reported in the existing literature?, and (iv) what recommendations and guidelines have been proposed to overcome the reported challenges? Following the systematic approach, n=57 articles from extant literature satisfying this study's inclusion and exclusion criteria were considered for analysis to find answers to these research questions. The findings reveal (i) research focus areas categorized into 6 categories (i.e., resource, service, learning style, self-care, data sharing & access, and human ITI capability), (ii) a set of variables to map publication trends and characteristics of existing research with *"evaluation research"*, *"constructive research"* and *"models"* recognized as the most common paper type, research methods, and contribution type respectively, (iii) 28 challenges related to ITI management in enterprises were identified, and (iv) 68 guidelines and recommendations for organizations and personnel were identified to manage the ITI more efficiently. The findings such as research focus areas and publication trends are important from a research perspective offering guidance to researchers to drive further research on the topic. Meanwhile, the challenges, recommendations, and guidelines have practical implications, providing practitioners with insights into better understanding and management of their respective ITI.

INDEX TERMS Challenges, complexity, digital services, IT infrastructure, security.

I. INTRODUCTION

Digital technologies form a worldwide techno-social atmosphere and offer a lot of opportunities to capture data [1]. The technological evolution supports enterprises in collecting, storing, processing, and using huge amounts of information which has become the key factor of success for any organization [2]. Recently, there has been a huge economic shift from product to service-based, particularly to digital services. Digital services include networked service systems to fulfill the needs of end users [3]. Companies like Apple, and General Electric are offering new services beyond simple sales of products and generating huge revenues from such offerings [4]. IT Infrastructure (ITI) offers the base for all digital operations/services of an organization. Management of ITI, a critical task for any enterprise, includes the management of IT processes and policies, IT components, data, human resources as well as any external contacts to ensure smooth running of IT operations.

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This work conducts a systematic mapping study (SMS) to get insights into existing research works in the context of IT infrastructure management (ITIM). This is the first SMS study about ITIM to the author's best knowledge. Though a few systematic literature review studies exist (refer to Table 1), none of these studies cover the management aspect of ITI. The introduction of innovative technologies such as artificial intelligence, machine learning, Internet of Things, blockchain, 5G, and cloud computing requires better ITIM to deal with the changed environment. This motivates us to explore research literature about ITIM and related issues. Current work presents a mapping of existing literature to come across useful insights and identify gaps for further research.

This SMS study obtains a comprehensive view of the key existing themes of ITIM and includes four research questions with a focus on ITIM. Following the systematic approach and in line with the research questions, n=57 publications were included in this study. The following are the major contributions of this study:

- It gives insights from existing studies about research focus related to ITIM.
- It identifies common contribution types in the context of ITIM.
- Next, it finds common research methods and paper types applied in existing studies for ITIM.
- It presents trends of publications like year-wise and most cited papers.
- It identifies a list of major ITIM challenges as per existing work.
- Finally, it provides guidelines to overcome the challenges related to ITIM.

The remainder of the paper is structured as follows: Section II provides background knowledge about ITI and its management. Section III presents the research approach along with research questions. Section IV discusses the results of the mapping study. Section V summarizes the findings, and includes a discussion about threats to validity, and limitations of this study. Section VI concludes the paper.

II. BACKGROUND

A. IT INFRASTRUCTURE AND ITS MANAGEMENT

Infrastructure is the foundation to support any information system [5]. It provides basic components like hardware, software, communication, collaboration networks, databases, and others that support the decision-making of a company [6]. Infrastructure is difficult to reproduce as it is created through collaboration between technology and people in the organization. ITI is a basic shared platform that provides different IT services to enterprises.

The various elements of ITI are presented in Figure 1 (drawing particularly on [7], [8]). ITI is a combination of three layers. The first base layer of this model consists of IT components such as hardware, software, and networks. The second layer includes human capabilities such as skills, and knowledge. Lastly, the third layer comprises a set of shared technology such as services and apps. This human infrastructure binds the IT components into a reliable set of shared ITI services. After McKay and Brockway [7], many researchers [9] added new elements (e.g., local apps, services, standards, policies) and concepts in the three-layer model of [7] to define and explain ITI. However, there are several studies carried out conceptually and empirically on the ITI flexibility and capability concept [10], [11], [12] and used this basic model in their research shown in Figure 1.

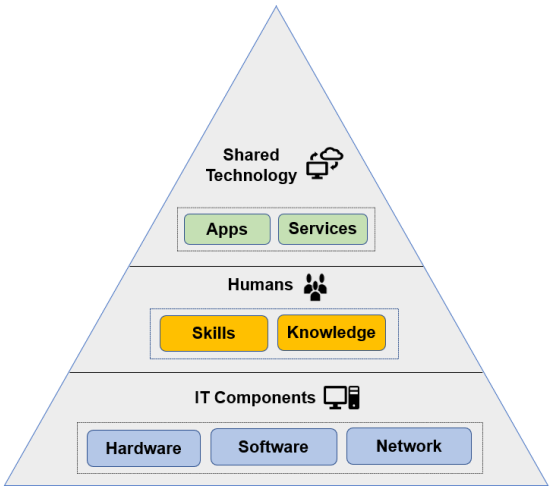

FIGURE 1. IT infrastructure elements.

ITI provides some major digital services to its users. Digital service is a benefit that one party can give to another through a digital transaction [13]. A rapid increase in the number of digital service users creates challenges for digital service providers who provide different services to users through the Internet. Digital technology enables and increases the opportunities for innovation [14]. Major industries such as social media (Facebook), entertainment (Spotify), transportation (Uber), and communication (Skype) utilize digital technologies to deliver value to consumers. Innovative technologies have a common characteristic of not delivering a physical product. Rather, they focus on creating novel experiences and new forms of value creation and thus are categorized as digital services. This shift toward service innovation generates a competitive advantage in the marketplace [15] and creates complexity in ITI.

Therefore, the management of ITI is a critical task for any enterprise. This includes the management of IT processes and policies, IT components, data, and human resources as well as any external contacts (i.e., vendors or security organizations) to ensure the smooth running of IT operations [16]. Standards provide guidelines that organizations can adopt to address new ITIM challenges and utilize the potential of modern technologies. There are many existing technology standards and frameworks that support various aspects of organizations e.g., ITIL [17], TOGAF [18], and COBIT [19].

TABLE 1. State of the art concerning SLRs in the domain.

Ref.	Focus	Data sources	Usable Sample	Time frame	Guidelines	Main Findings	Research Methodology
[21]	IT operation management to ensure the feasibility of all processes depends on IT services & ITI	ICIS, EDOC, BISE	34	2005-2012	Kitchenham et al.	Active research area, Research approaches, IOTM approaches	SLR
[12]	Discuss how to find better dealing with ITI through Configuration Management (CMs) and Maturity Models (MMs)	ACM, Science Direct, Springer Link, IEEE, Research Gate	80	1990-2019	Kitchenham et al.	Except for two MMs, none of the MMs were found that address the CM practices and focus on IT Services	SLR
[22]	Present the relationship between knowledge sharing, ITI, and innovative capability	Scopus, Science Direct and ProQuest	43	2004-2018	Not specified	Develop a model to analyze the influence of the ITI on the relationship between knowledge sharing and innovative capability.	SLR
[23]	Discuss ITI monitoring to maintain the the health of ITI components.	Scopus, IEEE, ACM, WOS	122	2009-2021	Kitchenham et al. and PRISMA	Inspect various tools and techniques proposed to mitigate ITI downtime in the existing literature	SLR
Current Work	Presenting state-of-the-art literature concerning research focus area in ITIM, challenges, and guidelines to overcome those challenges in managing ITI	Scopus, WOS	57	1985-2023	Petersen et al., Kitchenham et al. and PRISMA	(i) Most Focused research areas in ITIM, (ii) challenges addressed, (iii) research trends and characteristics (iv) recommendations and guidelines from the existing literature	SMS

B. RELATED WORK

Information systems are constantly changing and evolving as IT continues to grow [20]. With these emerging technologies ITI bears a lot of technological and operational changes. The research community is trying to manage digital infrastructure and mitigate the challenges faced by adopting the latest technology. Subsequently, multiple studies have been published on understanding the phenomena of ITI, challenges, and mitigation techniques. A few systematic literature reviews (SLR) have been published over the past years to synthesize the knowledge and guide future research in the topic area. A list of SLRs describing their focus, data sources, publication types used, usable sample size, the time frame of the review, guidelines followed, and the main findings and research types of these reviews are presented in Table 1.

It is important to note that there are no systematic literature reviews and mapping studies on the topic of management of ITI. The authors [21] focused only on the management aspect of IT operations through IT services; however, they considered only 2 conferences and one journal of the specific area by limiting their research. Serrano and Pereira [22] conducted an SLR and discussed the management of ITI through MMs in the CMs domain focusing on the IT services field. Cassia et al. [23] presented an SLR in which they observed the relations of interaction between three constructs which are knowledge sharing, ITI, and innovative capability without focusing on their management perspective. In addition to the topic coverage, the SLR [23] had methodological limitations too which were conducted without using any review guidelines. Authors of [24] targeted maintaining the health of ITI components and emphasized the use of system logs for anomaly or failure detection and prediction within ITI to improve its availability and reliability.

Proposed Work: In this research paper, we closely examine several important aspects of ITI management. First, we explore major research focus areas in this field, how these research focus areas have changed over time, and what trends have emerged. This helps us understand the big picture. Next, we dive into the challenges that organizations face when managing their ITI. These challenges are related to security, scalability, and compliance, among others, and the ever-advancing technology landscape. Finally, this study provides practical advice to organizations and their IT staff on how to overcome these challenges. This paper offers straightforward guidelines and recommendations, making it easier for everyone to manage ITI effectively. By bringing together all these aspects, this study provides a complete guide to

better ITI management in a rapidly changing technological world.

III. RESEARCH METHODOLOGY

This SMS study adopts the methodology proposed by Petersen et al. [25]. It is relevant to state that in addition to the method proposed in [25], this study incorporated the methodology proposed by Kitchenham et al. [26] to investigate the research questions (RQ3 and RQ4) that could not be answered by mappings alone. Furthermore, to proficiently execute and report this procedure, this study also benefits from the elements of the preferred reporting items for systematic reviews and meta-analysis (PRISMA) methodology. It is worthwhile to justify the selection of research methods. Firstly, Systematic literature reviews (SLR) are, conducted for the identification, evaluation, interpretation, and comparison of all existing research works linked to a research question [25]. Instead of answering a detailed research question, SMS maps existing works and it complements SLR [27]. This research opts for SMS because it can deal with broad research areas and provides a systematic and objective method to identify, categorize, and analyze existing research.

Furthermore, in line with methodology, this study was conducted in three phases: planning, conducting, and reporting. The details of the planning and conducting phase are presented in the following sub-sections, however, the reporting phase is presented in Section IV.

A. PLANNING THE SMS

This phase involves the following activities, (i) formulating the research questions, (ii) defining the search string, (iii) selecting the databases for search, and (iv) defining the inclusion and exclusion criteria.

1) FORMULATING THE RESEARCH QUESTIONS

This SMS study obtains a comprehensive view of the key existing themes of ITIM and includes the following four research questions with a focus on IT infrastructure management.

RQ1: What focus areas related to the management of IT Infrastructure have been considered in the extant literature?

RQ2: What are the publication trends and characteristics of existing research on IT Infrastructure Management?

RQ3: What are the main challenges in the context of managing IT Infrastructure reported in the existing literature?

RQ4: What recommendations and guidelines have been proposed to overcome the reported challenges?

2) DEFINING THE SEARCH STRING

The 4-step strategy from [28] was used to create our search string. The first step defines the main keywords based on the research questions, followed by the second step which checks for the already known papers in the area. Step 3 looks for other forms of the keywords and the final step uses the Boolean operator to synthesize them into one final search string as follows:

We considered three synonyms for ITI after consulting dictionaries. We confirmed the synonyms from research articles.

> Manage* AND (“IT infrastructure” OR “information technology infrastructure” OR “digital platform” OR “digital ecosystem” OR “digital infrastructure”)

The synonyms were “digital platform”, “digital ecosystem” and “digital infrastructure”. To limit the number and get the true picture of search results from both databases, each part of the search string was placed in quotation marks to find the exact phrase.

3) SELECTING THE DATABASES FOR SEARCH

To retrieve the publications, a search was performed using the query presented earlier across Scopus and Web of Science(WoS) databases. The reason for the selection of these databases is due to their coverage which includes all major journals on ITI belonging to prominent publishers such as IEEE, ACM, Science Direct, and Elsevier.

4) DEFINING THE INCLUSION AND EXCLUSION CRITERIA

The inclusion and exclusion criteria are an important step in doing a mapping study [25]. This step identifies only appropriate articles for analysis. This study applies inclusion criteria (IC) and exclusion criteria (EC) as provided below:
IC1: Only conference and journal peer-reviewed papers written in English.

IC2: Full-text availability in online databases and repositories.

IC3: Papers focusing on ITI and some management aspects (after reading the full text).

EC1: The papers that lie outside of the ITIM domain.

EC2: Dissertations, thesis, book chapters, internal reports, web and news articles, editorial notes, grey literature.

EC3: Duplicate papers.

B. CONDUCTING THE SMS

In line with the RQs, the above-mentioned search string applied to the selected digital libraries to reveal the publication published until Oct 2023. Initially, the search string was applied to title, abstract, and keywords which resulted in a large number of studies i.e., 7545 and 4757 from Scopus and WoS databases respectively. Considering this huge number, we limited our final search to titles only during the identification stage, which resulted in 232 and 100 studies from Scopus and WoS databases respectively. Our further analysis is based on studies found after the application of search string on titles only. During the screening phase, 174 and 76 studies from Scopus and WoS databases respectively were retrieved. The screening was done based on the inclusion and exclusion criteria. After the screening process, 113 publications were eligible for reading the full text. The fifth step of Figure 2 depicts this step where 68 papers

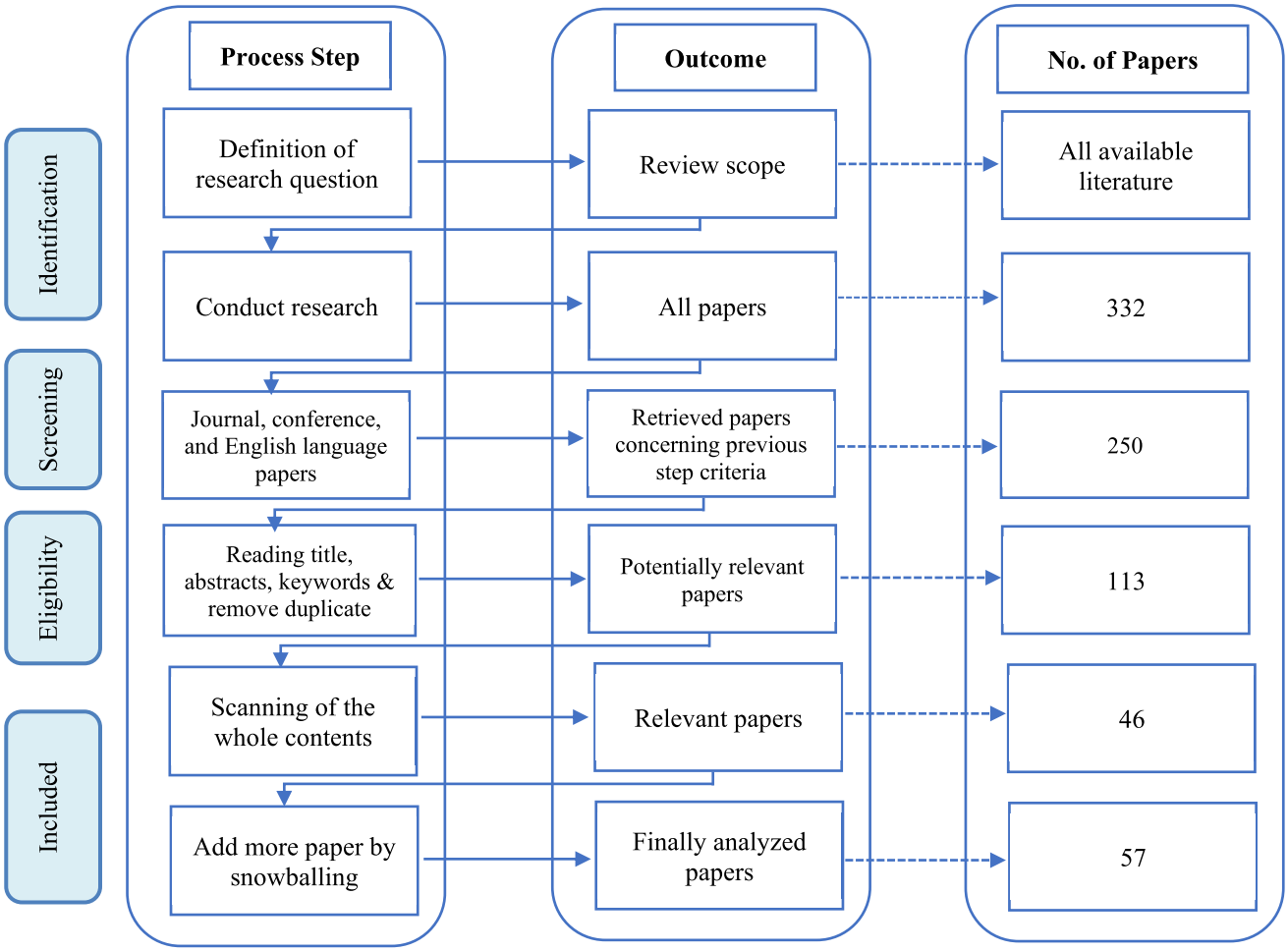

FIGURE 2. Research process.

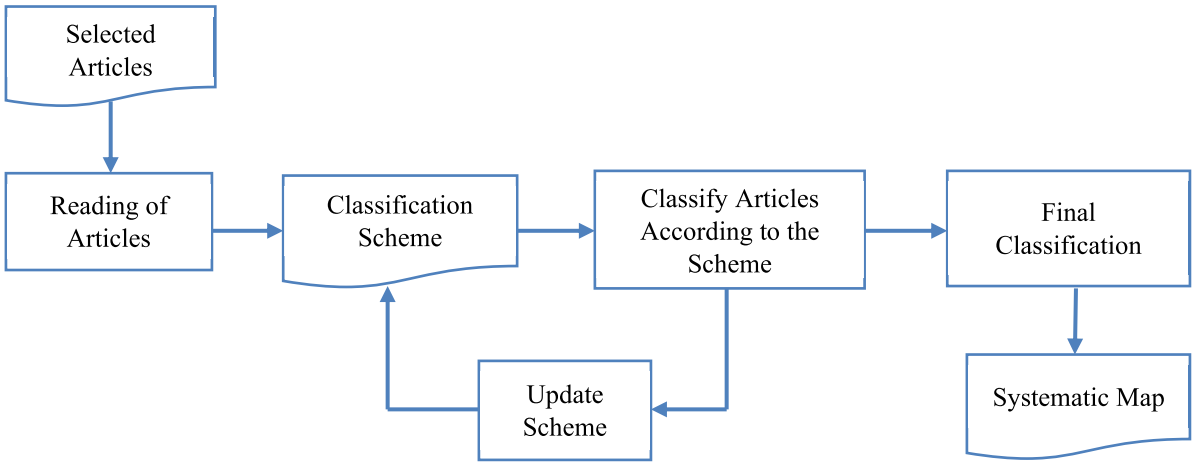

FIGURE 3. Classification process.

were excluded which lie outside of the ITIM domain after reading the whole text and finding only 46 relevant papers. Moreover, we used snowballing to find potential publications that might have missed out. The last step of Figure 2 corresponds to this where 11 articles were included through snowballing.

Finally, 57 publications were included in this study. Zotero was used to manage the references and to assist in removing

TABLE 2. Actual research results.

Database/Phase	Scopus	WoS	Total
(1) Initial keyword search (Title, abstract, and keywords)	7545	4757	12302
(2) Second keyword search (only title base)	232	100	332
(3) 1st Refinement (Journal, conference, and only papers published in the English language)	174	76	250
(4) 2nd Refinement (Title and abstract review and duplicates removal)	86	27	113
(5) 3rd Refinement (full-text review)	29	17	46
(6) Forward and Backward search	11*		57

* This includes five papers from Scopus, three from WoS, and three from other

the duplicates so that we could end up having unique articles for our analysis.

Figure 2 provides the overall SMS process used in this study, which was performed as per instructions by Petersen et al. [25] and grouped as per the stages identified in the PRISMA method.

A stepwise sequence of steps applied from the initial keyword search to the forward and backward search (the last step of our search) lists the number of studies left after each step for both the chosen databases provided in Table 2.

For each eligible article, the following details were extracted from and added into a data repository (maintained in Microsoft Excel) for further analysis, these details include:

- Focus area of the research
- Context of study
- Contribution type
- Paper type
- Research method
- Challenges addressed
- Publication type

The 57 studies in the final dataset (see Appendix) were analyzed to answer the research questions considered in this study.

Furthermore, in line with the methodology of Peterson et al., [25] adopted for this study, developed a classification scheme to classify and analyze the shortlisted articles. The details of the process of the classification scheme are presented in Figure 3.

The resulting classification framework is shown in Figure 4, in which four facets were created to classify the publications, each of which addresses its corresponding RQ. One facet categorized research focus area to managing ITI. The second facet comprises publication trends and research characteristics such as paper type, research methods, and contribution type. The third facet specified challenges while managing ITI and the fourth facet summarized the guidelines and recommendations to overcome the reported challenges within IT. We adopted the approach of categorizing studies into facets [25] and designed a rigorous classification framework based on these four facets and several subordinate data items. The detail of these facets is described in Section IV.

TABLE 3. Distribution of papers and references by research focus.

Research Focus	No. of Papers	Reference
Resource management	12	[29][30][31][32][33][34][35][36][37][38][39][40]
Human ITI capability management	7	[41][42][11][43][44][45][46]
Learning styles management	7	[47][48][49][50][51][52][53]
Service management	6	[54][55][6][56][57][58]
Data sharing and access management	6	[59][60][61][62][63][64]
Self-care management	5	[65][66][67][68][69]
Others (management)	10	[34][70][71][72][73][74][75][76][77][78]
No particular focus	4	[24][79][10][80]
Total	57	

IV. REPORTING THE RESULTS

This section presents the outcome of the formulated research questions based on the mapping results of selected 57 articles comprising 35 journal articles and 22 conference papers. This section is arranged according to the research question.

A. RQ1 (WHAT FOCUS AREAS RELATED TO THE MANAGEMENT OF IT INFRASTRUCTURE HAVE BEEN CONSIDERED IN THE EXTANT LITERATURE?)

To answer RQ1, the classification of 57 articles per research context was conducted by going through the title, abstract, and keywords. We categorized this research context into broader categories and labeled it research focus. This research focus (see Table 3) consists of six different management categories such as resource, service, learning style, self-care, data sharing & access, and human ITI capability. Works that do not fall into any major category but cover some other management phenomena such as change, environment, and supply chain were categorized as others. Four papers were without any management focus. These are presented in detail concerning the parent study in Appendix.

However, as a further step in the analysis, we grouped these research focus into high-level themes namely shared technology, humans, and IT components (see Figure 5) which are the basic elements of ITI concerning the discussion of Section II.

1) SHARED TECHNOLOGY

This layer comprises a set of shared services such as management of large-scale data processing, or management of organization-wide databases and apps which are providing different types of services to their users. In this study shared technology is classified into the following categories:

a: SERVICE MANAGEMENT

Service management is a management discipline aimed at offering quality services that customers will value, buy, and use. A few studies [54,55,6,58] proposed IT frameworks for organizations to deliver services efficiency, better

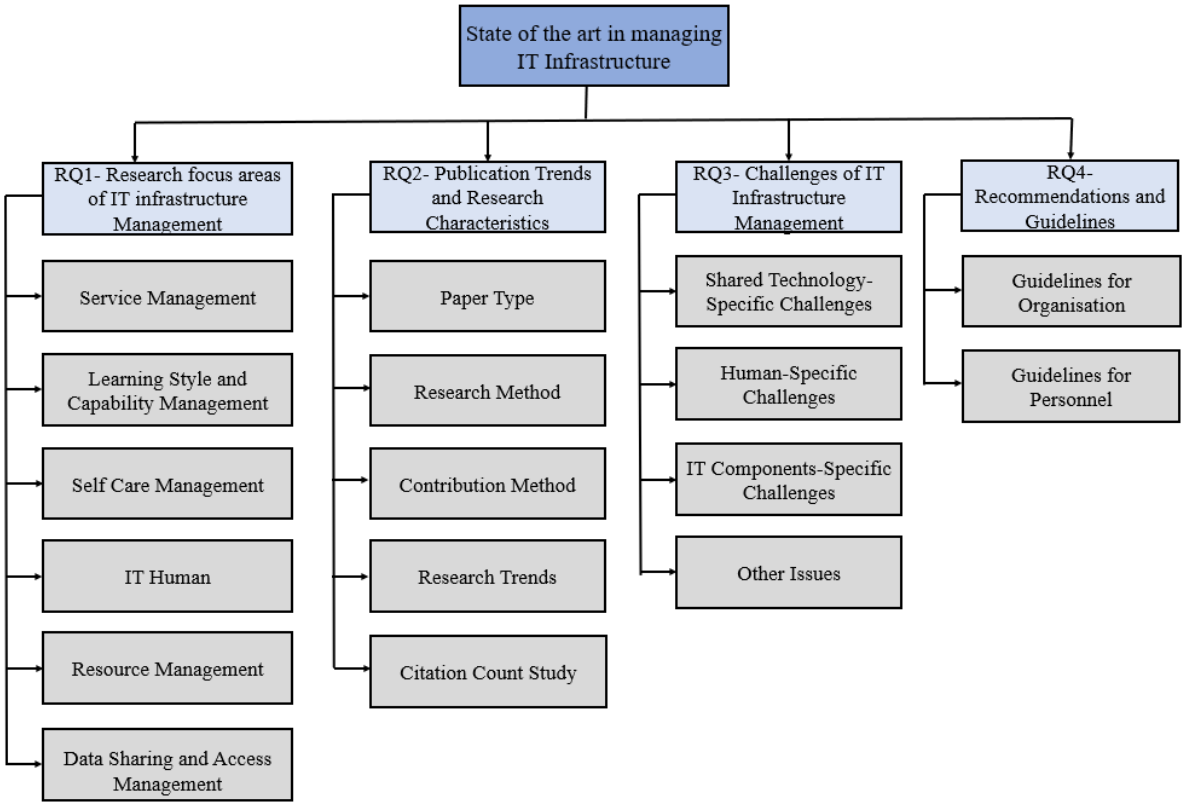

FIGURE 4. Classification framework.

management of ITI, servitization through digital platforms, and opportunities to manage complexity [56]. Another study discussed ITI-related practices and guidelines to provide high-quality services to their end users [57].

b: LEARNING STYLES MANAGEMENT

A management discipline providing how individuals characteristically approach different learning tasks that come under learning style management. The adoption of digital platforms in the education sector is increasing due to massive digital transformation to bring awareness to educational institutes [53]. Researchers are investigating the strategic management techniques employed within the higher education industry during and after the COVID-19 pandemic using digital platforms [47]. Teaching models [48], student learning models [49], and curriculum models [50] were developed for the management of personal learning processes and training activities. One exciting trend is the e-assessment/exams [51] with an effort to create a secure environment for digital exams.

c: SELF-CARE MANAGEMENT

Self-care management means the actions taken by an individual to manage symptoms, treatment, emotions, and lifestyle changes as part of living with a chronic condition. Self-management is recognized as a vital component of care for people with multiple diseases to maintain good health [81]. Particularly, older adults, with multiple chronic conditions need another person in multiple tasks to monitor their health condition [65]. A few studies provided a digital platform for self-management during cardiovascular disease and real-time monitoring and management of diabetes patients [68], [69]. Researchers in their study [66] are also discussing security concerns of e-health devices in managing the self-care of patients.

2) HUMAN

This Layer covers human IT capabilities including their skills and knowledge which is described below:

a: HUMAN IT CAPABILITY MANAGEMENT

IT professionals who have several skills i.e., managerial, technical, and organizational to innovate and support significant business activities. Attracting, grooming, and retaining IT professionals is a major management concern for IT executives. IT professionals require technical, behavioral, and business knowledge and skills to serve their organizations effectively [82,41]. A research model was developed to associate IT personnel capabilities as a component of ITI capabilities [11], [43]. In a few studies, frameworks were designed to identify the IT human factor in delivering flexible ITI and the impact of IT personnel skills on IS Infrastructure [45], [46].

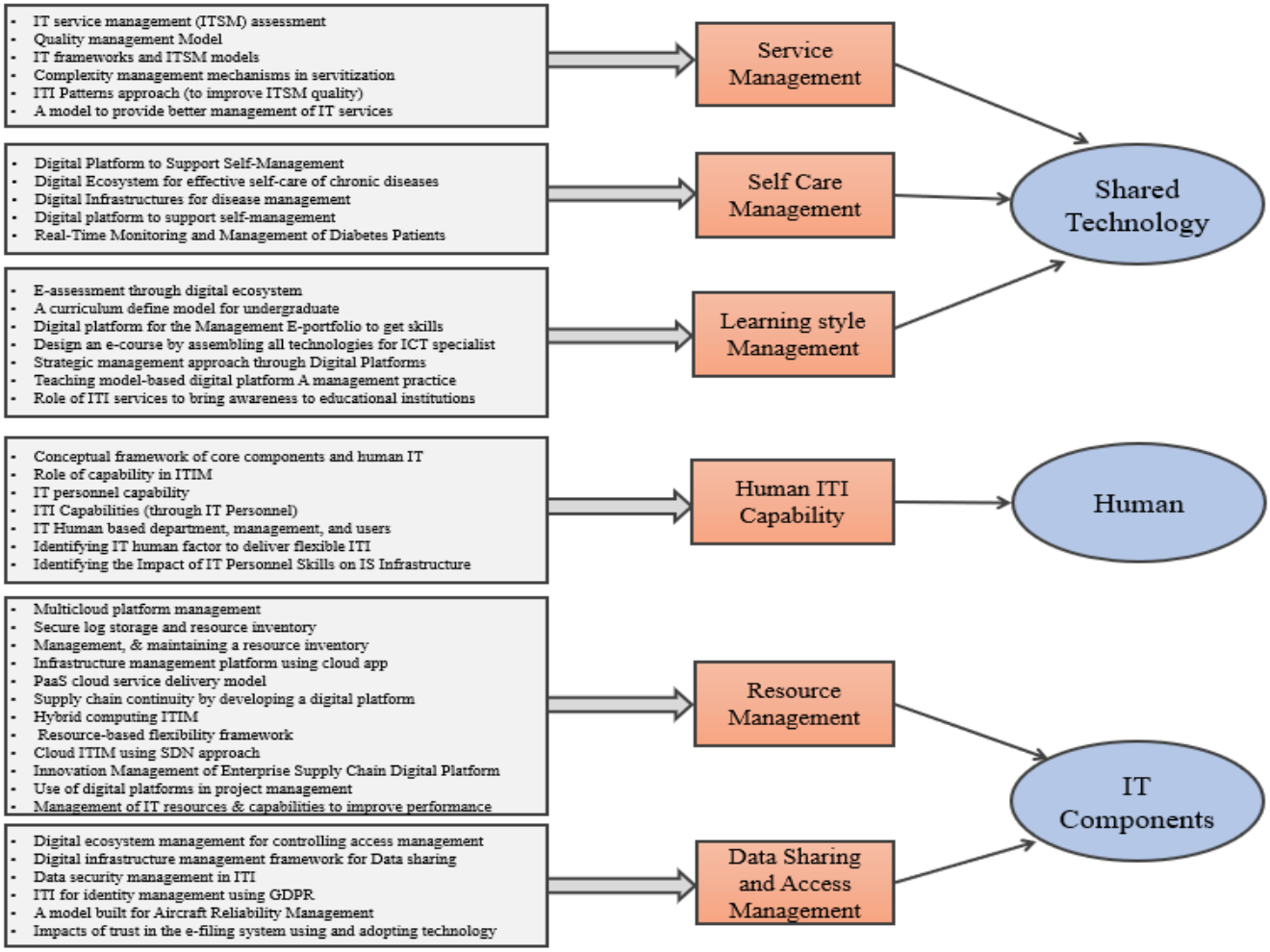

FIGURE 5. Categorization scheme of research focus areas concerning ITIM.

3) IT COMPONENTS

The base layer of ITI consists of IT components which include hardware devices (e.g., computers, servers, network devices, and data storage devices), software (e.g., OS, a suite of productivity apps and security software) and networks comprised both hardware and software components and the configurations you set up to control and manage network access for various users (e.g., cables, firewalls, switches, routers, application interfaces and web servers). According to this current review Resource management Data sharing & access management come under this IT component category. The detail of these categories is given below:

a: RESOURCE MANAGEMENT

Resource management is a process of assigning computing, storage, networking, and energy resources to attain the organization's goals. Articles with emphasis on the management of resources through digital platforms such as supply chain management within enterprises [38] come under this category. Authors [29] provided solutions to manage enterprise resources based on multi-cloud systems. A study provided insights into the design of heuristics to decide how many machines need to be reserved on the cloud for short-term future use [36]. Cloud infrastructures are characterized by a significant extent of resources and their management [32]. Oliveira and Cruz [30], [31] presented tools with a single point of resource management through distributed ledger technology. A few studies communicated about the development and maintenance of ITI-related resources to achieve the core objectives of the organization [33], [34], [37].

b: DATA SHARING AND ACCESS MANAGEMENT

The process of making the same data resources available to multiple applications, users, or organizations with proper authentication is known as Data sharing and access management. In this digital era, people use the internet for communication and exchanging their personal and business data [60]. Pranata and Skinner [59] proposed a security mechanism for the protection of digital systems from unauthorized users during data access. Identity management and access

TABLE 4. Distribution of papers and references per paper type.

Paper Type	No. of papers	% of papers	References
Evaluation research	25	44%	[29][30][54][34][56][71][73][65][51][67][36][75][50][77][49][68][37][11][43][10][69][53][45][40][46]
Solution proposal	10	17%	[31][57][55][33][72][32][63][38][39][58]
Philosophical papers	9	16%	[24][84][47][66][61][62][42][76][80]
Validation research	9	16%	[35][70][48][60][6][74][41][52][64]
Experience papers	4	7%	[59][79][44][78]

management systems are used to track users' activities, make data logs, and record their access [61], [62].

B. RQ2 (WHAT ARE THE PUBLICATION TRENDS AND CHARACTERISTICS OF EXISTING RESEARCH ON IT INFRASTRUCTURE MANAGEMENT?)

To map publication trends and characteristics of existing research while managing ITI, a set of variables was chosen which focus on each study's publication and bibliographic data. The details of these variables are given in the following subsequent sections:

1) PAPER TYPE

Paper type specifies the classification of papers into six categories: evaluation research, validation research, solution proposal, philosophical papers, experience papers, and opinion papers specified by [83]. Evaluation research was the dominant paper type while no study was tailored to the criteria of opinion papers. Table 4 shows the paper type-wise distribution of articles and related references.

2) RESEARCH METHOD

In this facet, the classification of papers is grouped into nine research methods: constructive study, discussion paper, survey, case study, mixed method, grounded theory, interview, action research, and literature study. Constructive study was the dominant research method details are given in Table 5.

3) CONTRIBUTION TYPES

This section followed the existing taxonomy [85] which classifies contribution types as weak (lessons learned, guidelines, and tools) and strong (framework, model, and theory) contributions. Table 6 provides a complete list of research outcomes of six contribution types. Framework turned out as a major contribution type.

4) RESEARCH TRENDS AND CITATIONS

The distribution of articles is provided in Figure 6 in periods of 4 years from 2001 to 2020 and then in periods of 3 years from 2021 to 2023. Starting from 2017, a sudden rise is noticeable with 23 articles during the 2021-2023 period indicating that the ITIM topic has been gaining attention from the research community during the last three years.

Top management of organizations and researchers have foreseen the current decade as the era of digital transformation and ITIM has merged as a major component toward the provision of quality digital services.

Table 7 lists the top 10 papers with the highest number of citations and with per year citation rate greater than or equal to three. The agility discussed through IT personnel capabilities by [11] stands on top considering both criteria.

TABLE 5. Distribution of papers and references by contribution type.

Research Method	No. of papers	% of papers	References
Constructive study	20	32%	[29][30][57][35][55][56][33][70][48][65][60][67][36][32][63][41][38][52][69]
Discussion paper	11	18%	[84][72][70][66][59][61][6][62][79][44][78][40]
Survey	9	14%	[54][50][49][37][43][64][45][46][53]
Case study	5	8%	[34][56][71][75][77]
Mixed method	5	8%	[72][75][74][11][10]
Interview	5	8 %	[71][65][76][39][58]
Grounded theory	4	6%	[47][34][34][51][68]
Action research	2	3%	[65] [73]
Literature study	2	3%	[24][42]

TABLE 6. Distribution of papers and references by contribution type.

Contribution Type	No. of Papers	Percentage of papers	Reference
Model	18	32%	[24][73][48][65][36][32][63][11][43][50][70][37][38][69][64][53][40][52]
Framework	16	29%	[29][54][35][55][71][66][59][60][41][76][10][72][77][80][45][46]
Lesson Learned	8	14%	[75][61][74][79][42][44][39][78]
Tool	6	9%	[31][30][33][67][62][49]
Theory	5	9%	[51][34][68][47][39]
Guidelines	3	5%	[57][84][6][58]

C. RQ3 (WHAT ARE THE MAIN CHALLENGES IN THE CONTEXT OF MANAGING IT INFRASTRUCTURE REPORTED IN THE EXISTING LITERATURE?)

To answer RQ4, identified 28 different types of challenges in the selected articles related to the management of ITI in enterprises. As a further step, these challenges are grouped and mapped on the basic elements of ITI which are discussed in detail in Section II.

A group of identified challenges is provided in Table 8.

1) SHARED TECHNOLOGY-SPECIFIC CHALLENGES

This study identified mainly five shared technology-related challenges that cover the aspect of shared services and apps,

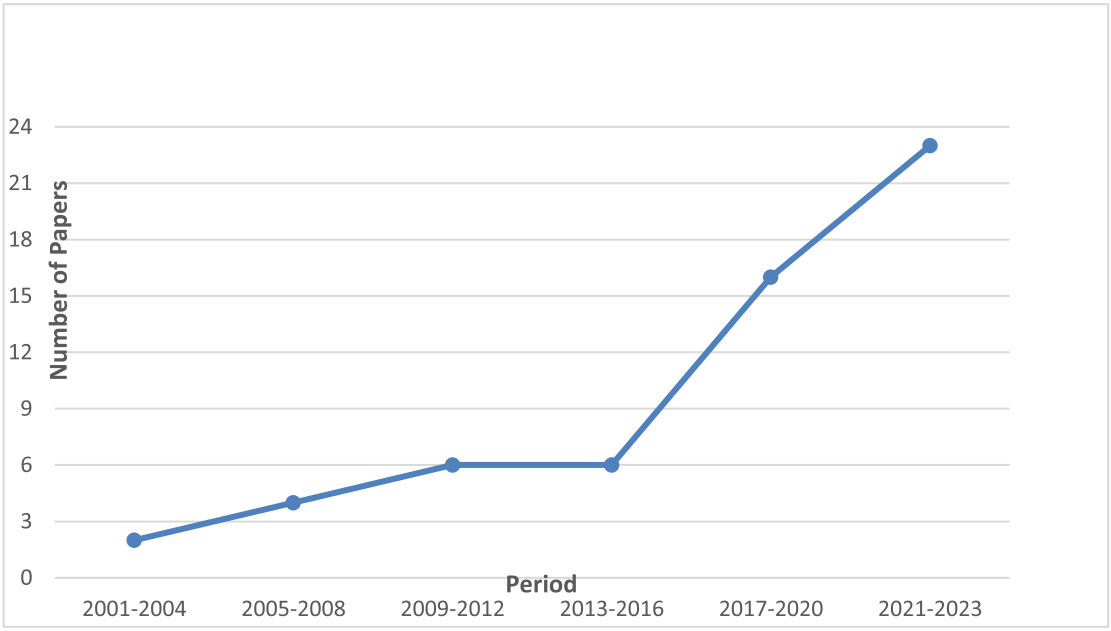

FIGURE 6. Period-wise publication count (a single line graph for Scopus and WoS and others).

TABLE 7. Papers with 10 or more citations and per year citation rate.

No.	Ref.	Title	Citation count	Citation rate (per year)
1	[11]	Gaining Agility through IT Personnel Capabilities: The Mediating Role of IT Infrastructure Capabilities	381	23.8
2	[53]	IT infrastructure services as a requirement for e-learning system success	211	21.1
3	[10]	Managing information technology infrastructure: a new flexibility framework	173	10.1
4	[40]	Delineating IT Resources and Capabilities to Obtain Competitive Advantage and Improve Firm Performance	91	11.3
5	[73]	A Multidimensional Framework for Digital Platform Innovation and Management: From Business to Technological Platforms	86	17.2
6	[71]	A process perspective on platform design and management: evidence from a digital platform in healthcare	48	12.0
7	[56]	A complexity management approach to servitization: the role of digital platforms	34	17.0
8	[58]	Strategic Management for IT Services Using the Information Technology Infrastructure Library (ITIL) Framework	29	7.25
9	[61]	User identity and Access Management trends in IT infrastructure- an overview	25	3.1
10	[77]	A holistic approach to the management of IT infrastructure for environmental monitoring and decision support systems with urgent computing capabilities	24	4.8

the detail of these challenges with existing literature is given below:

a: RELIABILITY

The probability that the system will meet certain performance standards and produce correct output for a particular period as defined in [57]. They discussed reliability w.r.t quality of services in critical systems. The reliability of technology and systems is discussed as redundancy in which redundant resources take over if the primary ones fail [41], [44].

b: QUALITY

A field of study and practice that describes the desirable attributes of software products. The collective effect of service performance determines the level of satisfaction of a user with the service [6]. A few studies proposed methods to manage the quality of services in critical infrastructure [57]. In terms of quality, they considered reliability and availability. ITI patterns are built to improve its design for the delivery of high-quality service to its users [6]. There is a need to consider the quality of service that includes various data transmission aspects and processing performance of multiple computing devices operating in emergency mode [77].

c: TRACEABILITY

An ability to identify and track back to its point of origin is termed traceability. Oliveira and Cruz [30], [31] talked about the traceability of the management of infrastructure where you can trace back log of changes. Moreover, you can record all changes together with the identification of the "author" of each change.

d: MANAGEABILITY

Manageability is the ability of a system to be controlled easily either using self-control or by providing certain techniques to ease external controls. It is identified as a challenge

TABLE 8. Challenges for managing ITI.

Category of challenges	Challenges	References
Shared Technology-Specific Challenges	Reliability	[40][53][41][63][6][51][84]
	Quality	[57][6][77][49]
	Traceability	[30][31]
	Manageability	[50][33][55]
	Efficiency	[29][72][41] [43][76][38][58]
Human-Specific Challenges	Lack of IT Personal Skills	[11][54][43][10][45]
	Lack of dedicated experts	[54][52][39]
	Lack of IT personal understanding	[55][53]
	Need for training of IT Personnel	[58]
	Personnel Change Resistance	[34]
	Lack of trust in IT personnel	[34]
	Inexperienced Employee	[54][34]
IT Components-Specific Challenges	Problems in integration	[34][71][70] [51][32]
	Connectivity Issues	[47][63][37] [10][69][46]
	High resource cost	[39][78]
	Compatibility	[46][45]
	Interoperability	[71][73] [51][67]
	Flexibility	[84][48][50][79][41][42][11][10][44][80]
	Sustainability	[53][45]
	Complexity	[54][72][60][41][38]
	Security	[56][79][39]
	Adaptability	[30][57][51][66][59][61][6][62][79][41]
	Scalability	[38][69][39][78][64]
Other Challenges	Lack of documentation	[58]
	Loss of control	[34]
	Lack of planning	[54]
	Lack of practical work	[33]
	Lack of efficient standards	[51][76]

faced during the management of information systems [55]. It ensures that all components defined as part of the scope are managed according to available support areas within the organization.

e: EFFICIENCY

Efficiency means the ability to produce something without wasting materials, time, or energy. Due to low efficiency, the errors and delays of cloud management are high. Barbosa et al. [28] talked about the low management efficiency of cloud data within ITI. Balabanova et al. [72] corresponded about improvements in the efficiency of logistics and energy efficiency for environmental management in the digital platform. Maciel et al. [36] talked about efficiency w.r.t managing hybrid computing infrastructure for business-driven models. Jirachiefpattana [43] and Damyanov [41] conferred efficiency as a personnel capability of ITI that becomes more efficient and effective if we have more humans with technical, behavioral, and business skills. A few studies presented efficiency and effectiveness as a challenge for the system which needs to be overcome via an effective IT governance framework [58].

2) HUMAN-SPECIFIC CHALLENGES

This study found seven issues related to workforce management, learning, and collaboration while managing ITI. The detail of each challenge with existing literature is given below:

a: LACK OF IT PERSONAL SKILLS

Lack of interpersonal skills when managing ITI can hurt an organization's overall effectiveness and success. The role of IT personnel capabilities is dependent upon extending ITI capabilities. In addition to the technical competence of IT personnel, their behavioral competence, which signifies their capacity to coordinate, implement, and oversee tasks in collaborative environments, significantly enhances the quality of infrastructure services [11]. IT personnel competency

is lacking inside the enterprises which includes both the skills and experience required for IT personnel to perform IT activities [10]. The lack of technical, managerial, and business capabilities of IT personnel affects ITI capability within enterprises [43], [45].

b: LACK OF DEDICATED EXPERTS

Over the past few years, there has been a consistent rise in the demand for IT professionals within the European Union's unified labor market. However, Europe is currently facing a shortage of qualified Information and Communication Technology (ICT) specialists to meet the expanding array of job openings across various sectors of the economy [86]. Many organizations are facing skill mismatch problems with their IT personnel which need to be resolved on the highest priority [39]. There is no dedicated team or expert in the field who recommends the needed latest infrastructure of the local universities and colleges [54]. Moreover, people are trying to tackle this issue by designing e-courses that provide all the information on one platform to become specialists in their IT profession [52].

c: LACK OF IT PERSONAL UNDERSTANDING

It typically refers to a situation where individuals working in an IT-related role or department do not have a sufficient or comprehensive understanding of certain aspects or components of their job, the technology they are responsible for, or the broader context in which they operate [53]. This lack of understanding can hinder their ability to effectively perform their duties and make the delivery of the service, as it can lead to failures in communication between the different teams that manage the environment [55].

d: NEED FOR TRAINING OF IT PERSONNEL

It signifies the requirement or demand for providing additional education, instruction, or skill development to individuals working in information technology (IT) roles within an organization. This training is necessary to enhance their knowledge, expertise, and proficiency in various IT-related areas, including technology, tools, processes, security, and best practices [58]. The need for training may arise due to technological advancements, changes in the organization's ITI, evolving industry standards, or a desire to improve the IT team's overall performance.

e: PERSONNEL CHANGE RESISTANCE

It is a natural tendency of employees within an organization to be hesitant, unwilling, or oppositional when confronted with changes in their work environment, including alterations in policies, procedures, technology, systems, or organizational structure. The main reason for employee resistance to the adoption of the latest digital platform could be that they perceived the new technology to be a burden on top of their current work resultantly, their workload increased [34].

f: LACK OF TRUST IN IT PERSONNEL

It indicates a situation where there is a deficit of confidence or belief in the ability and commitment of IT personnel to protect the privacy and security of sensitive data. This lack of trust can stem from various factors, including concerns about data breaches, unauthorized access, or inadequate data protection measures [34]. It may be that IT personnel are not following best practices or security protocols.

g: INEXPERIENCED EMPLOYEE

This term is used to describe a worker who lacks the knowledge, skills, and practical experience typically expected in a specific job or field. Such an employee may be new to the role or industry or may not have the qualifications, capability, or expertise required to perform the job effectively [34], [54].

3) IT COMPONENTS SPECIFIC CHALLENGES

In total eleven challenges were found which are associated with individual elements or components of an IT system. The detailed description of each challenge concerning the existing literature is as follows:

a: PROBLEMS IN INTEGRATION

In the context of IT and systems, refers to difficulties that arise when trying to connect or combine different software applications, systems, or technologies in a way that allows them to work together seamlessly. Multiple studies discussed the integration of different digital services with third-party tools for example in the health sector [71] and educational institutes [51] to make it smoother for performing specific functionality, but this type of complex integration may be challenging to implement and maintain. A few studies found data integration problems during data migration from one system to another and identified that integration is not even a standard base creating difficulties in managing the system [51].

b: HIGH RESOURCE COST

It means that the allocation of significant resources, including time, money, personnel, and technology, poses a difficulty in the effective management of an organization's ITI. Even the case of training or educating personnel to enhance their skills to adopt technology includes high cost, and this is a major weakness of using digital platforms [39], [78].

c: CONNECTIVITY

Connectivity is the competence of IT components to make internal and external electronic linkages which include connections among units, branches, and external parties [80]. Shibambu and Dista [37] discussed ITI connectivity related to a higher degree of improved public sector services. Connectivity is a major challenge faced by students and teachers in terms of poor internet connection during learning sessions [47]. To improve the overall functionality of the ITI enterprises, need to boost connectivity [45].

d: INTEROPERABILITY

It refers to challenges that arise when different software, hardware, systems, or devices within an organization's IT environment are unable to work together smoothly or effectively. Fürstenau et al. [71] discussed key issues including interoperability concerning healthcare service providers. Chirumamilla and Sindre [51] conferred interoperability as a main feature and challenge in their e-exams and LMS systems. There are opportunities created by digital infrastructures while confirming the interoperability of cross-site data for research [67].

e: FLEXIBILITY

This challenge is related to the adaptability and responsiveness of an organization's IT systems, hardware, software, and infrastructure to changes in technology, business needs, or unforeseen circumstances. Flexibility creates a linkage between different organizations' information systems as one network and is adaptive to change when the number of users increases. A few studies highlighted the challenges faced in achieving flexibility and the importance of standards in supporting flexible ITI [84,44]. Flexibility issues arise while managing ITI in a multi-cloud environment [48]. Multiple studies discussing flexibility issues while implementing ITI in the construction industry focused on dimensions that can improve management efficacy [45], [80].

f: SUSTAINABILITY

Sustainability covers the manufacturing, use, management, and disposal of information technology in a way that minimizes its impact on the environment. A Study discussed the sustainability issues related to the use of digital platforms for environmental management, focusing on the challenges of data quality and accessibility [72]. The sustainability issues highlight the need for a data-sharing framework to manage digital infrastructure effectively [54], [60] and to adopt sustainable practices in the design, operation, and disposal of IT systems [41].

g: COMPLEXITY

Complexity is a state of having many distinct parts connected or related to each other in a complicated way. Eloranta et al. [56] analyzed complexity management in servitization w.r.t digital platform. They identified that servitization has been adopted to reduce or absorb complexity. Another study [39] found complexity as a challenge in managing a project. They try to minimize this complexity in large projects through digital platforms.

h: SECURITY

Security is a practice to protect critical systems and IT assets (i.e., hardware, and software) against physical and cyber threats. Savola and Sihvonen [66] emphasized the privacy of sensitive data and discussed three fundamental security metrics i.e., effectiveness, efficiency, and correctness for IoT applications. There should be an extended control list only for authorized users and a security policy for routers to detect management activities to ensure secure internet access [6]. A tool developed using distributed ledger technology to provide a secure log storage and resource inventory of ITI [30]. Defend ITI security via specialized hardware and software, permanent end-user education, and proper testing in government and public institutions [41], [57]. A secure e-exam environment was provided using Moodle LMS and ensured data authenticity and security [51]. Security mechanisms are proposed for digital ecosystems to protect resources and information [59].

i: ADAPTABILITY

Adaptability is a skill that allows you to be flexible and accept change easily. It is one of the core and essential capabilities of a system. A few studies discussed adaptability as a challenge in the convergence of manual to digital platforms in education and supply chain management sectors [34], [47].

j: SCALABILITY

Scalability is the degree to which hardware/software can be scaled and upgraded on existing infrastructure [10]. A study discussed scalability issues related to the management of cloud ITI, including challenges in handling increasing workloads and the need for efficient resource allocation and utilization. It also highlights the importance of scalability in ensuring the high availability and performance of cloud services [32]. Another study referred to the need for scalable ITI patterns to meet the increasing demands and provide high-quality IT services [6].

k: COMPATIBILITY

Compatibility is a state in which two things can exist or appear together without any conflict or problems. A study [45] discussed compatibility issues related to the implementation of flexible ITI in the industry, including the lack of compatibility between different IT systems and the compatibility challenges between existing workflows and the new ITI. Another study [46] discussed compatibility issues between IT personnel skills and IS infrastructure, as well as their impact on competitive IS.

4) OTHER CHALLENGES

Five other issues are not specified in the above-given classification, but organizations face within their environment. The details are given below:

a: LACK OF DOCUMENTATION

It refers to a situation where necessary details, processes, and guidelines have not been adequately documented, leading to difficulties in comprehending, replicating, or maintaining certain aspects. A study [58] discussed the challenges and issues related to the lack of documentation in the implementation of IT service management strategies using the ITIL framework. It highlights how this can lead to communication

TABLE 9. Recommendations for organizations.

Categories of guidelines	Guidelines	Applicability			References
		SMEs	Large Organization	Not Specified	
Design and follow policies and standards	- Defining standardized routines and processes		✓		[38][43] [56][64] [84]
	- Need to improve relevant laws and regulations	✓	✓		
	- Design policies and programs based on technological, organizational, and environmental factors		✓		
	- Design human resource policies			✓	
	- Standards need to be flexible and adaptable to new requirements	✓			
User training and awareness programs	- Explain policies, goals, current business status, and environmental constraints of the organization to IT personnel		✓		[10][53] [43][54] [39]
	- Provide training courses for academic staff to use e-learning systems	✓			
	- Training and organizational development programs	✓	✓		
	- Needs training to increase the capability of existing employees to resolve problems	✓			
	- Develop a program to enhance managerial skills of IT personnel (e.g., leadership role)		✓		
	- Training of employees is geared towards eliminating skills mismatches when new technology is introduced into an organization			✓	
Implement policies for IT components	- Rotate IT personnel to learn different jobs every six months, for example, rotate a system analyst to become a project manager		✓		[10]
	-Implement hardware/software that is reputable or based on current technological trends		✓		
	- Develop a plan for expanding and upgrading hardware and software at least for the next six months	✓			
	- Create a manual or documentation for each hardware and software		✓		
	- Develop connectivity by creating electronic linkages among departments and branches as well as external parties (e.g., customers, suppliers)		✓		
	- Maintain compatibility. If possible, use the same operating system throughout the organization If not, ensure the interoperability among applications and operating systems			✓	
	- Implement web services platform (e.g., Microsoft's .NET) to interact with other applications using open standards		✓		
	- Provide Regulatory Compliance			✓	
Implement and follow security policies	- Make policies that define security roles and responsibilities within an organization		✓		[75][69] [6][10]
	- Provides an authentication and authorization framework		✓		
	- All network devices only accessed by authorized person	✓	✓		
	- Implement auditing and reporting protocol		✓		
	- Design policies that deal with the operational aspect of the organization including physical security and employee training			✓	
	- Implement backup strategies		✓		
	- Keep data in a safe place in addition to the office	✓			
	- Create a disaster plan for recovery				

gaps, difficulties in knowledge transfer, and an overall lack of clarity regarding processes and procedures.

b: LOSS OF CONTROL

The loss of control issues arising from the increasing reliance on digital platforms in transnational supply chain management. It highlights the risks associated with the loss of direct control over key processes and decision-making, as well as the potential for cyber-attacks and disruptions in the digital ecosystem [34].

c: LACK OF PLANNING

It refers to the absence or lack of structured and thorough preparation for various aspects of IT operations. The lack of long-term strategic planning and the absence of contingency plans were identified as key issues on the maturity level of ITI in educational institutes [54].

d: LACK OF PRACTICAL WORK

The challenges of laboratory and practical work in distance learning include limited access to hands-on experience and equipment, safety concerns, and the need for effective assessment and collaborative learning solutions. Adaptations like virtual labs and simulations are employed, but they may not fully replicate traditional in-person practical experiences [33].

e: LACK OF EFFICIENT STANDARDS

It refers to a situation where there is an absence or inadequacy of well-defined and widely accepted guidelines, protocols, or criteria for a particular process, product, or industry. There are multiple processes such as planning, change adoption, integration, etc. where enterprises do not follow the standards [51]. Moreover, using only one standard may not address the specific needs and requirements of all IT systems,

potentially leading to issues related to security, performance, or compatibility. In practice, organizations need to adopt a combination of standards, guidelines, and best practices to manage their ITI comprehensively [76].

D. RQ4 (WHAT GUIDELINES AND RECOMMENDATIONS HAVE BEEN PROPOSED TO OVERCOME THE REPORTED CHALLENGES?)

By reviewing the existing literature on the topic and categorizing it, we synthesized the guidelines and recommendations from existing literature that could help mitigate the reported challenges while managing the ITI. These recommendations and guidelines are grouped based on their relevance for (i) organizations and (ii) personnel.

1) GUIDELINES AND RECOMMENDATIONS FOR ORGANIZATIONS

In total, 27 guidelines and recommendations for organizations were extracted from the existing literature. A synthesis of the detailed guidelines and recommendations extracted from the existing literature is presented in Table 9.

These extracted guidelines and recommendations are grouped into 4 categories covering small and medium enterprises (SMEs) and large organizations. The detailed description of each of the categories concerning the existing literature is as follows:

a: DESIGN AND FOLLOW POLICIES AND STANDARDS

It's good to establish a set of protocols and procedures that govern the way tasks and operations are carried out within the IT department or organization [56]. It also builds the necessity of creating and updating relevant laws and regulations frameworks that ensure the security, privacy, and effective operation of IT systems and data [38]. These guidelines and standards should be created considering the different aspects of the organization such as technological, organizational, and environmental [64]. By creating guidelines and procedures to ensure the effective recruitment, training, development, and retention of IT personnel. These policies aim to establish a strong workforce, promote employee satisfaction, and align their skills and knowledge with organizational goals and objectives in the IT department [43]. Lastly, standards should be dynamic and easily adjustable to meet the evolving needs of the IT landscape while facilitating efficient operations and technological updates [84].

b: USE TRAINING AND AWARENESS PROGRAMS

It is essential to effectively communicate the organization's policies, goals, current business status, and environmental constraints to IT personnel. This ensures that the IT team understands the organization's expectations, adapts its strategies, and aligns toward meeting business objectives while considering environmental limitations [10]. Offer training and educational programs for staff to enhance their knowledge and skills in utilizing digital systems as part of managing ITI [53], [54]. These training courses aim to enable members to effectively navigate, boost their skills, and enable them to utilize digital tools and platforms efficiently for organizational purposes [10], [39]. Sometimes, Implementing a rotation system is also effective as it involves periodically shifting employees between different roles. For instance, a system analyst could become a project manager, allowing them to expand their skill set and gain new perspectives within the organization. This practice facilitates cross-training, improves understanding across various functions, and enhances overall productivity [10].

c: IMPLEMENT POLICIES FOR IT COMPONENTS

Develop a plan for implementing, expanding, and upgrading hardware and software which must involve preparing for future technological advancements. This plan should cover a timeframe of at least six months and align with current trends in the industry. By doing so, businesses can ensure they stay up to date with technology and optimize their ITI [10]. It is a good practice to create and maintain documentation or manual of every IT component including hardware and software. It creates electronic linkages by developing connectivity among departments and branches including external parties [10]. Implement a web services platform like Microsoft's. NET or Sun's Java 2 Enterprise Edition to enable seamless communication between different applications, utilizing open standards. This facilitates integration and data exchange, enhancing the efficiency and compatibility of ITI [10].

d: IMPLEMENT AND FOLLOW SECURITY POLICIES

Create policies to clearly outline security roles and responsibilities within the organization and ensure regulatory compliance [75]. These measures establish a framework for protecting data and systems while sticking to legal and industry-specific requirements, thereby enhancing the management of ITI [69]. Implementing an authentication and authorization framework with regulatory compliance is crucial for securing sensitive information and ensuring that your systems and applications adhere to legal and industrial standards [75]. Implementing robust backup strategies, ensuring data redundancy, and creating a disaster recovery plan are essential components of a comprehensive data protection and business continuity strategy [10].

2) GUIDELINES AND RECOMMENDATIONS FOR PERSONNEL

In total, 41 guidelines and recommendations were extracted for the personnel. A synthesis of the detailed guidelines and recommendations extracted from the existing literature is presented in Table 10.

These guidelines and recommendations for personnel are classified into six categories. The detailed description of each of the categories concerning the existing literature is as follows:

TABLE 10. Recommendations for personnel.

Personnel	Guidelines	Reference
For Developers	- All data should be on one platform - Content must be perceivable -Technical support when needed, including face-to-face training during deployment and technical training via the application - Interface components in the content must be operable - Content and controls must be understandable - Content should be robust enough to work with current and future user agents - Build user-friendly applications (e.g., web-based, menu-driven) -Design Manual for using a digital app	[65][10]
For CEOs	- Make sure standards should be compliant and adaptable to new requirements - Existing infrastructure must be developed in a way that the installed base can be linked together with new technology - Provide budgets for IT personnel to gain new knowledge (e.g., seminars, IT professional certificates) - Set goals and evaluate the performance of IT personnel at least once a year - Offer an incentive or a reward to IT personnel who can successfully introduce and apply new technologies to solve business problems	[84][10]
For CIOs	- Need to develop perpetual training practices aiming at keeping employees updated on digital trends which may emerge, to overcome their resistance - A team of IT experts must be carefully selected, To align between business and ITI, IT personnel who develop the IT systems must understand the nature of the business that they are working on, and be expert in using IT, they must be aware of the changes in business needs, as well as in technology. - Encouraged IT professionals to learn new information technologies - Closely follow the trends in current information technologies - Make sure strategies of the IT unit and the company's strategies are well aligned - Able to interpret business problems and develop appropriate technical solutions - They should be knowledgeable about business functions	[84][10] [34][80] [11][75]
For IT Managers	- Should be self-directed and proactive - They could plan, organize, and lead projects - Make sure about the expert people in the field - The ability to plan and execute work in a collective environment - Ability to work well in cross-functional teams addressing business problems - They are cross-trained to support other IT services outside their primary knowledge domain - Track user activity with auditing and reporting -To cross-check their suppliers in emerging markets not only for the price of their offering but also for the adaptability to macro shocks and their technological readiness	[54][80] [11][75] [34]
For Technical Staff	- Should be skilled in multiple structured programming, CASE methods, or tools - Be an expert in distributed processing or distributed computing - Be skilled in network management and maintenance - They should be skilled in developing Web-based applications - Be skillful in data warehousing, mining, or marts	[11]
For Researchers	- Design and Implement digital tools for managing the progress of overall ITI - There should be a tool to identify the potential risk of the project as identification of risks makes it easier to mitigate them - Develop a framework to enhance the collaboration between team members while working on the same project - Design a model for proper planning and monitor & track all processes - Design a self-healing system that can predict the failure of a system before it occurs with minimum human intervention - There should be a basic quality management model for ITI - Design overall ITI to handle an increase in users, workload, and transactions, for example, use a hub or switch that supports ten percent more connections than the number of staff	[29][39] [30][24] [57][10]

a: FOR DEVELOPERS

They should prioritize unifying data onto a single platform to enhance accessibility and efficiency. To ensure content is perceivable, they should focus on clear presentation and accessibility features. Technical support, both in-person during deployment and through application-based training, is essential for a seamless user experience. Making interface components operable and content understandable is crucial for usability. In addition, developers should ensure their content is robust enough to work with current and future user agents, promoting long-term functionality and adaptability [65]. They need to create user-friendly applications, focusing on intuitive design and consistency to enhance user experience. Moreover, designing a comprehensive manual for using the digital app is crucial. This manual should feature clear step-by-step instructions, and troubleshooting guidance, so that users can easily navigate the application and access helpful resources when needed, ultimately promoting usability and user satisfaction [10].

b: FOR CEOs

They should prioritize several key initiatives to foster technological growth within their organizations. Firstly, ensuring that established standards are both compliant with regulations and flexible enough to meet emerging requirements is essential. Secondly, it's crucial to develop the existing infrastructure in a way that allows seamless integration of new technologies, thereby maximizing efficiency and scalability (Sirkemaa, 2002). Providing budgets for IT personnel to enhance their knowledge through avenues like seminars and professional certificates can empower your tech workforce to stay current. Regularly setting clear goals and evaluating the

performance of IT staff at least annually can help maintain a high level of productivity and accountability. Lastly, incentivizing and rewarding IT professionals who successfully introduce and apply new technologies to solve business challenges not only motivates your team but also drives innovation, efficiency, and user satisfaction in the organization [10].

c: FOR CIOs

They play a pivotal role in steering their organizations toward digital success. To achieve this, they should prioritize continuous training programs to keep employees updated on emerging digital trends, thereby addressing any resistance to change [34]. Building a skilled IT team is vital; IT personnel should not only be technology experts but also possess a deep understanding of the business they serve, aligning ITI with the organization's needs [80]. Effective communication is key, as CIOs should clearly explain organizational policies, goals, and environmental constraints to their IT personnel [10]. Encouraging a culture of learning and staying current with information technology trends is essential for staying competitive. Additionally, CIOs must ensure that IT unit strategies align seamlessly with the overall company strategies. Moreover, IT professionals should be capable of interpreting business challenges and devising technical solutions while possessing knowledge of various business functions [64]. This holistic approach will enable the IT department to drive innovation and support the organization's success.

d: FOR IT MANAGERS

IT managers are pivotal in driving technology initiatives within organizations. To excel in this role, they must exhibit self-directed and proactive behavior, taking the initiative to identify and address technological challenges and opportunities [11]. They must possess the ability to effectively plan, organize, and lead projects, ensuring that technology-related endeavors are executed successfully. Surrounding themselves with a team of experts in their field is paramount, as this expertise can provide valuable insights and problem-solving capabilities [54], [80]. Collaborative skills are essential, allowing IT managers to work effectively in cross-functional teams, particularly when addressing complex business problems. Cross-training in various IT services beyond their primary domain knowledge enhances their versatility and ability to support different aspects of the organization [11]. Tracking user activity through auditing and reporting ensures security and compliance [75]. Additionally, in a globalized world, IT managers should carefully assess suppliers, not just based on cost but also on their ability to adapt to macroeconomic shocks and technological readiness, providing resilience in the supply chain [34].

e: FOR TECHNICAL STAFF

Technical staff members are the backbone of an organization's technology infrastructure. To excel in their roles, they should possess a versatile skill set. This includes proficiency in structured programming and the use of Computer-Aided Software Engineering methods and tools. Additionally, they should be experts in distributed processing and distributed computing, which is essential for optimizing performance and scalability [11]. A strong grasp of network management and maintenance is crucial, ensuring that the organization's connectivity remains stable and secure. Technical staff should also be experts at developing web-based applications, as this is often a key component of modern business operations. Lastly, skills in data warehousing, mining, and data marts are valuable, enabling them to extract insights from data and support informed decision-making [11]. By combining these skills, technical staff can contribute significantly to the organization's technological success and innovation.

f: FOR RESEARCHERS

In the field of ITI, several important recommendations can guide the researcher's work. First, they should focus on designing and implementing digital tools that enable the efficient management of ITI progress, as emphasized in [29]. Identifying potential risks is crucial, so the development of risk identification tools, as proposed by Khatib et al. [39], is paramount. Furthermore, researchers should work on creating collaboration-enhancing frameworks, such as those suggested in [39], to promote teamwork on IT projects. Models for planning, monitoring, and tracking processes, like the one outlined [30], can significantly improve project management. To address system reliability, a self-healing system that predicts failures with minimal human intervention, as proposed [24], is important. Additionally, a quality management model specific to ITI, as recommended by Kolesnik and Rolik [57], should be developed to ensure high standards. Finally, ITI should be designed with scalability in mind, capable of accommodating increased users, workloads, and transactions, as noted by [10]. These recommendations can guide researchers in advancing the field of ITI and solving critical industry challenges.

V. DISCUSSION

This section provides a summary of the findings, validity threats, and limitations of the study.

A. SUMMARY OF FINDINGS

This SMS gives detailed insights into the management aspects of ITI. This study is useful for researchers and domain experts who may use the results of this study to start their research and projects in the context of ITIM.

In this mapping study, we searched through the chosen databases with the defined criteria. Resultantly, we came across 332 articles. We defined inclusion and exclusion criteria as all studies were not related and unique. Then, we were left with 46 relevant and unique articles. Before starting the analysis, we applied the forward and backward approach to 46 papers and found 11 more papers. To provide an analysis of 57 papers, we developed a classification scheme that comprises 4 facets, namely, research focus, publication trends

TABLE 11. Systematic map overview.

Ref.	ITIM Focus	Context	Contribution Type	Paper Type	Research Method	Challenge addressed	Publication Type
[29]	Resource management	Multicloud platform management (SDN Cloud)	Framework	Evaluation research	Constructive study	Efficiency	Journal
[30]	Resource management	To provide a secure log storage and resource inventory of the ITI	Tool	Evaluation research	Constructive study	Security Traceability	Conference
[31]	Resource management	To provide a single point of management, & maintaining a resource inventory	Tool	Solution proposal	Constructive study	Traceability	Conference
[54]	Service management	ITSM Assessment	Framework	Evaluation research	Survey	Sustainability, Lack of planning, Lack of capability to resolve issues, Lack of dedicated expert	Conference
[24]	No particular focus	Failure condition avoidance model	Model	Philosophical paper	Literature study	Not specified	Journal
[57]	Service management	Quality management Model	Guidelines	Solution proposal	Constructive study	Security, Quality	Conference
[84]	Others (Change)	ITI Development Standards	Guidelines	Philosophical paper	Discussion paper	Reliability, Flexibility	Conference
[35]	Resource management	Infrastructure management platform using TOSCA-based cloud app	Framework	Validation research	Constructive study	Not specified	Conference
[55]	Service management	IT frameworks and ITSM models	Framework	Solution proposal	Constructive study	Manageability, lack of understanding of IT personnel	Journal
[47]	Learning styles management	Strategic management approach through Digital Platforms	Theory	Philosophical paper	Grounded theory	Adaptability, Connectivity	Journal
[34]	Resource Management	Supply chain continuity by developing a digital platform	Theory	Evaluation research	Case study, Grounded theory	Adaptability, Employee resistance to usage of digital platforms, difficulties in integration in ERP, data privacy and trust problems, loss of control, lack of employee experience, risk of a greater number of new entrants	Journal
[56]	Service management	Complexity management mechanisms in servitization through a digital platform	Theory	Evaluation research	Constructive study, Case study	Complexity	Journal
[71]	Others (Development process)	Design and management framework of digital platform	Framework	Evaluation research	Case Study, Interview	Interoperability Integration	Journal
[33]	Resource management	Digital platform management tool based on PaaS cloud service delivery model	Tool	Solution proposal	Constructive study	Manageability, Problem of laboratory, and practical work in e-learning	Journal
[72]	Others (Environment)	digital platforms for environmental management	Framework	Solution proposal	Mix method, Discussion paper	Efficiency, Sustainability	Conference
[70]	Others (MIS)	Digital platforms of business management	Model	Validation research	Discussion paper, Constructive study	Integration	Conference
[73]	Others (Strategic)	Digital platforms innovation & management model	Model	Evaluation research	Action research	Interoperability	Journal
[48]	Learning styles management	Digital platform-based Enterprise management practice (Teaching model)	Model	Validation research	Constructive Study	Effectiveness, Flexibility	Journal
[65]	Self-care management	Digital Platform to Support Self-Management (ProACT)	Model	Evaluation research	Constructive Study, Action research, Interviews	lack of information in self-management	Journal
[51]	Learning styles management	E-assessment through the digital ecosystem	Theory	Evaluation research	Grounded theory	Reliability, Security, Integration Interoperability Scalability, Integration is not standard based, Data quality low	Journal
[66]	Self-care management	Management Framework Digital Ecosystem for effective self-care of chronic diseases	Framework	Philosophical paper	Discussion paper	Security	Conference
[59]	Data sharing and access management	Digital Ecosystem Management for controlling access management (enforcing permission)	Framework	Experience paper	Discussion paper	Security	Journal

TABLE 11. *(Continued.)* **Systematic map overview.**

[60]	Data sharing and access management	Digital infrastructure management framework for Data sharing, disaster emergency response, remote sensing data	Framework	Validation research	Constructive Study	Sustainability	Conference
[67]	Self-care management	Digital Infrastructures for disease management	Tool	Evaluation research	Constructive Study	Interoperability	Journal
[36]	Resource management	Hybrid computing ITIM	Model	Evaluation research	Constructive Study	Efficiency	Journal
[32]	Resource management	Cloud ITIM using SDN approach	Model	Solution Proposal	Constructive study	Integration Scalability	Conference
[75]	Others (Construction for knowledge)	ITI for Knowledge management	Lesson Learned	Evaluation research	Mix method, Case study	Not specified	Journal
[61]	Data sharing and access management	Data security management in ITI (user authentication and authorization)	Lesson Learned	Philosophical paper	Discussion paper	Security	Conference
[50]	Learning styles management	A Curriculum Define Model for Undergraduate	Model	Evaluation research	Survey	Flexibility, Manageability	Journal
[6]	Service management	ITI Patterns approach (to improve ITSM quality)	Guidelines	Validation research	Discussion paper	Security, Quality Reliability, Scalability	Conference
[74]	Others (Construction for knowledge)	ITI for Knowledge management	Lesson Learned	Validation research	Mix method	Not specified	Conference
[77]	Others (environment)	ITI management for environmental monitoring	Framework	Evaluation research	Case study	Quality	Journal
[62]	Data sharing and access management	ITI for identity management using GDPR	Tool	Philosophical paper	Discussion paper	Security	Conference
[49]	Learning styles management	Digital platform for the Management E-portfolio (to get training for acquiring skills) for final year project in bachelor	Tool	Evaluation paper	Survey	Quality	Conference
[68]	Self-care management	Digital platform to support self-management	Theory	Evaluation research	Grounded theory	Effectiveness	Journal
[63]	Data sharing and access management	A model built for Aircraft Reliability Management	Model	Solution Proposal	Constructive study	Reliability, Connectivity	Conference
[79]	No particular focus	Digital Infrastructure Management (Challenges and Opportunities in Post covid era)	Lesson Learned	Experience paper	Discussion paper	Complexity, Flexibility, Security	Journal
[41]	Human ITI capability	Conceptual framework of core components and human IT	Framework	Validation Research	Constructive study	Flexibility Efficiency Security, Reliability Sustainability	Journal
[42]	Human ITI capability	Role of Capability in ITIM	Lesson Learned	Philosophical paper	Literature study	Flexibility	Journal
[37]	Resource management	Flexibility contribution	Model	Evaluation Research	Survey	Connectivity	Journal
[11]	Human ITI capability	IT personnel capability	Model	Evaluation Research	Mix method	Flexibility, Lack of IT personnel skills, ability	Journal
[43]	Human ITI capability	ITI Capabilities (through IT Personnel)	Model	Evaluation Research	Survey	Efficient Effective, Lack of effective personnel capabilities	Journal
[76]	Others (frameworks integration)	IT management frameworks integration: ITIL, COBIT, Enterprise architecture	Framework	Philosophical paper	Interview	Efficient, one standard is not enough to follow	Journal
[10]	No particular focus	Flexibility framework	Framework	Evaluation Research	Mix method	Flexibility, Connectivity Scalability, Lack of IT personnel competency	Journal
[44]	Human ITI capability	Human IT (IT department, management, users)	Lesson Learned	Experience paper	Discussion paper	Flexibility	Journal
[38]	Resource Management	Innovation Management of Enterprise Supply Chain Digital Platform	Model	Solution Proposal	Constructive study	Security Efficiency, Sustainability	Journal
[80]	No particular focus	ITI Flexibility Framework	Framework	Philosophical paper	Literature study	Flexibility, Connectivity	Journal
[52]	Learning styles management	Design an e-course by assembling all technologies to make an ICT specialist	Model	Validation Research	Constructive study	Less skilled people (specialist)	Conference
[69]	Self-care management	Real-time monitoring and Management of Diabetes Patients	Model	Evaluation Research	Constructive study	Connectivity, security	Conference

TABLE 11. *(Continued.)* **Systematic map overview.**

[39]	Resource Management	Use of digital platforms in project management	Lesson learned	Solution Proposal	Interview	Cost-intensive, Skill mismatch, Security, Complexity	Conference
[78]	Others (Virtual reality)	To serve better IT operations through Virtual reality	Lesson learned	Experience paper	Discussion paper	Cost, Security	Conference
[58]	Service Management	Design a model to provide better management of IT services	Model, Guidelines	Solution Proposal	Interview	Efficiency, No documentation, need for training human resources	Conference
[64]	Data sharing and access management	Impacts of trust in the e-filing system using and adopting technology	Model	Validation Research	Survey, Questionnaire	Security	Journal
[53]	Learning styles management	role of ITI services to bring awareness to educational institutions	Model	Evaluation Research	Survey	Reliability, Flexibility, and lack of understanding of e-learning functions	Journal
[45]	Human ITI capability	Identifying IT human factor to deliver flexible ITI	Framework	Evaluation Research	Survey	Flexibility, compatibility, connectivity, Lack of technical and managerial skills	Journal
[40]	Resource Management	Management of IT resources and capabilities to improve firm performance	Model	Evaluation Research	Survey	Reliability	Journal
[46]	Human ITI capability	Identifying the Impact of IT Personnel Skills on IS Infrastructure	Framework	Evaluation Research	Survey	Connectivity, Compatibility, Cost efficiency	Journal

& research characteristics, challenges, and guidelines and recommendations (refer to Figure 4).

Concerning research focus (RQ 1), we concluded that ''Resource management'' especially in a cloud environment is the major research focus with 12 articles (refer to Table 3).

RQ2 focuses on paper types, research methods, and contribution types. This study found that ''Evaluation research'' with 25 articles is the most frequently employed paper type, however, ''Experience papers'', was the least used paper type with only 4 papers (refer to Table 4). ''Constructive study'' with 20 articles was the dominant research method, however, ''Action research'', and ''Literature study'' were the least used research methods each with 2 papers only (refer to Table 5). Lastly, ''Model'' with 18 appearances is the most frequently employed contribution type followed by'' frameworks'' with 16 articles (refer to Table 6).

RQ3 addressed challenges in which ''Security'' and ''Flexibility'' were the most common ITIM issues with 15 and 12 articles respectively. Interestingly, ''Compatibility'' and ''Adaptability'' were among the least focused challenges with only 2 articles (refer to Table 8). In total 28 challenges were found of which, 5 challenges were related to shared technology services. There were 8 challenges related to IT Humans. Additionally, 12 challenges were specified under IT components. Lastly, a few challenges were categorized as other miscellaneous challenges (refer to Table 8).

RQ4 highlights the guidelines and recommendations. In this study, 27 guidelines and recommendations were proposed for organization and 41 for personnel (refer to Tables 9 and 10 respectively). By adhering to these guidelines and recommendations, organizations can effectively manage their ITI, ensuring it remains secure, efficient, and aligned with their strategic goals.

B. THREATS TO VALIDITY

In any SMS, identification of potential problems of bias and validity is necessary. Since there are some threats to the validity of this research, the validity evaluation of this mapping study is important. According to Perry et al. [87], at least three kinds of threats namely (i) construct validity, (ii) internal validity, and (iii) external validity exist that should be addressed to validate the credibility of the results.

To assure construct validity, we explicitly provided the research questions and objectives in Section III. Therefore, it would be helpful to have the same understanding for other researchers who may be interested in repeating this research activity in the future. We defined and refined our search queries based on the attained results and our search string used synonym words and performed search queries in well-established and related electronic databases. The purpose of this exercise was to find the maximum number of related papers to our research questions for this study. we tried to include as many studies as possible from the chosen electronic databases. It is still possible that we might have missed some articles.

Regarding internal validity, we restricted our study to the specific techniques to extract data, which was provided in Section III, and showed the findings through graphs, diagrams, and tables. In other words, applying a well-defined methodology minimized the bias of the study. We guarantee external validity as this work does not make any claims, generalizations, or projections.

C. LIMITATIONS

This SMS contains a few limitations. Firstly, this study is limited to 2 major scientific databases, thus it does not cover

all the existing journal and conference databases. Moreover, it considers only peer-reviewed journal and conference articles, and it excludes any book sections or magazines.

In the sphere of search keywords, we apply synonym words to get a maximum number of results. For example, we used ''platform'' and ''ecosystem'', as the alternatives for ''infrastructure'' and ''digital'' as the alternative of ''information technology''. However, some articles using other terms may be missing.

VI. CONCLUSION

The focus of this study was to review existing literature regarding ITIM management based on four research questions. We used the SMS method [25] to determine the research focuses, contribution types, and issues studied in the ITIM domain. We categorized the existing studies based on the research focus, publication trends, challenges, and recommendations. The findings offer a guideline to support the research community to plan their future research via research gaps.

This SMS study identified 57 conference and journal articles which were categorized based on 4 facets; moreover, this study observed the distribution of papers and research trends over the years. This SMS study revealed that each research focus is addressed in 6 to 7 studies except for ''Resource management'' with 12 studies. ''Models'' and ''Frameworks'' were dominating contribution types while studies about guidelines appeared rarely. Most existing studies discussed ''Evaluation research'' as a paper type while ''Experience papers'' were rarely discussed. ''Constructive study'' with 20 studies was the major research method. ''Security'' and ''Flexibility'' turned out to be dominating research challenges. The paper identifies and classifies existing challenges in managing ITI. In addition, the paper also presents 68 guidelines and recommendations for organizations and personnel to overcome the challenges.

This mapping study has implications not only for researchers but also for practitioners. Research focus classified as ''Evaluation research'' (refer to Table 4) is helpful for practitioners in realizing that management of cloud resources is more significant. This work offers a good insight for the research community regarding prevailing research gaps in ITIM. Research demands more focus on empirical methods. From trends of published studies, researchers can apprehend that ''Evaluation research'' has more tendency for publications.

The basic future research implication is to use empirical methods like interviews and surveys for data collection and knowledge about management challenges. Enterprises can solve their ITI issues efficiently provided they overcome the major barrier of ITIM challenges realization. Then, we can provide a framework as a solution to overcome ITIM challenges.

APPENDIX

See Table 11.

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