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DIGITALIZATION IN GREEN PROCUREMENT: A REVIEW OF E-PROCUREMENT SYSTEMS AND BLOCKCHAIN TECHNOLOGY

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Abstract: *The increasing importance of sustainability in global supply chains has led to the adoption of digital technologies to enhance green procurement practices. This paper reviews the role of digitalization in green procurement, focusing on the integration of e-procurement systems and blockchain technology. E-procurement systems streamline procurement processes by automating supplier selection, reducing resource consumption, and improving compliance with environmental standards. Blockchain technology enhances transparency and traceability, builds trust, reduces fraud, and supports circular economy initiatives by offering a decentralized ledger for managing supply chain transactions. Despite the potential benefits, challenges such as technological barriers, data privacy concerns, regulatory hurdles, and resistance to change remain significant. This review identifies key opportunities for future research, including the integration of artificial intelligence (AI) with e-procurement systems, expanding blockchain applications in supply chain management, and developing policies to standardize digital procurement practices. Addressing these challenges and opportunities can drive sustainable procurement practices, contribute to global environmental goals, and promote the widespread adoption of green procurement initiatives.*

Keywords: *Green Procurement, Digitalization, E-Procurement Systems, Blockchain Technology, Sustainable Supply Chain, Artificial Intelligence, Circular Economy.*

1.0 INTRODUCTION

The shift toward sustainability has become increasingly crucial in the wake of global challenges such as climate change, environmental degradation, and resource depletion. Procurement, as a fundamental aspect of business operations, plays a vital role in this transition. Green procurement, also referred to as sustainable procurement, is the practice of integrating environmental considerations into purchasing decisions to minimize negative environmental impacts throughout the lifecycle of goods and services (Palmujoki et al., 2010; Mosgaard, (2015). The primary goal of green procurement is to promote the use of environmentally friendly products and services that contribute to the reduction of carbon footprints and the efficient utilization of natural resources (Walker & Brammer, 2009). As governments and businesses alike recognize the importance of sustainability, there has been an increasing focus on green procurement practices globally.

Historically, procurement was driven primarily by cost considerations, with environmental and social factors taking a back seat (Preuss, 2009). However, with the rise of corporate social responsibility (CSR) and increasing environmental regulations, organizations are increasingly shifting towards sustainable procurement to ensure that their activities align with environmental goals (Camilleri, 2017). Despite this shift, organizations face numerous challenges in implementing green procurement. Some of these barriers include evaluating suppliers' sustainability performance, ensuring transparency in the supply chain, and verifying suppliers' environmental claims (Giunipero et al., 2012). The complexities of these

processes often discourage businesses from adopting green procurement practices, despite their long-term benefits.

The advent of digitalization, however, has presented new opportunities for overcoming these challenges. Technologies such as e-procurement systems and blockchain are revolutionizing procurement processes by improving efficiency, transparency, and accountability (Gunasekaran et al., 2019). E-procurement refers to the use of digital platforms for purchasing goods and services, streamlining the procurement process, reducing costs, and ensuring compliance with environmental standards (Waithaka & Kimani, 2021; Bobowski&Gola, 2018). These systems also facilitate the evaluation of suppliers based on sustainability criteria, allowing organizations to make informed decisions that support their green procurement goals (Khalfan et al., 2022; Singh & Chan, 2022).

Similarly, blockchain technology offers significant potential to enhance transparency and traceability in supply chains, which is crucial for ensuring that suppliers adhere to environmental standards (Saberi et al., 2019). By providing a decentralized and immutable ledger of transactions, blockchain can help procurement professionals track the origin of materials, verify sustainability claims, and prevent greenwashing (Kouhizadeh & Sarkis, 2018). Together, e-procurement systems and blockchain technology offer powerful tools for advancing green procurement and ensuring that organizations meet their sustainability targets (Mugge et al., 2020).

The urgency of addressing global environmental issues has led to a growing emphasis on sustainable practices across industries. Green procurement is particularly significant as it addresses a wide range of environmental impacts, from resource depletion to waste generation and pollution (Walker & Phillips, 2009). According to the United Nations' Sustainable Development Goals (SDGs), particularly Goal 12, which focuses on responsible consumption and production, businesses are encouraged to adopt sustainable practices, including green procurement, to reduce their environmental footprint (UN, 2015). In response to these global initiatives, many governments have established policies and regulations to promote green procurement, requiring organizations to incorporate sustainability criteria into their procurement processes (Brammer & Walker, 2011).

For example, the European Union has implemented policies aimed at integrating environmental criteria into public procurement, with the goal of reducing carbon emissions and promoting eco-friendly products and services (Blažo et al., 2019). Similarly, various countries, such as South Korea, have developed e-procurement systems that prioritize sustainability by enabling the evaluation of suppliers based on their environmental performance (Lim et al., 2008). The implementation of these systems is critical in achieving long-term environmental goals and ensuring that procurement practices align with sustainability objectives (Shahin et al., 2024).

E-procurement systems have transformed traditional procurement practices by digitizing the procurement process, which allows organizations to automate tasks, reduce paperwork, and improve supplier management (Rejeb et al., 2018). These systems enable procurement officers to access a larger pool of suppliers, compare their sustainability credentials, and make data-driven decisions that support their green procurement objectives (Beaumont & Underwood, 2015). One of the primary benefits of e-procurement systems is their ability to enhance transparency, providing organizations with real-time data on suppliers' environmental performance, which is essential for sustainability reporting and compliance (Amakye, 2023).

Moreover, e-procurement systems have been instrumental in improving efficiency by reducing transaction costs and minimizing the time required to complete procurement processes (Gunasekaran et al., 2019). By automating repetitive tasks such as supplier evaluation and contract management, these systems free up resources that can be directed toward more strategic procurement activities, including the assessment of suppliers based on environmental criteria (Gupta & Kohli, 2006). As a result, e-procurement systems play a critical role in advancing green procurement by making it easier for organizations to evaluate suppliers and select those that meet sustainability standards (Singh & Chan, 2022).

The successful implementation of e-procurement systems in green procurement has been demonstrated in several countries. For example, South Korea's KONEPS system, which is an e-procurement platform used for public procurement, integrates environmental criteria into the procurement process, ensuring that suppliers meet sustainability standards (Lim et al., 2008). This system not only enhances transparency but also promotes the use of eco-friendly products and services, thereby contributing to the country's environmental goals (Lim et al., 2008).

Blockchain technology offers a unique solution to the challenges of transparency and traceability in green procurement. As an immutable and decentralized ledger, blockchain ensures that all transactions in a supply chain are recorded and verified by multiple parties, making it difficult for any single entity to alter the records (Kouhizadeh & Sarkis, 2018). This is particularly important in green procurement, where verifying the sustainability claims of suppliers is often challenging due to the complexity of global supply chains (Saberi et al., 2019).

One of the key advantages of blockchain technology is its ability to provide a verifiable record of the origin and environmental impact of products and services (Mugge et al., 2020). For instance, in the textile industry, blockchain has been used to track the sourcing of sustainable materials, ensuring that suppliers adhere to environmental standards throughout the production process (Saberi et al., 2019). This level of transparency is crucial in preventing greenwashing, where companies falsely claim that their products are environmentally friendly (Kouhizadeh & Sarkis, 2018). By using blockchain, procurement professionals can ensure that their suppliers meet the required sustainability standards, thereby supporting their green procurement objectives (Kouhizadeh & Sarkis, 2018).

Blockchain's potential to enhance transparency in green procurement has been recognized by various industries. In the energy sector, for example, blockchain is being used to track the production and distribution of renewable energy certificates, ensuring that buyers can verify the source of renewable energy (Mugge et al., 2020). This use of blockchain technology not only supports green procurement but also promotes trust and accountability among stakeholders in the supply chain (Saberi et al., 2019).

The convergence of e-procurement systems and blockchain technology offers a powerful solution for advancing green procurement. While e-procurement systems streamline the procurement process and enable organizations to evaluate suppliers based on sustainability criteria, blockchain ensures that the data used in these evaluations is accurate and verifiable (Gunasekaran et al., 2019). Together, these technologies provide a comprehensive framework for organizations to achieve their green procurement goals by enhancing efficiency, transparency, and accountability (Saberi et al., 2019).

In the future, the integration of e-procurement and blockchain technology is likely to become increasingly important as organizations seek to meet more stringent environmental regulations and consumer expectations for sustainability (Mugge et al., 2020). By adopting these technologies, organizations can ensure that their procurement practices not only comply with environmental standards but also contribute to the broader goal of sustainable development (Kouhizadeh & Sarkis, 2018). Consequently, this paper takes a critical review of the role of digitalization (e-procurement and blockchain technology) in advancing green procurement processes in organizations

2. Conceptual Framework

This section provides a conceptual overview of the key components that underlie the role of digitalization in green procurement, with a focus on e-procurement systems and blockchain technology. These concepts are critical for understanding how technology-driven procurement practices can enhance sustainability and efficiency.

2.1 Green Procurement

Green procurement is the process of purchasing goods, services, and works with a reduced environmental impact throughout their lifecycle. It emphasizes the inclusion of environmental criteria in procurement decisions, prioritizing suppliers and products that are energy-efficient, resource-efficient, and environmentally friendly (Walker & Brammer, 2009). The core goal of green procurement is to mitigate environmental harm by encouraging the use of renewable materials, promoting waste reduction, and ensuring sustainable resource utilization (Thomson & Jackson, 2007; Yap et al., 2024).

In public sector procurement, governments worldwide are increasingly incorporating green procurement into their policies as a response to global environmental challenges. For example, the European Union's Green Public Procurement (GPP) initiative sets environmental criteria that must be met during procurement processes, ensuring that sustainable practices are promoted across different sectors (Testa et al., 2012). Similarly, public agencies in countries like South Korea and Japan have developed national strategies to integrate green procurement practices into their operations, with e-procurement platforms providing support for sustainability evaluations (Lim et al., 2008).

Green procurement offers several benefits. It not only helps organizations meet regulatory and compliance obligations but also fosters innovation by encouraging suppliers to develop eco-friendly

products and services (Giunipero et al., 2012). However, one of the main challenges is assessing the environmental credentials of suppliers, especially in complex global supply chains. This is where digitalization, including e-procurement systems and blockchain technology, can play a pivotal role by offering tools to enhance transparency, streamline processes, and track the environmental performance of suppliers (Kouhizadeh & Sarkis, 2018).

2.2 Digitalization in Procurement

Digitalization in procurement refers to the use of advanced technologies to automate and streamline procurement activities. Technologies such as artificial intelligence (AI), data analytics, and cloud computing are transforming procurement by enabling data-driven decision-making, enhancing efficiency, and improving supplier relationship management (Gunasekaran et al., 2019). These technologies provide procurement professionals with real-time insights into supplier performance, enabling better evaluations based on criteria such as cost, quality, and sustainability.

In the context of green procurement, digitalization facilitates the integration of environmental criteria into the procurement process. For instance, digital procurement platforms allow organizations to automate the assessment of suppliers' environmental credentials, such as their carbon footprint, resource efficiency, and compliance with environmental regulations (Visentini, 2019). Moreover, digital technologies support the standardization of procurement processes across departments and regions, ensuring that environmental standards are consistently applied (Patrucco et al., 2021).

One of the most significant contributions of digitalization is its ability to enhance supply chain visibility, which is essential for evaluating the environmental impact of procurement decisions. Through data analytics and cloud-based solutions, procurement teams can track and assess the environmental performance of suppliers across the entire supply chain, helping organizations make more informed and sustainable procurement decisions ([2]Gunasekaran et al., 2019).

2.3 E-Procurement Systems

E-procurement systems are digital platforms that facilitate the online management of procurement processes, from supplier selection to contract management. These systems are critical in modernizing procurement operations by offering automation, efficiency, and enhanced transparency (Neupane et al., 2012). E-procurement systems enable organizations to move away from manual, paper-based procurement processes, reducing operational costs and minimizing errors.

The relevance of e-procurement systems to green procurement lies in their ability to streamline the evaluation of suppliers based on environmental performance. By using e-procurement systems, organizations can incorporate environmental criteria into supplier databases, allowing procurement teams to compare suppliers based on sustainability factors (Singh & Chan, 2022). For example, the South Korean KONEPS platform integrates green procurement criteria into its e-procurement system, enabling public agencies to select suppliers based on their environmental credentials (Lim et al., 2008).

Moreover, e-procurement systems help organizations comply with environmental regulations by providing digital records of procurement activities, ensuring transparency and accountability (Hochstetter et al., 2023). These systems also allow organizations to track and manage sustainability certifications, making it easier to ensure that suppliers meet environmental standards and requirements (Brammer & Walker, 2011). This level of transparency is crucial in green procurement, as it ensures that sustainability claims made by suppliers can be verified, reducing the risk of greenwashing (Kouhizadeh & Sarkis, 2018).

2.4 Blockchain Technology in Procurement

Blockchain technology offers a decentralized, secure, and transparent ledger system that records transactions in an immutable manner. The application of blockchain in procurement is particularly significant in addressing challenges related to transparency, traceability, and trust in supply chains (Saberi et al., 2019). Blockchain's ability to provide a verifiable and immutable record of procurement activities ensures that organizations can track the origin and environmental impact of products and services throughout the supply chain.

In the context of green procurement, blockchain technology can be used to verify the environmental claims of suppliers, ensuring that products meet sustainability standards (Mugge et al., 2020). For instance, blockchain can provide a digital trail of materials used in the production of goods, allowing

procurement professionals to verify whether the materials were sourced sustainably (Saberi et al., 2019). This is particularly important in industries where environmental claims are difficult to verify due to complex supply chains, such as in the textile and electronics sectors (Kouhizadeh & Sarkis, 2018).

Furthermore, blockchain technology enhances transparency by enabling all stakeholders in the supply chain to access real-time information on procurement activities, reducing the risk of fraud and ensuring accountability (Mugge et al., 2020). This increased visibility supports green procurement by enabling organizations to make more informed decisions about suppliers and ensuring that sustainability claims are accurate and verifiable (Saberi et al., 2019). In addition, blockchain can facilitate the tracking of carbon emissions and resource usage throughout the supply chain, providing valuable data for organizations seeking to reduce their environmental impact (Kouhizadeh & Sarkis, 2018).

3. The Role of E-Procurement Systems in Green Procurement

E-procurement systems have emerged as powerful tools in supporting green procurement by offering digital platforms that enhance supplier selection, optimize resource use, reduce waste, and streamline compliance and reporting. These systems provide an efficient, transparent, and standardized approach to managing procurement activities, contributing significantly to the achievement of sustainability goals.

3.1 Enhancing Supplier Selection

E-procurement systems play a critical role in enhancing the supplier selection process by offering tools that evaluate suppliers based on multiple criteria, including environmental performance. By utilizing these systems, procurement professionals can assess and rank suppliers according to factors such as their carbon footprint, use of renewable resources, and compliance with environmental regulations (Searcy & Elkhawas, 2012). E-procurement platforms enable organizations to automate supplier evaluations and track key performance indicators related to sustainability, ensuring that green procurement goals are met (Gunasekaran et al., 2019).

The integration of environmental criteria into supplier databases facilitates the identification of suppliers who offer eco-friendly products or services. This allows organizations to make informed decisions that align with their sustainability objectives. For instance, organizations can use e-procurement systems to prioritize suppliers with environmental certifications, such as ISO 14001, ensuring that they meet recognized sustainability standards (Testa et al., 2012; Islam, 2024; Alnuaimi et al., 2024). Moreover, these systems enhance transparency by providing digital records of supplier performance, allowing for better accountability and monitoring over time (Lim et al., 2008).

3.2 Optimizing Resource Use and Reducing Waste

One of the key advantages of e-procurement systems in green procurement is their ability to optimize resource use and reduce waste. E-procurement systems reduce the need for paper-based procurement processes, thereby minimizing the environmental impact associated with printing, mailing, and storing documents (Neef, 2001). Additionally, digital procurement platforms can automate repetitive tasks, reducing the time and energy spent on procurement activities, ultimately lowering an organization's overall carbon footprint (Segun-Ajao, 2024).

E-procurement systems also help organizations manage inventory and resource utilization more effectively. For example, procurement teams can use digital platforms to track the consumption of raw materials and monitor stock levels in real-time, allowing them to order only what is necessary and avoid overstocking (Gunasekaran et al., 2019). By optimizing resource use in this manner, organizations can reduce excess inventory and minimize waste, contributing to their sustainability objectives.

In addition to minimizing waste, e-procurement systems enable the procurement of eco-friendly materials, products, and services that have a lower environmental impact throughout their lifecycle. For instance, these platforms can flag suppliers offering products made from recycled or biodegradable materials, making it easier for procurement professionals to select options that align with the organization's green procurement policies (Kouhizadeh & Sarkis, 2018).

3.3 Streamlining Compliance and Reporting

E-procurement systems play a crucial role in streamlining compliance with environmental regulations and facilitating sustainability reporting. These systems provide procurement teams with tools to automatically track and manage compliance with environmental standards, ensuring that suppliers and

products meet required sustainability criteria (Brammer & Walker, 2011). Through automated checks and balances, organizations can ensure that their procurement activities align with national and international environmental regulations, such as the European Union's Green Public Procurement (GPP) criteria (Flechsig et al., 2022).

Furthermore, e-procurement systems offer detailed reporting capabilities that make it easier for organizations to monitor and report on their sustainability performance. For instance, procurement teams can generate reports that summarize the environmental impact of their procurement activities, including data on the carbon emissions, waste generation, and resource consumption associated with purchased goods and services (Singh, 2024; Olanrewaju et al., 2024). These reports can be used to demonstrate the organization's commitment to sustainability, helping to meet internal and external reporting requirements ([2]Gunasekaran et al., 2019).

In addition to facilitating compliance with environmental regulations, e-procurement systems provide a framework for monitoring supplier performance over time. Procurement teams can track changes in suppliers' environmental credentials and performance metrics, ensuring ongoing compliance with green procurement standards (Bohari et al., 2020). This level of transparency helps build trust with stakeholders, as organizations can provide evidence that they are sourcing products and services from environmentally responsible suppliers.

3.4 Case Studies of E-Procurement in Green Procurement

Several case studies highlight the successful implementation of e-procurement systems in promoting green procurement across different sectors. One notable example is the Korean On-line E-Procurement System (KONEPS), which integrates green public procurement criteria into its e-procurement platform. By doing so, public agencies in South Korea can prioritize suppliers who meet environmental standards and track the sustainability performance of purchased goods and services (Lim et al., 2008). KONEPS has helped streamline the procurement process while ensuring that sustainability remains a key consideration in supplier selection and contract management.

Another example can be seen in the European Union, where e-procurement systems are used to implement the GPP initiative. The European Union has developed digital tools that allow procurement professionals to evaluate suppliers and products based on their compliance with GPP criteria, such as energy efficiency, recyclability, and the use of environmentally friendly materials (Testa et al., 2012; Renata et al., 2020). This has led to a significant increase in the adoption of green procurement practices across EU member states, demonstrating the effectiveness of e-procurement systems in promoting sustainability.

In the private sector, companies such as Unilever and Walmart have implemented e-procurement systems that integrate environmental criteria into their supplier evaluation processes. These companies use digital platforms to assess the sustainability performance of their suppliers, ensuring that products are sourced from environmentally responsible vendors (Kouhizadeh & Sarkis, 2018). By leveraging e-procurement systems, these companies have been able to reduce their environmental impact and enhance the sustainability of their supply chains.

4. The Role of Blockchain Technology in Green Procurement

Blockchain technology, with its decentralized, immutable, and transparent nature, has shown significant potential in transforming green procurement. Its ability to track transactions and supply chain activities in real-time makes it an ideal tool for ensuring transparency, strengthening trust, reducing fraud, and enhancing circular economy initiatives in green procurement. As organizations seek to align their procurement strategies with sustainability goals, blockchain offers a range of benefits that support these objectives.

4.1 Ensuring Transparency and Traceability

One of the most significant contributions of blockchain to green procurement is its ability to ensure transparency and traceability throughout the supply chain. Blockchain records every transaction in a decentralized ledger, making it nearly impossible to alter or falsify information. This feature is critical in green procurement, where organizations need to verify that suppliers are adhering to environmental standards and sourcing sustainable materials.

Blockchain enables the tracking of products from the point of origin to the final consumer, providing a clear view of the entire supply chain (Saberi et al., 2019). For example, organizations can use blockchain to trace raw materials to their sources, ensuring that they are sourced from sustainable practices such as eco-friendly mining or renewable agriculture (Kouhizadeh & Sarkis, 2018). This level of traceability allows organizations to verify that their suppliers are meeting the necessary environmental criteria and supports compliance with green procurement regulations.

Moreover, blockchain can help eliminate the “greenwashing” problem, where companies falsely claim to be environmentally friendly. By recording all relevant data on the blockchain, organizations can provide verifiable proof of their environmental claims, such as certifications and audits, thereby enhancing the credibility of their green procurement initiatives (Manski, 2017). The transparency offered by blockchain also enables stakeholders, including consumers, to access real-time information about the environmental impact of their purchases, promoting greater accountability.

4.2 Strengthening Trust and Reducing Fraud

Blockchain technology strengthens trust among stakeholders in the procurement process by ensuring the integrity of data and reducing the risk of fraud. Since blockchain is decentralized and tamper-resistant, it creates an environment of trust where no single party can alter the procurement records (Chang et al., 2020). This is particularly important in green procurement, where trust between buyers and suppliers is essential to ensure adherence to sustainability commitments.

By using blockchain, organizations can prevent fraudulent activities such as the falsification of certifications or environmental compliance documents. For example, in traditional procurement systems, suppliers might submit fraudulent documentation claiming that their products meet green procurement standards, even if they do not (Treiblmaier, 2018). Blockchain eliminates this risk by providing an immutable record of all transactions and documents, making it easier to verify the authenticity of certifications, audits, and other environmental credentials.

Additionally, smart contracts, which are self-executing contracts with terms written directly into code, can be implemented on blockchain platforms to automate procurement processes (Casino et al., 2019). These contracts ensure that sustainability requirements, such as the use of eco-friendly materials or compliance with emissions standards, are met before payments are released. This reduces the risk of non-compliance and strengthens trust between buyers and suppliers, as both parties are bound by the contract's automated enforcement mechanism.

4.3 Enhancing Circular Economy Initiatives

Blockchain technology also plays a crucial role in supporting circular economy initiatives by promoting resource efficiency and waste reduction. A circular economy focuses on minimizing waste and maximizing the use of resources by recycling, reusing, and repurposing materials. Blockchain can enhance circular economy initiatives by tracking the lifecycle of products and materials, ensuring that they are properly recycled or reused at the end of their life cycle (Saberi et al., 2019).

For instance, blockchain can be used to track the ownership and condition of products throughout their lifecycle, allowing organizations to implement “product-as-a-service” models, where goods are leased rather than sold outright. This model encourages manufacturers to design products that are durable, repairable, and recyclable, as they retain ownership of the product and are responsible for its disposal or repurposing (Kouhizadeh & Sarkis, 2018). By leveraging blockchain, organizations can ensure that products are returned at the end of their lifecycle and that the materials are properly recycled, contributing to a more sustainable procurement strategy.

Blockchain can also support extended producer responsibility (EPR) programs, where manufacturers are held accountable for the disposal and recycling of their products. By tracking materials on the blockchain, manufacturers can ensure that their products are collected and recycled at the end of their use, thus reducing waste and promoting resource efficiency (Treiblmaier, 2018). This contributes to a circular economy by extending the lifecycle of materials and minimizing the need for new resource extraction.

4.4 Case Studies in Blockchain for Green Procurement

Several case studies illustrate the successful implementation of blockchain technology in green procurement, demonstrating its potential to enhance sustainability initiatives across different industries.

One such example is the partnership between IBM and Everledger, which uses blockchain to track the provenance of diamonds. By recording the entire journey of a diamond on the blockchain, from the mine to the consumer, this initiative ensures that diamonds are sourced ethically and without environmental harm, aligning with green procurement principles (Saberi et al., 2019). The transparency and traceability offered by blockchain in this case could be replicated in other industries to ensure that raw materials are sustainably sourced.

Another case study involves the use of blockchain in the food industry. Walmart, in collaboration with IBM, has implemented a blockchain-based system to track the supply chain of food products, ensuring that they are sustainably sourced and free from contamination (Casino et al., 2019). This system enables Walmart to trace products back to their origin in seconds, allowing the company to verify that suppliers meet sustainability criteria, such as organic farming practices or reduced pesticide use. This enhances the credibility of Walmart's green procurement initiatives and reduces the risk of non-compliance with environmental regulations.

In the renewable energy sector, blockchain has been used to track the generation and consumption of renewable energy. For example, the Energy Web Foundation has developed a blockchain-based platform that allows companies to purchase renewable energy certificates (RECs) directly from renewable energy producers (Treiblmaier, 2018). This system ensures that companies are sourcing renewable energy in line with their green procurement commitments and provides transparency into the renewable energy supply chain.

5. Challenges in Implementing Digitalization in Green Procurement

While digitalization has significant potential to transform green procurement, the transition to e-procurement systems and blockchain technology is not without its challenges. These challenges include technological barriers, data privacy and security concerns, regulatory and policy issues, and resistance to change. A comprehensive knowledge of these barriers is pivotal for organizations seeking to implement digital solutions in their green procurement strategies.

5.1 Technological Barriers

The adoption of digital technologies in green procurement often faces significant technological barriers, which can impede the effectiveness and scalability of e-procurement systems and blockchain technology. One of the key technological challenges is the lack of adequate infrastructure to support these digital systems, particularly in developing countries where internet access and digital literacy may be limited (Mendling et al., 2018). For example, in regions where internet connectivity is unstable, organizations may struggle to maintain the continuous data flows required for blockchain technology and real-time e-procurement systems.

Furthermore, integrating digital systems with existing procurement platforms can be a complex and costly process. Organizations often rely on legacy systems that are not compatible with new digital technologies, leading to interoperability issues ([2]Gunasekaran et al., 2019). This lack of compatibility can hinder the seamless adoption of e-procurement systems and blockchain, as organizations must either invest in expensive upgrades or develop custom solutions to bridge the technological gaps.

Another technological barrier is the scalability of blockchain systems. While blockchain has the potential to enhance transparency and traceability, the technology still faces scalability issues, particularly in industries with high transaction volumes (Saberi et al., 2019). The decentralized nature of blockchain can result in slower transaction processing times and higher energy consumption, which may limit its applicability in large-scale green procurement initiatives.

5.2 Data Privacy and Security Concerns

Data privacy and security are major concerns in the implementation of digital solutions in green procurement. E-procurement systems and blockchain technologies rely on the collection, storage, and sharing of vast amounts of data, including sensitive information about suppliers, contracts, and transactions. This creates significant risks related to data breaches, cyberattacks, and unauthorized access to confidential information (Casino et al., 2019).

Blockchain technology, in particular, raises concerns about data privacy due to its immutable nature. Once data is recorded on a blockchain, it cannot be altered or deleted, which could pose problems if sensitive information is mistakenly recorded or if privacy laws, such as the General Data Protection Regulation (GDPR), require the deletion of personal data (Zavolokina et al., 2020). While blockchain can provide transparency and traceability, organizations must balance these benefits with the need to protect sensitive information and comply with data privacy regulations.

In addition, the decentralized nature of blockchain systems can make it difficult to ensure accountability and enforce security standards across all participants in the supply chain (Chang et al., 2020). Each participant in the blockchain network must adhere to the same security protocols, and any vulnerabilities in one part of the network can compromise the entire system. As a result, organizations must invest in robust cybersecurity measures and establish clear data governance policies to mitigate these risks.

5.3 Regulatory and Policy Challenges

The regulatory and policy environment surrounding digital technologies in procurement can also pose significant challenges. Many governments and regulatory bodies have yet to establish clear guidelines or standards for the use of blockchain and e-procurement systems in green procurement, leading to uncertainty and hesitancy among organizations (Chang et al., 2020). Without clear regulations, organizations may struggle to navigate compliance issues, particularly when dealing with cross-border procurement activities that involve multiple jurisdictions with differing legal requirements.

In addition to the lack of regulatory clarity, existing procurement policies may not be well-suited to accommodate digital technologies. Traditional procurement frameworks are often based on manual processes and paper-based documentation, which can be difficult to adapt to the digital environment (Gunasekaran et al., 2019). As a result, organizations may face challenges in aligning their procurement practices with the capabilities of e-procurement systems and blockchain technology.

Another regulatory challenge is the need for standardization. The lack of standardized protocols for digital procurement systems can result in inconsistencies and inefficiencies in the implementation of these technologies. For example, blockchain platforms often use different consensus mechanisms and data formats, which can hinder interoperability between different systems (Saberi et al., 2019). Policymakers and industry stakeholders must work together to develop standardized frameworks that facilitate the adoption of digital technologies in green procurement.

5.4 Resistance to Change

Resistance to change is a common challenge in the adoption of new technologies, particularly in industries that have traditionally relied on manual and paper-based processes. Employees and stakeholders may be reluctant to embrace digital solutions due to concerns about job displacement, the complexity of new systems, or a lack of familiarity with technology (Zavolokina et al., 2020). This resistance can slow the adoption of e-procurement systems and blockchain technology, particularly in organizations where there is a strong preference for traditional procurement methods.

One of the key factors contributing to resistance is the perceived difficulty of learning and using new digital tools. E-procurement systems and blockchain platforms often require specialized knowledge and training, which can be a barrier for employees who are not familiar with these technologies (Mendling et al., 2018). Organizations must invest in comprehensive training programs to ensure that employees are equipped with the skills and knowledge needed to effectively use digital procurement systems.

Additionally, resistance to change can stem from concerns about the cost and complexity of implementing digital solutions. Organizations may be hesitant to invest in new technologies if they perceive the implementation process as too expensive or disruptive to their existing operations (Chang et al., 2020). To overcome this resistance, organizations must demonstrate the long-term benefits of digitalization, such as increased efficiency, cost savings, and enhanced sustainability outcomes.

6. Opportunities for Future Research and Development

The digital transformation of procurement systems opens up numerous opportunities for future research and development. Key areas of focus include the integration of artificial intelligence (AI) with e-procurement systems, expanding the applications of blockchain technology in supply chain management, and the development of policy frameworks and standardization efforts to ensure

widespread adoption of digital procurement solutions. Each of these areas presents significant potential to enhance the efficiency, transparency, and sustainability of procurement processes.

6.1 Integrating Artificial Intelligence with E-Procurement Systems

One promising area for future research is the integration of artificial intelligence (AI) with e-procurement systems to improve decision-making, streamline operations, and reduce procurement risks. AI has the potential to automate various procurement tasks, such as supplier selection, contract management, and risk assessment, by analyzing large datasets and providing predictive insights (Jiang et al., 2020). For example, machine learning algorithms can analyze historical procurement data to identify patterns, predict supplier performance, and recommend optimal procurement strategies (Spreitzenbarth et al., 2024).

The integration of AI with e-procurement systems can also enhance supplier relationship management by providing real-time insights into supplier behavior, performance, and risks. AI-driven analytics can help procurement managers detect potential supply chain disruptions, fraud, or non-compliance with sustainability standards, enabling more proactive and informed decision-making (Pandey et al., 2024). Furthermore, AI-powered chatbots and virtual assistants can automate routine tasks, such as responding to supplier inquiries or managing procurement documentation, thereby reducing administrative burdens and improving efficiency (Mikalef et al., 2019).

Despite its potential, the integration of AI with e-procurement systems presents challenges that warrant further research. For example, there is a need for research into the ethical implications of using AI in procurement, particularly with respect to data privacy, algorithmic bias, and accountability (Jiang et al., 2020). Additionally, future studies should explore how AI can be effectively integrated into existing procurement processes and what training and change management strategies are required to ensure successful adoption.

6.2 Expanding Blockchain Applications in Supply Chain Management

Blockchain technology has already demonstrated significant potential in enhancing transparency, traceability, and trust in supply chain management, but there is still much room for expanding its applications. Future research could explore how blockchain can be further utilized to support circular economy initiatives, ensure compliance with sustainability standards, and facilitate collaboration among supply chain stakeholders (Saberi et al., 2019).

One key area for future research is the use of blockchain in managing the entire lifecycle of products, from raw material sourcing to end-of-life disposal or recycling (Wang et al., 2019). Blockchain can provide immutable records of a product's journey through the supply chain, enabling consumers and regulators to verify that products meet environmental and social standards. This could be particularly useful in industries such as electronics, textiles, and automotive manufacturing, where the environmental impact of production and disposal is significant (Kouhizadeh & Sarkis, 2018).

Moreover, blockchain can facilitate more efficient and transparent collaboration between supply chain partners by providing a shared, decentralized platform for exchanging information and coordinating activities. Future research could investigate how blockchain-enabled smart contracts can automate procurement processes, such as payments, inventory management, and quality control, while reducing the risk of disputes and fraud (Chang et al., 2020). Additionally, researchers should explore the potential of integrating blockchain with other emerging technologies, such as the Internet of Things (IoT) and AI, to create more intelligent and autonomous supply chains (Saberi et al., 2019).

6.3 Policy Development and Standardization

As digital technologies continue to transform procurement and supply chain management, there is a growing need for policy development and standardization to ensure the safe, ethical, and effective use of these technologies. Governments, industry associations, and international organizations must work together to establish clear regulatory frameworks and technical standards that address the challenges posed by digital procurement systems, such as data privacy, cybersecurity, and interoperability (Casino et al., 2019).

One area for future research is the development of policies that support the integration of e-procurement and blockchain technologies in public procurement processes. Public procurement is often subject to strict regulations and scrutiny, and the adoption of digital technologies in this context requires clear

guidelines to ensure transparency, accountability, and compliance with legal requirements (Kashiwagi et al., 2019). Researchers could investigate how existing procurement regulations can be adapted to accommodate digital technologies and what new policies are needed to address emerging risks, such as data breaches and algorithmic bias.

Standardization is also crucial for ensuring that digital procurement systems can interoperate across different organizations, industries, and jurisdictions. Future research could focus on developing standardized protocols for blockchain transactions, data formats, and smart contracts to facilitate seamless collaboration between supply chain partners (Zavolokina et al., 2020). Additionally, researchers should explore how international standards, such as ISO 20400 on sustainable procurement, can be updated to reflect the growing use of digital technologies in procurement processes (Spreitzenbarth et al., 2024).

In conclusion, the future of digitalization in green procurement presents exciting opportunities for research and development. By exploring the integration of AI with e-procurement systems, expanding the applications of blockchain technology, and developing robust policy frameworks and standards, researchers can help drive the adoption of digital technologies in procurement and contribute to more sustainable and efficient supply chain practices.

7. Conclusion

The rapid advancement of digital technologies has transformed procurement processes, offering significant potential for enhancing sustainability through green procurement practices. The integration of e-procurement systems and blockchain technology has emerged as a powerful enabler of transparent, efficient, and environmentally responsible supply chains. This review has examined the role of digitalization, particularly through e-procurement and blockchain, in promoting green procurement and identified the opportunities, challenges, and future research directions necessary to advance these technologies.

E-procurement systems, as discussed, streamline procurement processes, enhance supplier selection, and promote compliance with environmental standards. By automating tasks and reducing paperwork, these systems minimize resource use and waste, aligning procurement practices with sustainability goals. The application of blockchain technology, meanwhile, ensures transparency and traceability across the supply chain, strengthens trust, and supports the circular economy by providing a decentralized ledger of transactions. Blockchain's ability to reduce fraud and improve collaboration between stakeholders presents substantial benefits for procurement, particularly when environmental and social sustainability are key concerns.

Despite these benefits, several challenges remain in the adoption of digital technologies in green procurement. Technological barriers, such as the high costs of implementation and limited technical expertise, hinder widespread adoption. Additionally, concerns about data privacy and security, regulatory and policy obstacles, and resistance to change continue to impede progress. Addressing these challenges will require coordinated efforts from policymakers, industry leaders, and researchers to develop solutions that promote the secure and equitable use of digital technologies in procurement.

Looking forward, there are several promising areas for future research and development. The integration of artificial intelligence (AI) with e-procurement systems offers significant potential to improve decision-making, automate routine tasks, and enhance supplier management. Additionally, further exploration of blockchain's applications in supply chain management, particularly in supporting circular economy initiatives, could pave the way for more sustainable production and consumption practices. The development of standardized policies and frameworks will be critical to ensure the ethical, transparent, and secure use of these technologies in procurement.

In conclusion, digitalization has the potential to revolutionize green procurement by making supply chains more transparent, efficient, and environmentally friendly. However, realizing this potential requires overcoming technological, regulatory, and cultural challenges, as well as fostering innovation through continued research and development. By addressing these challenges, organizations can leverage digital tools such as e-procurement systems and blockchain technology to create more sustainable and resilient procurement processes, ultimately contributing to global environmental goals.

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