Review

A Systematic Literature Review of the Digital Transformation in the Arabian Gulf's Oil and Gas Sector

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Abstract: Digital transformation has emerged as a significant driver of innovation globally, with Gulf Cooperation Council (GCC) nations actively participating in this evolution. This systematic review provides a comprehensive assessment of the digital transformation in the GCC's oil and gas sector over the past decade. Through a rigorous bibliometric analysis of 505 documents sourced from the SCOPUS database, this study examines trends in research outputs, affiliations, and publication types. The analysis reveals dynamic trends in research outputs, with the GCC showing a substantial growth in publications in recent years, particularly mirroring global trends, albeit on a smaller scale. Despite this progress, GCC publications in 2023 represent approximately 30% of the decade's total, reflecting opportunities for increased research investment and international collaboration to enhance scientific output. Key findings highlight the United Arab Emirates as a leading contributor with (35%) of publications, followed by Saudi Arabia (29%) and Kuwait (26%). Oman, Bahrain, and Qatar exhibit comparatively fewer publications, suggesting potential areas for increased research focus. Conference papers dominate the scholarly output, comprising 92% of the publications, underscoring their role in disseminating research findings effectively. The top six world-leading research centers in digital transformation in oil and gas were analyzed and found to represent approximately 26% of global publications in the research field. This review contributes to the global discourse on technological adoption, innovation, and sustainable development by synthesizing the existing literature. It emphasizes the imperative of sustained research investment and strategic initiatives to strengthen scientific output in the GCC's digital transformation of the oil and gas sector. By providing robust analysis and insights into regional contributions, this study informs policymakers, industry leaders, and researchers aiming to advance digital initiatives across the GCC.

Keywords: digital transformation; GCC countries; systematic review; sustainable development; case studies

1. Introduction

In recent years, digital transformation has become a driving force for societal and economic progress worldwide. The GCC countries actively embrace artificial intelligence (AI), big data analytics, cloud computing, and the Internet of Things (IoT) to foster economic growth and diversification. Each nation has its own digital agenda, including smart city projects and e-government platforms. However, successful transformation requires not only technology but also awareness, skills, and cost-effective solutions. Analyzing the GCC's digital journey over the past decade, this study aims to understand motivations, identify strategies, and evaluate sector impact. Ultimately, it contributes to shaping effective policies and fostering collaboration [1].

The concept of digital transformation transcends mere technological adoption and extends into organizational culture, leadership, and the ability to adapt to changing dig-

ital landscapes [2]. It represents a holistic and strategic approach to leveraging digital capabilities to remain competitive, responsive to market trends, and customer-centric. It emphasizes the need for organizations to embrace agility and flexibility while fostering an innovation-driven culture to navigate the complexities of the digital age [3].

Digital transformation operates at multiple levels, from the individual level, impacting how people interact with technology, to the organizational level, affecting business processes and value chain design [4]. Governments, industries, and societies are continually grappling with digital technologies' transformative potential and their profound impact on the way services are delivered, information is accessed, and businesses are conducted. The digital transformation literature delves into this multifaceted concept's dimensions and components. It outlines the role of emerging technologies such as AI, blockchain, and IoTs in driving digital innovation [5]. Furthermore, researchers have explored the challenges associated with digital transformation, including issues related to data privacy, cybersecurity, and managing the transition from legacy systems to modern digital infrastructure [6].

In the context of the GCC countries, where digital transformation is seen as a key enabler of economic diversification and sustainable development, the definition of digital transformation takes on unique nuances. The regional focus often emphasizes the alignment of digital strategies with national development visions, such as Saudi Arabia's Vision 2030 or the United Arab Emirates' (UAE) National Agenda [7]. Understanding the cultural, political, and socio-economic context in which digital transformation initiatives are implemented is crucial for crafting effective policies and strategies.

1.1. Overview of Digital Transformation Initiatives in GCC Countries

The GCC countries have emerged as frontrunners in embracing digital transformation, recognizing its potential to drive economic diversification, enhance government services, and foster innovation across various sectors. Each member country, including Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the UAE, has developed its digital agenda and strategies tailored to its unique economic and social priorities.

For instance, the UAE has positioned itself as a regional leader in digital transformation, with the "Smart Dubai" initiative serving as a flagship program to create a seamless, efficient, and user-centric city experience for residents and visitors alike [8]. Meanwhile, Saudi Arabia's Vision 2030 aims to harness digital technologies to enhance citizen services, promote entrepreneurship, and stimulate innovation in various sectors, including healthcare, education, and finance [9].

The region's ambition to become a global leader in the digital space has led to many transformative initiatives that span smart cities, e-government services, digital infrastructure development, and digital skills enhancement. Digital transformation initiatives in the GCC encompass various domains, addressing both public and private sectors. Governments have been actively working on modernizing their services through the development of e-government platforms, allowing citizens to access public services online, leading to streamlined processes and enhanced citizen engagement [10]. The GCC countries are investing heavily in building smart cities, where data-driven technologies and IoT innovations are deployed to optimize resource utilization, enhance public safety, and improve overall urban living standards [11]. Moreover, the region's dynamic private sector has engaged in digital transformation, adopting cutting-edge technologies to enhance productivity, drive innovation, and compete effectively globally.

Despite the progress in digital transformation initiatives, the region also faces specific challenges. These include ensuring digital inclusion to bridge the digital divide, especially among underserved populations [12]. Furthermore, cybersecurity remains a critical concern, given the growing threats of cyberattacks and data breaches. Ensuring data privacy, protection, and resilience of critical digital infrastructure is essential for maintaining trust in digital services [13]. Addressing these challenges necessitates a comprehensive and collaborative approach, with governments, businesses, and civil society stakeholders

working in unison to capitalize on the opportunities offered by digital transformation while mitigating potential risks.

1.2. Theoretical Perspectives and Models of Digital Transformation in the Region

Understanding digital transformation in the context of the GCC countries requires drawing upon relevant theoretical perspectives and models that capture the complexities of technological adoption, organizational change, and societal impact. One such theoretical lens is the Technology–Organization–Environment (TOE) framework, which examines the interplay between technological factors, organizational characteristics, and the external environment in shaping the success of digital transformation initiatives [14]. In the GCC context, this framework can be used to analyze how technological readiness, organizational culture, and the region's unique socio-economic landscape influence the adoption and implementation of digital technologies.

Moreover, the Innovation Diffusion Theory (IDT) offers valuable insights into technology adoption and diffusion patterns within organizations and societies [15]. According to IDT, the rate of technology adoption is influenced by factors such as perceived relative advantage, compatibility, complexity, trialability, and observability. Applying IDT to digital transformation in the GCC can help explain the variation in the pace and extent of digital technology adoption across different industries and government sectors. It also provides a lens to examine the factors contributing to the successful diffusion of digital innovations within the region.

Another relevant theoretical perspective is the Resource-Based View (RBV), which focuses on how organizations leverage their unique resources and capabilities to gain a competitive advantage [16]. In the context of digital transformation in the GCC, the RBV can illuminate how organizations utilize their digital assets, data analytics capabilities, and human capital to drive innovation and create value. By identifying the strategic resources that enable successful digital transformation, regional organizations can craft tailored approaches to leverage their strengths and address their weaknesses.

This systematic review of the academic literature highlights a growing interest in digital transformation within the GCC countries. Over the past decade, research studies exploring digital initiatives have surged. Notably, the UAE, Saudi Arabia, and Qatar lead in this field, contributing significantly to scholarly publications. The GCC countries' strategies for digital transformation play a pivotal role in shaping publication patterns across different domains. The UAE's digital transformation strategies significantly influence publication trends across various domains. The "Smart Dubai" initiative, championed by the government, has drawn substantial research interest. Focusing on smart city development, IoT applications, and e-government services, the UAE continues to lead in digital innovation. [17].

Similarly, Saudi Arabia's Vision 2030 has stimulated considerable research on the country's efforts in digital transformation. With strategic priorities encompassing economic diversification and digital development, the Kingdom's publications have focused on various aspects, including e-government adoption, health informatics, and the role of digital technology in energy and sustainability [18]. Qatar's "Smart Qatar" program has also contributed to the growing number of research publications, particularly in the areas of smart energy, renewable technologies, and digital infrastructure development [19]. Other GCC countries, such as Bahrain, Kuwait, and Oman, are also witnessing an increase in digital transformation research, albeit at a slightly slower pace, as they actively pursue digital strategies to enhance their socio-economic landscapes [20].

Digital transformation has gained significant attention in specific fields within the GCC, notably healthcare and e-government. Researchers explore the application of digital technologies, such as telemedicine, health information systems, and digital health records, to enhance medical services and improve patient care. Meanwhile, studies focus on the effectiveness of digital initiatives in enhancing citizen services, government efficiency, and transparency.

While this literature review highlights progress in digital transformation research, it also reveals research gaps. While the UAE and Saudi Arabia lead digital transformation efforts, other GCC countries may need additional support to embrace digital innovation fully. Future research can identify challenges and recommend strategies for accelerating digital transformation. Leading GCC countries, including the UAE and Saudi Arabia, have comprehensive digital transformation strategies that shape publication patterns across various domains. Healthcare and e-government have emerged as prominent research fields. Ongoing collaborative efforts are crucial for unlocking the full potential of digital technologies in the region's socio-economic development.

This research is guided by key questions: What are the primary drivers and motivations behind digital transformation initiatives in the GCC? Which case studies and best practices have been successful? What impact have these initiatives had on various sectors? What challenges are faced in implementing digital transformation strategies? These questions aim to provide a comprehensive view of digital transformation in the GCC region.

The methodology involves a systematic review of the literature from academic journals and conference proceedings. This study aims to offer valuable insights for policymakers, industry leaders, and researchers, ultimately enhancing understanding and guiding future advancements in digital technology.

2. Research Methodology

This paper employs a systematic review methodology to comprehensively analyze the literature on digital transformation in GCC countries. By utilizing this approach, this study ensures a rigorous and transparent process of identifying, evaluating, and synthesizing relevant studies, thereby enabling the extraction of valuable insights, trends, and patterns from a diverse range of sources. The inclusion criteria focus on studies on digital transformation initiatives, policies, challenges, or outcomes in the GCC countries, while the exclusion criteria filter out irrelevant or low-quality publications. A systematic and comprehensive search strategy covers key academic databases (SCOPUS), ensuring the thorough identification of relevant studies. Data extraction follows a structured approach to gather pertinent information, while synthesis methods involve categorizing and clustering findings based on thematic areas. Overall, the systematic review methodology adopted in this study aims to contribute valuable insights to understanding digital transformation in the GCC countries, specifically in the oil and gas sector, and inform future initiatives in this domain. Figure 1 presents the research method, which consists of 6 phases.
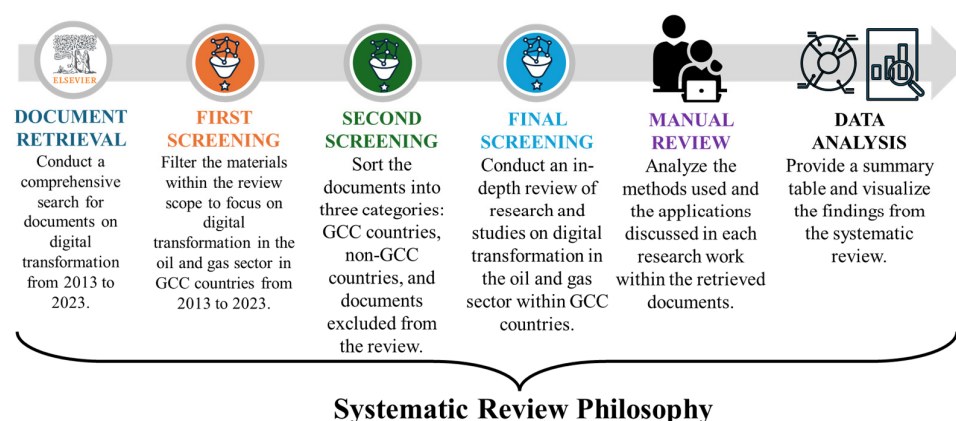

Figure 1. Research method.

Undertaking a systematic literature review on digital transformation in the oil and gas sector from 2013 to 2023 adheres to a structured methodology, reflecting a philosophical commitment to thoroughness and rigor. The process unfolds across six distinct phases, each designed to ensure methodological integrity and comprehensive coverage of the

subject matter. Initiated with a meticulous search across the SCOPUS database, this review narrows its focus during the first screening phase to target materials relevant to the oil and gas sector, specifically within GCC countries. This stage involves a broad literature search to identify all documents about digital transformation in GCC countries. The search term "digital transformation" was used to locate articles published between 2013 and 2023. This initial search yielded a total of 40,318 documents, with 946 of them being published works affiliated with GCC countries. The literature accessed included various types, such as journal articles, conference papers, reviews, and conference reviews. Following identifying the relevant literature, the focus was narrowed to macro-level estimations, specifically within the oil and gas sector, achieved through automatic filtering based on sector categorization. Consequently, phase 2 involved a thorough review and manual filtering of materials not aligned with this study's scope. This paper primarily centers on assessing the feasibility of digital transformation; accordingly, the search term "oil and gas" was used to address the research work of the oil and gas sector. Further analysis led to the retrieval of 505 documents, with 62 published works affiliated with GCC countries.

In phase 3, a comprehensive analysis was conducted to ensure proper studies are included in the research and exclude duplicates or missing details. These studies cover both GCC and non-GCC publications. The sources were categorized by various factors such as author, year of publication, methodology, country studied, application system, and dissemination system. This phase ensured a structured and transparent reference, facilitating a thorough analysis and understanding of the digital transformation landscape. Phase 4 focused specifically on the GCC countries, offering in-depth information about digital transformation initiatives in oil and gas sector. This phase aimed to thoroughly examine the region's digital transformation journey, contributing valuable insights into the existing knowledge base and informing future initiatives. This structured approach aids in understanding the unique challenges and opportunities within the GCC region.

In phase 5, the methods and applications of digital transformation were analyzed and reviewed for each publication. In phase 6, the data were analyzed systematically to ensure a methodologically sound and comprehensive exploration of digital transformation within the specified context, aligned with the principles of systematic literature review philosophy. Table 1 presents the bibliometric analysis of the digital transformation in GCC counties' oil and gas sector studies between 2013 and 2023, presenting the publication authors' names, year of publication, country of affiliation, the novel method used, the application and idea of the existing research, and the disseminated document type.

Figure 2 depicts the bibliometric analysis results, illustrating studies from the last 10 years for the GCC specifically and the world generally. This reveals a dynamic trend in research outputs. While both the GCC and global trends experienced fluctuations, the GCC showed more pronounced volatility. In contrast, the global research community demonstrated consistent and gradual growth. Notably, the sharp increase in the GCC's publications in 2022 and 2023 mirrors the global trend of rising research outputs, albeit on a smaller scale.

Table 1. Bibliometric analysis of the digital transformation in GCC counties' oil and gas sector studies between 2013 and 2023.

Authors	Year	Country	Method Used	Applications/Ideas	Main Recommendations	Document Type *
Al-Jasmi, Nasr [21]	2013	Kuwait	Digital transformation using steady-state nodal-analysis with AI.	Engineering and oil and gas (O&G) industry.	Invest in smart flows and advanced diagnostics to optimize well performance.	Conf.
Al-Jasmi, Nasr [22]	2013	Kuwait	Digital transformation through intelligent digital oilfield (iDOF) operations.	Engineering and O&G industry.	Implement a collaborative action-tracking system to optimize field operations.	Conf.
Al-Jasmi, Goel [23]	2013	Kuwait	Digital transformation through iDOF operations using automated AI work processes.	Engineering and O&G industry.	Develop smart flows with AI to enhance well surveillance and decision-making.	Conf.
Al-Jasmi, Nasr [24]	2013	Kuwait	Digital transformation through iDOF operations using automated AI work processes.	Engineering and O&G industry.	Implement the Well Performance Evaluation (WPE) smart flow to optimize production.	Conf.
Al-Jasmi, Nasr [21]	2013	Kuwait	Digital transformation through iDOF operations using automated AI work processes.	Engineering and O&G industry.	Use ESP smart flow with AI diagnostics to optimize well performance and prevent downtime.	Conf.
Al-Jasmi, Nasr [25]	2013	Kuwait	Digital transformation through iDOF operations using automated AI work processes.	Engineering and O&G industry.	Develop smart flow to optimize waterflooding performance using real-time data analysis.	Conf.
Carvajal, Wang [26]	2013	Kuwait	iDOF integrates real-time data analysis, enhancing decision-making in petroleum engineering.	Petroleum sector adopts iDOF for streamlined operations and improved asset performance.	Smart completions with internal control valves (ICVs) can be used to enhance reservoir sweep and reduce water production.	Conf.
Vaidyula, Al-Khaledi [27]	2015	Kuwait	Massively Open Online Courses (MOOCs).	O&G industry	Adopt MOOCs to revolutionize oil and gas workforce training and development.	Conf.
Shaik, Abdullah [28]	2017	UAE	O&G industry, focusing on corporate security strategy.	Holistic approach to cybersecurity.	Adopt holistic cybersecurity strategies to protect oil and gas digital infrastructures.	Conf.
Turai, Ballard [29]	2018	Saudi Arabia	Utilization of Artificial Neural Networks (ANN) for power demand prediction.	Off-grid solar photovoltaic energy storage systems for remote O&G facilities.	Use ANN models for accurate load demand prediction in off-grid systems.	Conf.
Maucec and Garni [30]	2019	Saudi Arabia	Data mining with multivariate predictive analytics.	Performance evaluation and optimization in O&G assets.	Use AI and ML for predictive analytics to optimize oil and gas production.	Conf.
Musameh and ALJadi [31]	2019	Kuwait	Big data, advanced analytics, surface and subsurface modeling.	Engineering (specifically O&G production).	Leverage digital transformation and advanced analytics to achieve operational excellence.	Conf.
Shayaa, Tamimi [32]	2019	UAE	AI, automated real-time drilling tools, data analytics.	Engineering (specifically drilling in the O&G industry).	Integrate AI and real-time data analytics for improved drilling efficiency.	Conf.

Table 1. *Cont.*

Authors	Year	Country	Method Used	Applications/Ideas	Main Recommendations	Document Type *
Jain, Al Hamadi [33]	2019	UAE	Data digitization, data integration, metadata capture.	Engineering (specifically exploration and production in the O&G industry).	Centralize E&P data, integrate for effective asset management and scalability.	Conf.
Ujjwal, Tummala [34]	2019	Kuwait	Advanced analytics, machine learning, Python programming.	Engineering (specifically waterflood management in O&G fields).	Integrate data for waterflood efficiency; use advanced analytics for reservoir management.	Conf.
Desai, Rane [35]	2019	Kuwait	Digital Oilfield technology, real-time data transmission, smart visualization tools.	Engineering (specifically O&G field management).	Ensure continuous support for digital tools and expertise for DOF sustainability.	Conf.
Al-Ghamdi, Debruyn [36]	2020	Saudi Arabia	Implementation of the online Corrosion Management Dashboard for digitizing corrosion management processes.	Industrial facilities, particularly in sectors like O&G.	Establish unified CM digitalization standards for effective industrial facility management.	Conf.
Gooneratne, Magana-Mora [37]	2020	Saudi Arabia	IoT and AI.	O&G industry.	Standardize IoT integration to maximize efficiency and profitability in drilling operations.	Artc.
Mezghani and Masrahy [38]	2020	Saudi Arabia	Automation of core description task using machine learning.	O&G industry for subsurface geological core analysis.	Implement automated core description using machine learning for efficiency and consistency.	Conf.
Haroon, Viswanathan [39]	2020	UAE	Utilization of open-source AI platforms.	O&G industry.	Embrace open-source AI platforms for agile and future-proof solutions.	Conf.
Alqahtani, Reddy [40]	2020	Saudi Arabia	Cross-functional transformation approach.	O&G industry.	Adopt a comprehensive digital strategy for agile and efficient well delivery.	Conf.
Kannankutty and Manoj Menon [41]	2021	UAE	Cognitive procurement using AI, big data, and market intelligence	O&G industry.	Embrace cognitive procurement for enhanced efficiency and strategic sourcing in Industry 4.0.	Conf.
Al Wahaybi, van Gilst [42]	2021	Oman	Implementation of an automated real-time data system (PetroAlert) for MicroSeismic monitoring.	O&G industry.	Expand automated MicroSeismic monitoring to enhance safety and production globally.	Conf.
Alabduljabbar [43]	2021	Saudi Arabia	Closed-loop model for Management of Change (MOC) process.	O&G industry safety management.	Implement a closed-loop digital MOC system for enhanced risk management.	Conf.
Temizel, Canbaz [44]	2021	Saudi Arabia	Literature review on Industry 4.0 solutions.	O&G upstream industry.	Embrace Industry 4.0 technologies for enhanced efficiency and innovation in oil and gas upstream operations.	Conf.
Alanazi, Almutairi [45]	2022	Saudi Arabia	Implementation of a hybrid model for private 5G deployment.	O&G industry, specifically at O&G facilities.	Embrace 5G for real-time data services and sustainable business transformation.	Conf.
Aydin and Temizel [46]	2022	Saudi Arabia	Thorough literature review and analysis.	Application of UAVs, drones, and robotics in O&G industry.	Customize UAV, drone, robotics solutions for optimal oilfield applications globally.	Conf.

Table 1. *Cont.*

Authors	Year	Country	Method Used	Applications/Ideas	Main Recommendations	Document Type *
Al Braiki, Davila [47]	2022	UAE	Development of an integrated web-based application.	Management of inactive wells in the O&G industry.	Digitally streamline well reactivation cycles for enhanced efficiency and profitability.	Conf.
Amer, Radwhi [48]	2022	Saudi Arabia	Developing a digital collaborative environment.	Streamlining O&G industry business processes.	Integrate cloud-based solutions for collaborative, efficient well planning in oil.	Conf.
Banihammad, Al Zaabi [49]	2022	UAE	Digital transformation through remote operations.	O&G industry.	Centralize digital control to optimize operational efficiency in asset management.	Conf.
Mohammed, Al Busaeedi [50]	2022	UAE	Smart Project Management System (SPMS).	O&G industry.	Integrate SPMS for proactive project management and enhanced productivity.	Conf.
Amer, Otaibi [51]	2022	Saudi Arabia	Machine learning (ML) algorithms.	O&G industry.	Implement ML for automated drilling operation classification and improved efficiency.	Conf.
Awadallah, Abdelkader [52]	2022	UAE	Three-dimensional printing, constructing a digital library.	O&G industry.	Adopt 3D printing to enhance supply chain resilience and cost efficiency.	Conf.
Al-Hannabi, Rehman [53]	2022	Saudi Arabia	Autonomous inspection robots, multiple inspection methods.	O&G industry.	Implement autonomous inspection robots for cost-effective and comprehensive pipeline inspections.	Conf.
Muhamed Salim, Traboulay [54]	2022	UAE	DOF organization assessment, discussions with key stakeholders.	O&G industry, digital transformation.	Establish a unified management system for Digital Oil Field operations.	Conf.
Reddicharla, Varnam [55]	2022	UAE	Data science competency model, online collaborative learning program.	O&G industry, specifically ADNOC Onshore.	Democratize AI and establish a digital business model for impactful business cases.	Conf.
Alsaeedi, Albadi [56]	2022	UAE	Smart technologies, direct wellhead measurement, Coriolis meter.	Gas field production monitoring, Opex optimization, digital transformation.	Implement Wet-Gas Coriolis meters across all wells for continuous production monitoring.	Conf.
Aftab, Hassanpoury-ouzband [57]	2022	Saudi Arabia	Review and analysis of challenges and future perspectives.	Geological hydrogen (H2) storage planning and implementation.	Prioritize careful planning and monitoring to mitigate challenges in geological hydrogen storage.	Rev.
Yaqot and Menezes [58]	2022	Qatar	Implementation of computerized machinery, data, and systems.	Digital transformation in the mining sector.	Embrace digital transformation strategically to enhance productivity and safety in mining.	Conf.
Mahaldar, Singh [59]	2022	Oman	Asset-led pilot project.	Digital transformation in the O&G industry.	Embrace agile methodologies to swiftly test and scale digital solutions, ensuring PDO remains at the forefront of innovation in the oil and gas sector.	Conf.

Table 1. *Cont.*

Authors	Year	Country	Method Used	Applications/Ideas	Main Recommendations	Document Type *
Kirilov, Chernyy [60]	2022	United Arab Emirates	Remote monitoring systems, robotic complexes for fire extinguishing, and software systems for scenario modeling.	Permanent state supervision, accident and evacuation scenario modeling, and virtual training of personnel.	Enhance cybersecurity and update protocols for reliable hazardous facility digital twins.	Article
Imran, Salama [61]	2022	UAE and Bahrain	Systematic literature review.	Cybersecurity risk management in O&G projects	Develop tailored cybersecurity frameworks for resilient oil and gas operations.	Conf.
Motaei and Ganat [62]	2023	Oman	Regression, artificial neural networks, fuzzy logic, support vector machines.	Proxy models for prediction, optimization, digital twins	Integrate real-time data validation and verification into proxy model workflows.	Artc.
Alohali, Alhabib [63]	2023	Saudi Arabia	Implementation of digital technologies in real-time drilling operations.	O&G industry, particularly in wellsite geological operations.	Implement mobility features for real-time access and faster decision-making.	Conf.
Khor, Limpasurat [64]	2023	Kuwait	Integrated asset modeling approach.	O&G production optimization.	Ensure continuous updating and integration of asset models for real-time decision support.	Conf.
Imran, Salama [65]	2023	UAE and Bahrain	Review of the literature from four databases (AAPG, ProQuest, Web of Science, SCOPUS).	Examining progress of smart factories and cyber risk management in O&G.	Integrate robust cybersecurity measures into digitalization frameworks.	Conf.
Ziadat and Kadadha [66]	2023	Saudi Arabia	Implementation of intelligent MPD with advanced algorithms.	Digital transformation in the O&G industry.	Implement intelligent MPD automation to enhance safety and operational efficiency.	Conf.
Al Jawhari, Bazuhair [67]	2023	UAE	Implementation of an inhouse developed production optimization system.	O&G production optimization in petroleum engineering.	Implement an in-house Production Optimization System for real-time well performance enhancement.	Conf.
Suyyagh [68]	2023	UAE	Data analysis and thematic analysis.	O&G industry.	Adopt digital technologies across offshore logistics to enhance supply chain efficiency.	Conf.
Almessabi, Al-saedi [69]	2023	UAE	Digital twin technology.	O&G industry.	Leverage Digital Twin technology to enhance safety, efficiency, and decision-making in the Oil & Gas industry.	Conf.
Albaddah [70]	2023	Kuwait	Custom-built blockchain application implementation.	Streamlining Shipment Nomination and Preparation Process in O&G.	Implement blockchain technology to enhance efficiency, accuracy, and cost-effectiveness in oil and gas shipment processes.	Conf.
Al-saedi, Al Awadhi [71]	2023	UAE	Transformation of maintenance overhaul strategy from time-based to condition-based.	O&G industry, specifically in rotating equipment maintenance.	Adopt condition-based maintenance overhaul strategies for rotating equipment to optimize costs and maximize plant availability.	Conf.

Table 1. *Cont.*

Authors	Year	Country	Method Used	Applications/Ideas	Main Recommendations	Document Type *
Voskresenskii, Pakhomov [72]	2023	Saudi Arabia	Utilization of Graph Neural Networks (GNNs) for oil flow rate forecasting.	O&G industry, specifically in production planning, resource allocation, and revenue estimation.	Adopt GNNs for oil flow rate forecasting to enhance efficiency.	Conf.
Al-Mudhaf, Al-Herz [73]	2023	Kuwait	Implementation of Neuro Autonomous Solutions for drilling operations.	Kuwait Oil Company's operations in North Kuwait.	Implement AI-driven autonomous solutions to revolutionize drilling efficiency and safety.	Conf.
Jalbout, Al Hai [74]	2023	UAE	Implementation of unified Real-Time Operations Center (RTOC) technology.	Steering rig operations in onshore O&G locations.	Expand unified Real Time Operations Center (RTOC) to optimize onshore rig operations globally.	Conf.
Benlizidia and Saeed [75]	2023	Saudi Arabia	Deployment and utilization of multiphase flowmeters.	O&G field operations.	Collaborate to optimize multiphase flow metering technologies for diverse operational conditions.	Conf.
Hussain, AlRashdi [76]	2023	UAE	Implementation of drilling forecast report.	O&G industry, specifically drilling operations.	Integrate automated drilling forecasting to optimize logistics, reduce costs, and enhance drilling performance.	Conf.
Hegazy, Alsawi [77]	2023	Kuwait	Implementation of an Operation Management System (OMS) software (Version 2020).	Enhancing operational excellence in the O&G industry.	Implement an integrated Operations Management System to enhance efficiency, reduce duplication, automate processes, and improve decision-making.	Conf.
Krikor, Bimastianto [78]	2023	UAE	Implementation of Mechanical Specific Energy (MSE) Ratio in real time.	Enhancing performance efficiency and preventing Non-Productive Time in drilling operations.	Enhance drilling efficiency with real-time MSE Ratio for proactive decision-making.	Conf.
Alfedaghi [79]	2023	Kuwait	Implementation of a citizen developer program.	O&G industry digital transformation and IT operational model enhancement.	Implementing citizen developer programs in oil and gas boosts innovation and efficiency.	Conf.

* Conf. = Conference paper, Artc. = Article paper, and Rev. = Review paper.
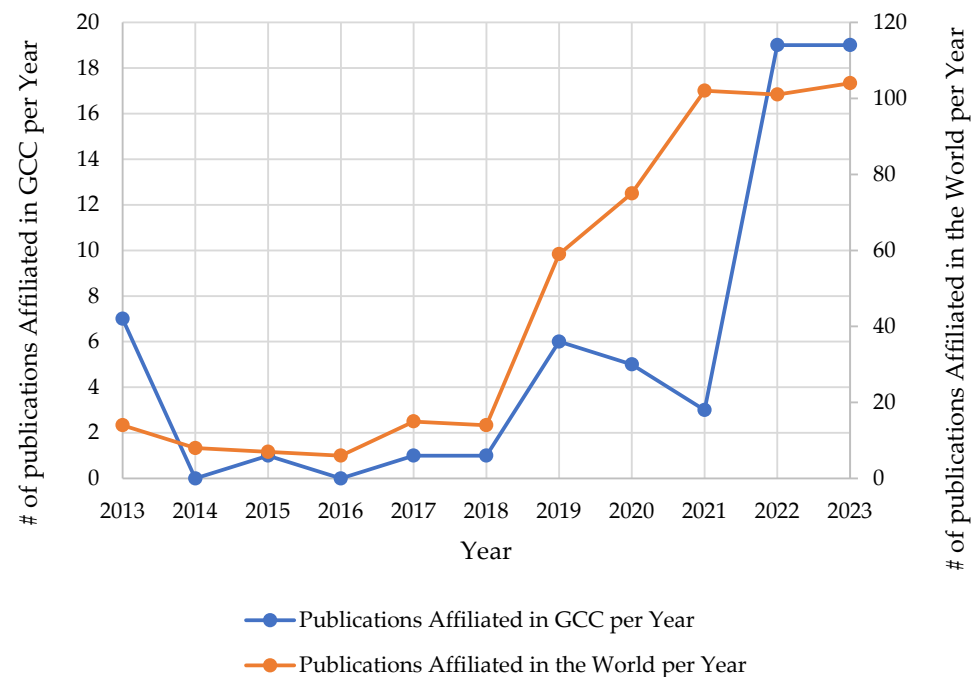
Figure 2. Search results from SCOPUS on digital transformation focus on the oil and gas sector: GCC vs. global trends (2013–2023).

The GCC's publications in 2023 account for approximately 30% of its total publications over the decade. Conversely, global publications in 2023 represent about 21% of the total published research on digital transformation in the oil and gas sector. Despite the significant strides made by the GCC in recent years, a considerable gap remains between its research output and that of the global community. Notably, GCC-affiliated research work represents around 18% of the global affiliated research in this area.

Overall, these trends highlight the importance of sustained investment in research and development, the need for strategic initiatives to boost scientific output, and the potential benefits of international collaborations to enhance the GCC region's research capabilities in the digital transformation of the oil and gas sector.

Based on the affiliation countries, document type, and the world-leading research centers in the digital transformation in the oil and gas sector, the bibliometric analysis results are analyzed in depth and illustrated in Figure 3, showcasing various studies conducted over the last 10 years. Figure 3b shows the global distribution of publications by country, with the United States leading at 16%, followed by China at 12%, and the Russian Federation at 5%. The United Arab Emirates also makes a notable contribution at 4%, while the remaining countries collectively account for the rest. Figure 3b illustrates the distribution of publications on digital transformation in the oil and gas sector across GCC countries from 2013 to 2023. The United Arab Emirates leads with 35% of the total publications, followed by Saudi Arabia with 29% and Kuwait with 26%. Oman, Bahrain, and Qatar have significantly fewer publications, indicating potential areas for increased research focus.

Figure 3c,d further breaks down the analysis. The distribution of publications across various types reveals insights into scholarly output, as seen in Figure 3c. Among the 62 publications analyzed, conference papers dominate the landscape, comprising 92% of the total. Articles and reviews make up the remaining 8%, with articles representing 5% and reviews 3%. This distribution underscores the prominence of conference contributions in disseminating research findings, with implications for academic discourse and knowledge dissemination strategies. Further examination of publication trends could yield valuable insights into the evolving scholarly landscape.
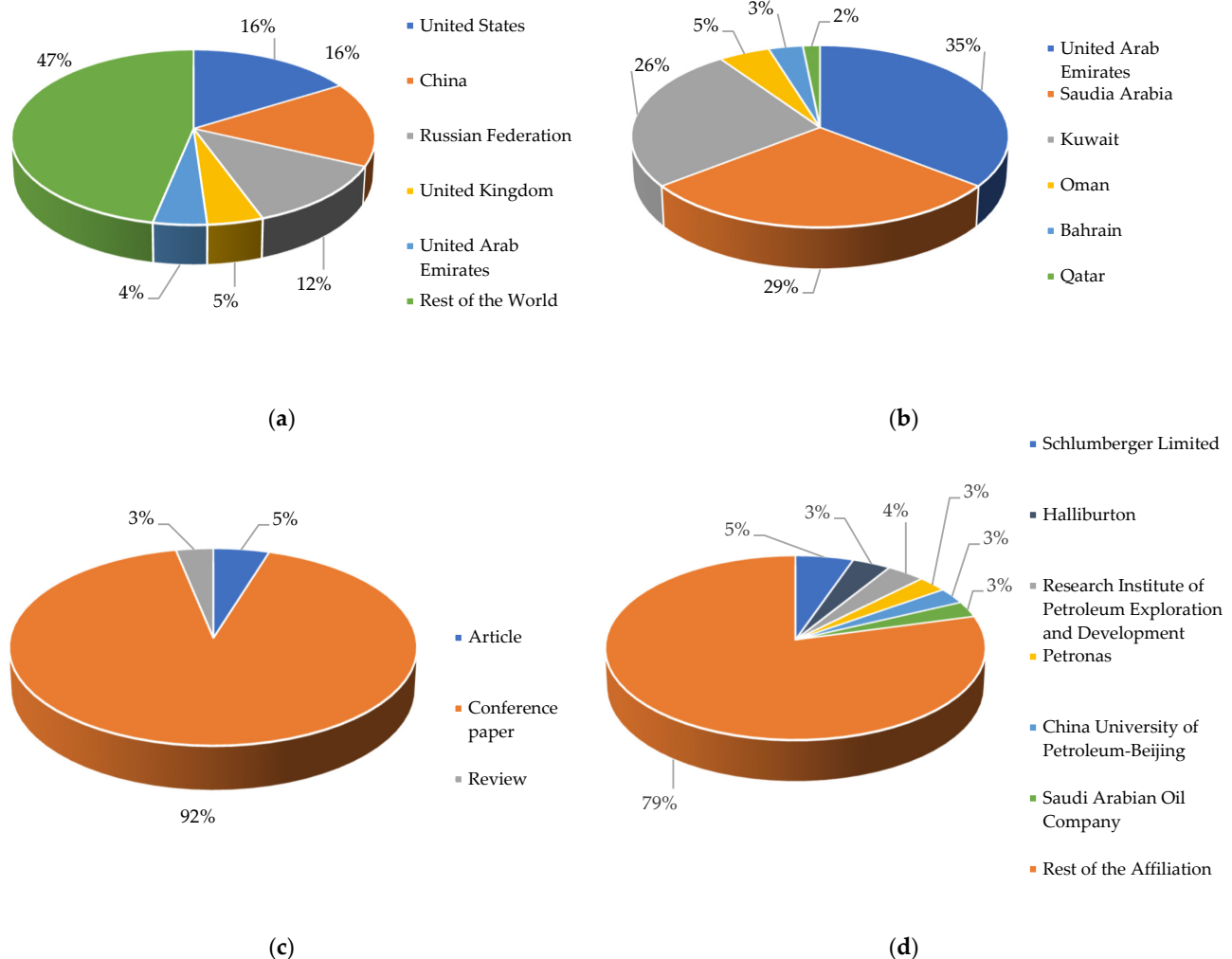
(a)

(b)

(c)

(d)

Figure 3. Literature review analysis of filtered documents based on (**a**) global countries, (**b**) GCC countries, (**c**) document type, and (**d**) world-leading research centers by affiliation.

Figure 3d highlights the distribution of publications by leading research centers. Schlumberger Limited leads with 5%, followed by Halliburton, the Research Institute of Petroleum Exploration and Development, Petronas, China University of Petroleum-Beijing, and Saudi Arabian Oil Company, each contributing between 3 and 4%. The remaining affiliations account for 79%, in which the top six leading research centers represent approximately 26% of the global published work by the affiliation institutes.

The systematic review methodology adopted in this study ensures a rigorous and comprehensive examination of the existing literature on digital transformation in the GCC countries. By following a structured approach to study selection, data extraction, and synthesis, this research aims to provide valuable insights into the region's digital transformation journey, contributing to the knowledge base and informing future initiatives in the GCC's pursuit of a digitally empowered future.

2.1. Overview of GCC Country's Digital Strategies and Their Impacts on GCC Countries

The digital transformation journey in the GCC countries is as diverse as the nations themselves, each guided by its distinct national development vision and strategic priorities. This section provides an extensive overview of the digital transformation agendas and strategies embraced by Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the UAE. It delves into the specific objectives, target sectors, and policy frameworks outlined in the digital roadmaps of each country, offering insight into the variety of approaches and ambitions

driving the adoption of digital technologies to propel economic growth, improve citizen services, and foster innovation.

Bahrain's digital agenda is deeply intertwined with its ambition to emerge as the region's leading financial and technology hub. Central to this vision are initiatives such as "Bahrain Vision 2030" and the "National eGovernment Strategy," which underscore the nation's commitment to driving innovation, fostering entrepreneurship, and enhancing public services through digital transformation. Key focus areas include bolstering digital infrastructure, promoting e-commerce, and advancing digital skills' development to nurture a thriving digital ecosystem [80]. Similarly, Kuwait envisions a knowledge-based economy propelled by digital innovation. The "New Kuwait 2035" strategy outlines the country's aspirations to promote e-government services, enhance digital education, and diversify the economy by fostering digital entrepreneurship. Kuwait's digital initiatives span sectors such as healthcare, education, and public services, aiming to improve citizen well-being and enhance government efficiency [81].

Oman's digital transformation journey aligns with its long-term vision encapsulated in the "Oman Vision 2040" strategy. The nation seeks to leverage technology to drive economic diversification, citizen empowerment, and sustainability. At the core of this strategy lies the "Digital Oman Strategy", which focuses on building digital skills, enabling e-services, and promoting local innovation. Oman's digital efforts extend across tourism, agriculture, and energy sectors, where digital technologies are harnessed to enhance competitiveness and efficiency [82]. Similarly, Qatar envisions a smart, sustainable, and connected future through its "Qatar National Vision 2030". The "TASMU Smart Qatar" program exemplifies the nation's commitment to harnessing emerging technologies such as AI, IoT, and blockchain to enhance government services, healthcare, transportation, and urban planning. Qatar's emphasis on smart cities and digital innovation aims to foster a thriving knowledge-based economy [83].

Meanwhile, Saudi Arabia's "Vision 2030" forms the cornerstone of its digital transformation agenda, aiming to reduce dependence on oil and drive economic diversification through digital initiatives. Projects like the "eGovernment Yesser Program" focus on streamlining government services, while sectors such as healthcare and education benefit from digital advancements. The country also encourages public–private partnerships to foster innovation and technology adoption [84]. Lastly, the UAE's ambition to become a global hub for innovation is evident in initiatives such as "UAE Vision 2021" and the "National Innovation Strategy". The "Smart Dubai" initiative exemplifies the country's commitment to transforming into a smart city by integrating cutting-edge technologies across sectors. The UAE's digital strategies encompass health, education, energy, and tourism, creating an environment conducive to entrepreneurship, research, and technological advancement [85].

Through the collective efforts of these nations, the GCC countries are poised to realize their vision of a digitally enabled future, driving economic prosperity, improving quality of life, and fostering innovation and sustainable development. Table 2 presents the digital transformation strategies and initiatives in GCC countries and the key achievements in the digital transformation journey.

These case studies highlight the diverse strategies, goals, and outcomes of successful digital transformation projects in the GCC countries. While each project has unique characteristics, several common success factors emerge. Strong leadership commitment, effective stakeholder engagement, clear alignment with national development visions, and a user-centric approach are recurrent themes that contribute to successful implementation. Additionally, these projects underscore the importance of continuous evaluation, adaptation, and scalability to ensure sustained impact in a rapidly evolving digital landscape.

Table 2. Digital transformation strategies and initiatives in GCC countries.

Country	National Vision	Agenda/Strategy	Initiative	Description	Year	Key Achievements
Bahrain [86]	Bahrain Vision 2030	National eGovernment Strategy	Digital infrastructure, e-commerce, digital skills	Focus on innovation, entrepreneurship, enhanced public services. It aims to emerge as the region's leading financial and technology hub	2022	• Enhanced sustainability through Network Leadership in Bahrain's oil and gas sector. • Enhanced efficiency and reduced cost through innovative digital tools.
Kuwait [87]	New Kuwait 2035	Digital initiatives	E-government services, digital education, healthcare, public services	Focus on the knowledge-based economy, digital entrepreneurship, citizen well-being. It aims to promoting e-government, enhancing digital education, diversifying the economy	2018	• Improved efficiency, production optimization, reduced health and safety risks. • Enhanced operational efficiency and productivity in oil and gas operations through automation and real-time monitoring.
Oman [88]	Oman Vision 2040	Digital Oman Strategy	Building digital skills, e-services, tourism, agriculture, energy	Focus on economic diversification, citizen empowerment, sustainability. It aims to leverage technology for economic diversification and sustainability	2019	• Digital Transformation of Healthcare
Qatar [89,90]	Qatar National Vision 2030	TASMU Smart Qatar program	AI, IoT, blockchain, smart cities, healthcare, transportation, urban planning	Focus on smart, sustainable, connected future, knowledge-based economy. It aims to harness emerging technologies for a smart, sustainable, and connected future	2017	• Smart Grid Program for optimizing energy consumption. • Digital Government Services Platform for online access to government services.
Saudi Arabia [91]	Vision 2030	eGovernment Yesser Program	Streamlining government services, healthcare, education	Focus on economic diversification, reduced oil dependence, public–private partnerships. It aims to reduce dependence on oil, driving economic diversification	2005	• Provision of over 2000 e-services. • Integration of government services through a unified platform. • Establishment of a national data center.
UAE [92]	UAE Vision 2021, National Innovation Strategy	Smart Dubai initiative	Health, education, energy, tourism, smart city development	Focus on global hub for innovation, entrepreneurship, research, technological advancement. It aims to transforme into a global hub for innovation and smart city development	2013	• Dubai Data Initiative for open data sharing. • Dubai Paperless Strategy for transitioning government transactions to digital platforms.

2.2. Challenges and Barriers Faced in Implementing Digital Transformation

The journey toward digital transformation in the GCC countries has its challenges and barriers. While the region is making significant strides in adopting digital technologies, numerous hurdles impede the seamless execution of digital initiatives. Understanding and addressing these challenges is crucial for devising effective strategies to realize digital transformation goals successfully. Figure 4 presents several challenges and barriers faced in implementing digital transformation.

Figure 4. Challenges and barriers faced in implementing digital transformation.

Addressing these challenges requires a multifaceted approach that involves collaboration between governments, private sector stakeholders, academia, and civil society. Strategies that prioritize capacity building, regulatory reform, cybersecurity enhancement, and stakeholder engagement can help overcome these barriers and set the stage for a transformative digital journey in the GCC countries.

The GCC countries, noted for their technological leadership, face significant cybersecurity threats due to their advanced digital infrastructure. As these nations integrate more deeply into the global digital economy, their vulnerabilities increase, necessitating robust cybersecurity measures. The cybersecurity landscape in the GCC is influenced by economic drivers and geopolitical dynamics, with the need to secure a digital economy often becoming intertwined with geopolitical issues such as surveillance technology sales and AI and 5G communications competition [93]. In Saudi Arabia, factors like trustworthiness, usage experience, and awareness hinder digital transformation, making it essential to foster innovation, invest in cybersecurity infrastructure, and enhance collaboration between organizations and government entities [94]. By adopting both strategic and technical security measures, such as those implemented by the Saudi National Cybersecurity Authority (NCA), organizations can create a dynamic and resilient cybersecurity framework that evolves with emerging threats [95].

Additionally, as Arab states, including those in the GCC, integrate into the global digital space, they contribute to the construction of the international information security system. The Global Cybersecurity Index, developed by the UN International Telecommunication Union, provides a framework for assessing the readiness of modern states to repel cyber threats, considering regulatory and legal systems, technical capabilities, organizational structures, capacity development measures, and international cooperation [96]. However, the unique political, financial, economic, historical, and cultural contexts of the Arab countries create a fragmented environment that often hampers collective responses to digital age

challenges. The implementation of e-government and Big Data Analytics (BDA) also plays a significant role in enhancing cybersecurity, as demonstrated by the UAE's leadership in adopting e-government systems and leveraging BDA for improved digital governance and security [97]. To ensure a secure digital future, GCC countries must prioritize cybersecurity within their digital transformation initiatives, addressing economic, geopolitical, and technical dimensions to enhance the resilience of their digital infrastructure.

2.3. Factors Contributing to the Success or Failure of Digital Initiatives

The success or failure of digital transformation initiatives in the GCC countries hinge on a complex interplay of various factors that shape the implementation and outcomes of these projects. Understanding these factors is essential for designing effective strategies that capitalize on strengths while mitigating challenges. This subsection examines the key determinants that can influence the trajectory of digital initiatives, shedding light on both enablers and barriers. Some factors that contribute to the success or failure of digital initiatives are illustrated in Figure 5.
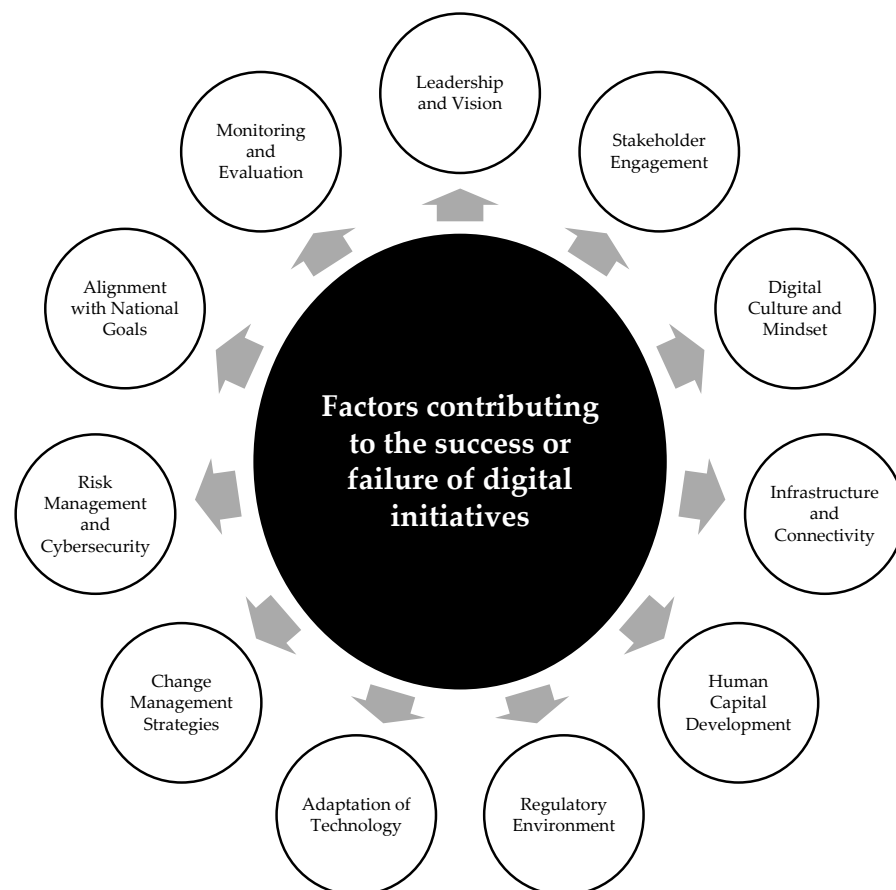

Figure 5. Factors contributing to the success or failure of digital initiatives.

The success or failure of digital transformation initiatives in the GCC countries are influenced by myriad factors that interact in complex ways. These factors, ranging from visionary leadership and stakeholder engagement to technology adaptation and risk management, collectively shape the trajectory and outcomes of digital projects. By recognizing and strategically addressing these determinants, policymakers, organizations, and practitioners can navigate the challenges and capitalize on the opportunities presented by the digital era, leading to impactful and sustainable digital transformation.

2.4. Assessing Digital Transformation Impact: Key Metrics for Success

Measuring the impact and success of digital transformation initiatives in the GCC countries demands a structured approach anchored in well-defined key performance indicators (KPIs) and success metrics. These metrics serve as the yardstick for evaluating the effectiveness and outcomes of digital endeavors.

KPIs such as user adoption and engagement are foundational to this evaluation, gauging the extent to which citizens, businesses, and stakeholders embrace digital services. Monitoring user registration, transaction volumes, and active usage provides insights into the value proposition and user satisfaction [98]. Equally crucial is the Quality of User Experience, with metrics like user satisfaction surveys, feedback ratings, and ease-of-use assessments offering insights into digital service quality. Positive user experiences correlate with successful adoption and sustained engagement [99].

Service Accessibility and Efficiency stand out as crucial KPIs in assessing the effectiveness of digital platforms in delivering services. Metrics like service availability, response times, and processing durations quantitatively demonstrate improvements in service accessibility and delivery speed [100]. Moreover, Operational Efficiency improvements are quantified by metrics like reduced manual data entry, minimized errors, and accelerated process completion times.

Cost Savings and Resource Optimization present tangible metrics showcasing efficiency gains achieved through digital initiatives. Calculating reductions in administrative overhead, paper usage, and manual interventions highlights the financial benefits [101]. Security and privacy are paramount, with KPIs related to Data Security encompassing metrics that quantify the effectiveness of cybersecurity measures. Monitoring incidents, breaches, and vulnerabilities underscores the protection of sensitive data [102].

Digital transformation initiatives must address concerns regarding Digital Inclusion and Equity. KPIs ensure that the benefits of digital transformation reach all segments of society. Tracking the reach of digital services across diverse demographics and identifying disparities are integral steps in addressing equity concerns [103]. Furthermore, Innovation and New Service Offerings are critical, measured by metrics such as introducing new digital services, updating frequency, and citizen feedback integration in service enhancements.

The Assessment of Economic Impact involves metrics measuring job creation, contributions to Gross Domestic Surplus (GDP), and revenue increases for businesses embracing digital solutions. Sustainability and Long-Term Impact evaluation necessitates tracking metrics over time, offering insights into continuous user engagement and evolving service offerings. Alignment with Strategic Objectives serves as a success metric, ensuring that digital initiatives contribute to broader national strategies and objectives [104]. Public Perception and Trust measurement can be achieved through public opinion surveys, user feedback sentiment analysis, and trust in data protection measures.

By employing a comprehensive array of KPIs and success metrics, decision-makers can objectively assess the impact and outcomes of digital transformation initiatives. This evaluation informs future strategies and enhances transparency and accountability in the digitalization journey.

3. Results and Discussion

3.1. Identifying Lessons Learned from Successful Digital Transformation Initiatives

The success of various digital transformation initiatives within the GCC countries offers invaluable insights that can guide future endeavors. This subsection delves into the lessons learned from these achievements, shedding light on the pivotal factors contributing to their success.

1. Clear Vision and Alignment: A clear, well-communicated vision underpins successful digital transformation initiatives. Lessons learned underscore the importance of aligning digital strategies with broader national development goals. Initiatives that align with a clear vision are more likely to garner stakeholder buy-in, secure resources, and sustain momentum over time.

2. Engagement and Collaboration: Lessons from successful initiatives emphasize the significance of engaging diverse stakeholders. Collaboration between government agencies, private sector partners, academia, and civil society amplifies expertise and fosters collective ownership. Involving end-users early in the process enhances solution relevance and user adoption.

3. User-Centric Design: Initiatives prioritizing user needs and experiences tend to yield higher levels of success. Lessons learned highlight the value of conducting thorough user research, usability testing, and feedback collection. A user-centric approach ensures that digital solutions are intuitive, effective, and resonate with the target audience.

4. Agile Implementation: Flexibility and adaptability are central to successful digital transformation. Lessons learned emphasize adopting agile project management methodologies that enable incremental progress, rapid prototyping, and the ability to adjust strategies based on emerging insights and challenges.

5. Change Management and Capacity Building: Organizations that invest in change management strategies and capacity-building reap rewards. Lessons from success stories emphasize the importance of preparing stakeholders for change, providing training programs, and fostering a culture of continuous learning to navigate the digital transition.

6. Leveraging Data for Decision-Making: Successful initiatives harness the power of data analytics to drive informed decision-making. Lessons learned highlight the importance of collecting, analyzing, and utilizing data to optimize processes, predict trends, and measure the impact of digital interventions.

7. Adaptation of Global Best Practices: Lessons from successful initiatives often involve adapting global best practices to the local context. While unique challenges exist in the GCC region, adapting proven strategies from other parts of the world offers a shortcut to effective implementation.

8. Political and Leadership Support: Political will and leadership commitment are integral to the success of digital initiatives. Lessons emphasize the need for high-level support that prioritizes digital transformation and allocates necessary resources for implementation.

9. Risk Management and Resilience: Successful initiatives acknowledge potential risks and devise strategies to mitigate them. Lessons learned stress the importance of developing contingency plans, managing cybersecurity threats, and building resilience to disruptions.

10. Continuous Evaluation and Improvement: Continuous evaluation and feedback loops are crucial for sustained success. Lessons highlight the value of monitoring key performance indicators, soliciting user feedback, and iteratively improving digital services.

3.2. Best Practices for Implementing Digital Transformation in GCC Countries

Implementing digital transformation in GCC countries is essential for driving socio-economic growth and improving public services. Given the region's distinctive socio-cultural and economic landscape, adopting a customized approach to digital transformation is imperative. This document presents ten best practices that can help GCC countries effectively navigate the complexities of digital transformation, ensuring alignment with national development goals and addressing local needs. Table 3 presents several best practices for implementing digital transformation in GCC countries.

By adhering to these best practices, GCC countries can navigate the complexities of digital transformation with a strategic and informed approach. Embracing digital transformation as a holistic endeavor enables the region to harness the full potential of digital technologies for sustainable development. Implementing these practices ensures that digital initiatives are innovative and aligned with the region's unique socio-economic landscape, ultimately contributing to the overall advancement of GCC countries.

Table 3. GCC countries' best practices in digital transformation.

Practice	Description	Examples/Case Studies
Develop a Clear Strategy and Roadmap	Establish a clear digital transformation strategy aligned with national development goals. Define objectives, prioritize initiatives, and create a roadmap that outlines milestones and timelines. This strategic approach ensures that digital initiatives are purposeful and contribute to socio-economic advancement.	UAE's Vision 2021 plan, Saudi Arabia's Vision 2030
Engage Stakeholders Collaboratively	Foster collaboration between government entities, private sector partners, academia, and citizens. Create avenues for open dialogue, feedback sharing, and co-creation to ensure initiatives address genuine needs. Successful digital transformation relies on the participation of diverse stakeholders.	Bahrain's National eGovernment Strategy, Kuwait's National Development Plan
Prioritize Citizen-Centric Design	Put citizens and end-users at the center of digital solutions. Conduct thorough user research, test usability, and continuously gather feedback to refine services. User-centric design ensures that digital solutions are intuitive, effective, and aligned with user expectations.	Dubai's Smart City initiative, Qatar's Hukoomi Portal
Adopt Agile Project Management	Embrace agile methodologies that emphasize flexibility, iterative development, and rapid prototyping. Agile project management enables adaptive responses to changing requirements, facilitates quick wins, and reduces the risk of project failures.	Saudi Arabia's NEOM project
Invest in Change Management	Recognize that digital transformation entails cultural and organizational shifts. Invest in change management strategies that prepare employees, stakeholders, and the public for change. Communicate the benefits, address concerns, and provide training to facilitate a smooth transition.	Oman's eOman Strategy
Embrace Emerging Technologies Wisely	Stay updated with emerging technologies but adopt them judiciously. Leverage technologies such as AI, blockchain, and IoT that align with strategic goals and have proven potential to drive impact.	UAE's AI Strategy 2031, Bahrain's Blockchain strategy
Build Digital Skills and Capacities	Enhance the digital skills of the workforce through training programs and upskilling initiatives. Equip employees with the competencies to leverage digital tools effectively and contribute to innovation.	Qatar's Digital Incubation Center, Kuwait's 'KuwaitTech' Initiative
Ensure Data Privacy and Security	Data privacy and security should be at the forefront of digital initiatives. Develop robust cybersecurity measures, comply with data protection regulations, and prioritize the responsible handling of user data.	UAE's National Cybersecurity Strategy, Saudi Arabia's National Cybersecurity Authority
Promote Interagency Collaboration	Establish mechanisms for interagency collaboration to avoid duplication of efforts and to share best practices. Cross-agency collaboration accelerates the exchange of knowledge and resources, leading to more comprehensive digital solutions.	GCC's Regional Data Exchange Initiative
Adapt Global Best Practices to Local Context	Adapt global best practices to the GCC's unique cultural, regulatory, and social context. Customize strategies to address regional challenges and leverage local strengths.	Adapting Estonia's digital governance model in the UAE, Localizing the Singapore Smart Nation initiative in Qatar

3.3. Policy Recommendations for Fostering Digital Innovation and Adoption

Creating an environment conducive to digital innovation and adoption in GCC countries is a multifaceted endeavor that demands a cohesive and interconnected approach. At the heart of this approach lies the imperative to empower digital skills among the populace. By prioritizing comprehensive initiatives that equip individuals with the necessary competencies to navigate the digital age, governments in the GCC region enable active participation in the digital economy and bridge the digital divide. This entails formal

education, vocational training, and continuous learning programs. Investing in digital literacy, coding skills, and data analytics training ensures citizens are well-prepared to harness the benefits of emerging technologies.

In tandem with skills empowerment, GCC countries must cultivate an innovation-friendly regulatory environment. Agile and adaptive regulations are essential, accommodating technological advancements while safeguarding data security, privacy, and ethical considerations establishing sandbox environments for testing new digital solutions, simplifying bureaucratic processes for startups, and providing incentives for research and development initiatives to catalyze innovation. Embracing open data policies and interoperable standards fosters collaboration and drives cross-sectoral digital initiatives, propelling the region's digital transformation agenda forward.

Additionally, supporting collaborative research initiatives is crucial for driving the region's technological advancement. GCC countries should encourage partnerships between academia, research institutions, and industries to address local challenges and explore emerging technologies. Funding research projects, promoting technology transfer, and fostering innovation clusters lead to breakthroughs directly contributing to the region's digital transformation goals.

By intertwining digital skills empowerment, innovation-friendly regulation, and collaborative research initiatives, GCC countries establish the foundations for a thriving digital ecosystem. This integrated approach not only fuels economic growth but also enhances the well-being of citizens. It positions the region as a frontrunner in the global digital landscape, where innovation thrives and societies flourish. Through concerted efforts and strategic policy interventions, the GCC can harness the transformative power of digitalization to chart a prosperous future for generations to come.

3.4. Assessing the Impact of Digital Transformation on Various Sectors

Digital transformation has ushered in profound changes across various sectors in the GCC countries, reshaping economies, societies, and public services. This section offers a comprehensive assessment of the impact of digital transformation on key sectors, highlighting both transformative successes and persistent challenges. Additionally, insights into future trends and challenges are provided to guide the region toward a digitally empowered and sustainable future. Table 4 summarizes successes, challenges, and future digital transformation trends in different sectors of the GCC countries.

Digital transformation in the GCC countries has yielded transformative benefits across sectors, yet challenges persist. However, the digital transformation trajectory holds exciting possibilities for the future, with greater integration of emerging technologies and advancements in various sectors. Embracing innovation and collaboration while addressing challenges collectively will be crucial for steering toward a digitally empowered and sustainable future in the GCC region. The future of digital transformation in the GCC holds promising possibilities, including greater integration of emerging technologies, advancements in smart cities, and innovations in sectors like fintech and healthcare. However, challenges such as digital inclusivity and cybersecurity must be addressed to realize the full potential of digital transformation. Research and development opportunities abound, providing avenues for sustainable growth and global competitiveness. Staying attuned to these trends and challenges will be key to navigating the future of digital transformation in the GCC region.

Table 4. Successes, challenges, and future trends of digital transformation in GCC countries for different sectors.

Sector	Impact of Digital Transformation	Successes	Challenges	Future Trends
Government Services	Government services' digitalization reshapes citizen interactions, streamlining delivery and enhancing engagement through online platforms and identity systems, fostering transparency and responsiveness [105].	• Increased transparency • Improved access to information • Enhanced citizen engagement	• Ensuring data security and privacy • Addressing digital literacy gaps • Managing the transition from legacy systems	• Greater integration of emerging technologies like AI, blockchain, and 5G networks • Evolution of smart cities • Sophisticated e-government services • Drive for digital innovation in sectors like fintech, renewable energy, and healthcare technologies • Expansion of the IoT footprint
Healthcare	Healthcare undergoes seismic digital transformation. EHRs enhance care coordination, while telemedicine expands access, and data analytics revolutionize disease surveillance [106].	• Improved patient care coordination • Expanded healthcare access • Enhanced disease surveillance	• Ensuring data security and privacy • Addressing interoperability challenges • Managing the adoption of new technologies by healthcare professionals	• Exploring the potential of AI, blockchain, and IoT in healthcare • Addressing digital inclusivity and cybersecurity concerns • Upskilling the healthcare workforce
Education	Education experiences digital revolution: e-learning platforms, online courses, and virtual classrooms offer flexible, personalized learning, crucial during COVID-19 disruptions [107,108].	• Flexible learning options • Personalized learning experiences • Facilitation of remote learning	• Ensuring digital access for all students • Addressing the digital divide • Maintaining engagement in remote learning environments	• Continued integration of digital tools in education • Focus on digital inclusivity and engagement • Research into emerging technologies for personalized learning experiences
Finance	The financial sector embraces fintech innovations, enhancing accessibility with mobile banking and digital payments. Blockchain streamlines transactions, while AI and big data analytics bolster risk management and fraud detection capabilities [109].	• Streamlined financial transactions • Enhanced financial inclusion • Improved risk management	• Ensuring data security and privacy • Addressing regulatory compliance • Managing cybersecurity risks	• Further integration of blockchain technology in financial transactions • Addressing regulatory challenges and cybersecurity risks • Upskilling finance professionals in emerging technologies

Table 4. *Cont.*

Sector	Impact of Digital Transformation	Successes	Challenges	Future Trends
Transport and Infrastructure	Transportation and infrastructure sectors optimize operations with digital technologies. Smart systems and real-time data improve traffic flow. Smart city initiatives expand to maintenance and energy conservation [110].	• Improved traffic flow • Enhanced user experiences • Optimal infrastructure maintenance	• Ensuring data accuracy and reliability • Addressing cybersecurity concerns • Managing integration challenges	• Advancements in smart transportation systems and traffic management • Expansion of smart city initiatives • Emphasis on energy conservation and sustainable infrastructure
Business and Industry	Digital transformation revolutionizes industries with automation, robotics, and IoT optimizing manufacturing and supply chains. Data-driven insights inform decisions, enhancing customer experiences [44].	• Optimized manufacturing processes • Enhanced supply chain efficiency • Informed decision-making	• Addressing workforce reskilling needs • Managing cybersecurity risks • Ensuring compatibility with existing systems	• Continued integration of automation and IoT in manufacturing and supply chain • Focus on cybersecurity and workforce upskilling • Exploration of emerging technologies for enhanced customer experiences
Energy and Environment	The energy sector optimizes production and distribution through digital technologies like smart grids and remote monitoring. Data analytics aids environmental monitoring and resource management [111].	• Enhanced energy efficiency • Improved sustainability • Optimized energy production and distribution	• Addressing interoperability challenges • Ensuring data security and privacy • Managing regulatory compliance	• Exploration of blockchain for transparent energy transactions • Focus on cybersecurity in energy infrastructure • Adoption of AI for predictive maintenance and resource optimization

4. Conclusions

4.1. Summary of Key Findings

Digital transformation is a significant driver of innovation, with GCC nations playing an active role. This systematic review provides a comprehensive assessment of digital transformation in the GCC's oil and gas sector over the past decade. A rigorous bibliometric analysis of 505 documents from the SCOPUS database revealed dynamic trends in research outputs, with the GCC showing substantial growth, particularly in 2022 and 2023. Despite this progress, GCC publications in 2023 accounted for approximately 30% of the decade's total, indicating increased research investment and international collaboration opportunities. The United Arab Emirates led with 35% of publications, followed by Saudi Arabia (29%) and Kuwait (26%), while Oman, Bahrain, and Qatar had fewer publications, suggesting areas for potential research focus. Conference papers dominated the scholarly output, making up 92% of the total. An analysis of the top six leading global research centers in digital transformation within the oil and gas sector revealed that they collectively account for approximately 26% of the worldwide publications in this field.

Despite the progress, there are notable gaps in the existing literature. First, there is a need for more empirical research focusing on the long-term impacts of digital transformation initiatives in the GCC. Second, comparative studies that evaluate the effectiveness of different digital strategies across GCC countries could provide valuable insights. Third, research exploring the intersection of digital transformation with other critical areas such as sustainability and economic diversification is limited and warrants further investigation. Future research should also focus on the development of robust methodologies for assessing the impact of digital transformation initiatives. Additionally, there is a need for studies that explore the socio-economic implications of digital transformation, particularly concerning workforce development and the digital divide.

GCC researchers play a crucial role in advancing the digital transformation agenda. The analysis shows that while there has been significant progress, the region's research output still lags behind global standards. To bridge this gap, GCC researchers should focus on producing high-quality, impactful research that addresses the specific challenges and opportunities within the region. Collaboration with international research centers and participation in global research networks can enhance the visibility and impact of GCC research.

4.2. Contributions to the Field and Practical Implications

Digital transformation in the GCC countries profoundly impacts various sectors, significantly driving economic growth, improving public service delivery, and enhancing the overall quality of life. One notable area of impact is productivity, particularly in industries like oil and gas, where AI and IoT technologies minimize downtime and maximize output. For instance, Kuwait has seen a 30% increase in e-government efficiency through digital initiatives. To further boost productivity, stakeholders should invest in cutting-edge technologies, develop public–private partnerships, and establish regulatory frameworks that encourage innovation while ensuring data security and privacy.

In the public sector, digital transformation has empowered citizens by improving engagement and access to services. Qatar's "TASMU Smart Qatar" program, for example, has achieved a 25% increase in public transportation efficiency. To enhance citizen empowerment, public sector administrators should implement comprehensive digital platforms that integrate various public services, making them more accessible and user-friendly. Additionally, promoting digital literacy programs will ensure all citizens can effectively utilize these new platforms, thereby streamlining government operations and improving public service delivery.

Investing in the future through upskilling initiatives is crucial for creating a robust tech workforce, driving economic diversification, and maintaining the GCC's competitiveness in the global digital age. Oman has seen a 40% rise in tech jobs due to such initiatives. To build a skilled workforce, educational institutions and employers should collaborate to design

curricula and training programs that align with industry needs, focusing on emerging technologies like AI, cybersecurity, and blockchain. Governments can support these efforts by providing incentives for businesses that invest in employee training and development.

In summary, the practical implications of digital transformation in the GCC region are extensive, driving efficiencies in traditional sectors, improving public services, and cultivating a skilled workforce. These advancements contribute to economic growth and societal well-being, positioning GCC countries as leaders in the global digital landscape. By implementing these specific and actionable recommendations, stakeholders can effectively harness digital transformation's benefits, addressing current and future challenges.

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