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ADVERSE IMPACT ANALYSIS OF BLOCKCHAIN APPLICATION ON SUSTAINABILITY FOR CHEMICAL INDUSTRY

MD RAFIQUL ISLAM

[1]*Department of Mechatronics, International Islamic University Malaysia, Kuala Lumpur, Malaysia*
[2]*Dept. of Information Technology Division, Bengal Commercial Bank Ltd, Dhaka, Bangladesh*

**Corresponding author: engrrafiqul@gmail.com*

ABSTRACT: Due to security, transparency, traceability, and efficiency, blockchain technology has become more popular in the financial, healthcare, education, and industrial sectors as well. However, before the commercial use of this technology for the chemical industry, the adverse impact of the same should be considered carefully. A study of detailed adverse impact analysis of blockchain applications on the sustainability of the chemical industry has been highlighted in this paper. This research complies with accepted publication standards, in particular, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) recommendations. A variety of primary and supplemental databases are used in our research. Scopus and Science Direct are two well-known databases that we have accessed, along with Emerald Insight, IEE Explore, and Google Scholar as other sources. After comprehensive adverse impact analysis on sustainability from chemical production to blockchain application has been considered such as 1) Environmental: Higher energy use and CO_2 emissions linked to the blockchain, 2) Social: The adoption of blockchain technology that may extend the digital divination in society who have less technological privilege, and 3) Economical: Resource-constrained businesses entities may face difficulties due to the costs of developing and integrating blockchain technology in business. This paper will help the stakeholders in the chemical production business to make wise decisions on the adoption of blockchain applications to maximize the benefits by identifying potential risks, developing mitigation strategies, and ensuring that blockchain applications align with sustainable development goals and practices.

KEYWORDS: *Blockchain, Chemical Industry, Proof-of-Work, sustainability.*

1. INTRODUCTION

The chemical industry, which is a pillar of contemporary civilization, plays a crucial role in supplying the materials and compounds required for a vast array of activities in our everyday lives. Numerous industries have undergone substantial change because of the quick development of technology where blockchain technology has an emerging potential to be used for increasing transparency, and real-time monitoring systems that may ultimately help to produce quality goods in fertilizers, pharmaceuticals, polymers, and numerous industrial chemicals in chemical industries [1]. However, the advantages this business offers frequently come at a price, with unfavorable environmental effects that pose serious problems for sustainability. Innovative technologies have arisen as possible change agents as the world struggles with the urgent need for more ethical and environmentally conscientious behavior.

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Though there are several benefits of blockchain application, a mentionable number of negative influences on sustainability due to environmental pollution, climate change, ecosystem, CO_2 emission, excessive electricity consumption, etc. cannot be ignored [2, 3]. The main objective of this study is to identify the adverse impacts of blockchain applications on sustainability in the chemical industry. Besides the adverse impact analysis, this paper also maps the relationship between environmental pollution, social, and economic impacts, and Sustainable Development Goals (SDGs) by answering the following research questions and hence presents the research gap analysis.

- RQ1: What are the negative effects of blockchain applications on the chemical industry's sustainability owing to CO_2 emissions?
- RQ2: What connection exists between SDG and the negative effects of blockchain applications in the chemical industry?

1.1 Present Work and Research Gap

In the review article [4], the authors clearly explained the negative impacts of blockchain technology on the environment, society, and economy. They also explained the impact of CO_2 on the environment as well as inequality in social life and they mapped the impacts with SDGs. In the research papers [5], [6], [7], and [8], the authors briefly highlighted the negative impacts on sustainability due to using PoW protocol and excessive use of electricity which generated extensive amounts of CO_2 in the environment. The authors in articles [9], [10], and [11] highlight how the environment can be affected by emitting CO_2 where they mentioned electricity consumption, air pollution, and climate changes. In this paper, the impact of using blockchain applications in chemical industries has been discussed in detail with related properties of environment, social, and economic as well as mapping of these effects with SDGs.

2. METHODOLOGY

The main objective of this study is to find out the adverse ecological effects of blockchain implementations on the chemical industry's sustainability, particularly concerning carbon dioxide (CO2) emissions. Additionally, this research also finds out how the Sustainable Development Goals (SDGs) relate to the negative effects of the chemical industry's implementation of blockchain technology. Systematic studies and literature reviews have been conducted based on the following criteria: 1) Relevant research work and articles related to blockchain applications in the chemical industry, 2) Sustainability and environmental impacts, 3) Related peer-reviewed journals, and 4) The information searched from 2018 to 2023. This systematic literature review was conducted based on the searching data from academic databases which included Scopus journals, Web of Science, newspapers, and online related articles. The peer-reviewed articles published in the journals, conferences, books, or symposiums that have been selected to search the databases. The Search strings such as "blockchain" and ("chemical industry*" or "SDGs*" or "environmental effects*" or "social*" or "economical*") have been used to collect the articles. It also analyzed several factors, including the effects on the environment (air, water, soil, climate, ecosystem), the effects on society (health, inequality, migration trends), and the effects on the economy (healthcare expenses, costs related to climate change, industrial costs).

2.1. Paper Screening Process

The databases were searched for articles with titles that were almost equivalent to this research report. Titles were taken into consideration, and publications that did not match the reviews were discarded. Retrieved papers were discarded if their titles made it very evident that they were not pertinent to this paper. The search protocol produced some papers, some of which were eliminated since they had nothing to do with the use of blockchain in the chemical industry. When a paper's relevance could not be quickly inferred from its title, it was moved on to the following stage for additional screening. Reading the abstracts of the papers that made it past the first step of screening made up the second phase of the screening process. Sometimes it was required to study a paper's opening and conclusion as well to see if it met our exclusion standards.

According to our exclusion criteria, we have to ignore the following: (1) Non-peer-reviewed papers, such as press releases and interviews, (2) Papers without full access, (3) Papers whose primary focus is unrelated to the use of blockchain technology in the chemical industry, (4) Duplicate papers, (5) Non-English papers, and (6) Retracted papers. The systematic literature review as per PRISMA [12] has been used to screen and select the records which is shown in Fig. 1.

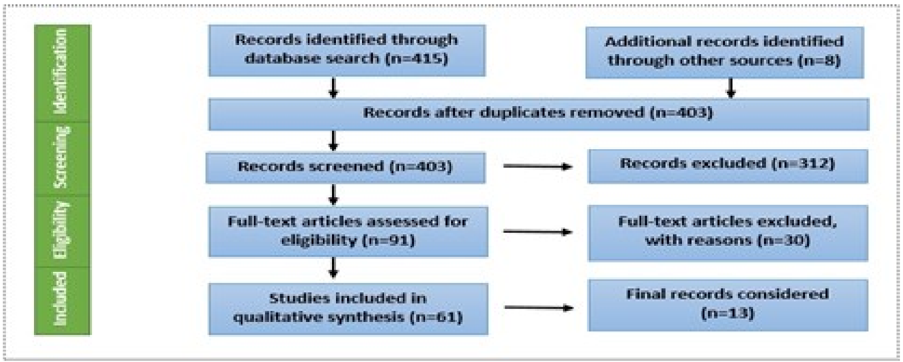

Fig. 1. Process flow diagram of screening and selection records.

3. ADVERSE IMPACT ANALYSIS ON SUSTAINABILITY

The adoption of blockchain applications in the chemical sector has major negative implications on sustainability, in contrast to the positive effects of blockchain technology on the Sustainable Development Goals (SDGs). These consist of areas: 1) Impact on the environment: The use of blockchain networks may result in higher energy use and resultant CO_2 emissions. This increased energy requirement for blockchain operations presents a problem for the environment because it could increase carbon emissions. 2) Social implications: The adoption of blockchain technology may make digital inequality worse. People with restricted access to technology can find it harder to participate in society, which could widen the digital divide. 3) Economic considerations: The expenditures involved with the development and integration of new blockchain technology into operations may provide challenges for companies operating on a limited budget. Smaller companies in the business can be financially burdened even more because of these costs.

3.1 Respone of RQ1 and RQ2

Table 1 provides an adverse impact analysis of the negative effects of blockchain applications on Sustainable Development Goals (SDGs). This research has highlighted the detrimental effects in this table based on the three main goals of the environmental, social, and economic sectors. This comprehensive analysis not only captures pertinent features but also offers mappings to SDG targets. We learn that blockchain applications may have an impact on SDGs spanning several fields, which has broad consequences. SDGs 3 (Good health and well-being), 6 (Clean water and sanitation), 9 (Industry, innovation, and infrastructure), 10 (Reduced inequalities), 11 (Sustainable cities and communities),13 (Climate action), 14 (Life below water), and 15 (Life on land) are at risk from these negative effects. Further investigation reveals that these effects also apply to several specific SDG targets, such as SDGs 3.1(Reduce Maternal Mortality*),* 3.8 (Achieve universal health coverage), 3.9 (Reduce illnesses and deaths from hazardous chemicals and pollution), 6.3 (Improve water quality, wastewater treatment, and safe reuse), 9.1(Develop sustainable, resilient and inclusive infrastructures), 10.2 (promote universal social, economic and political inclusion), 10.4 (Adopt fiscal and social policies that promote quality), 10.7 (Responsible and well-managed migration policies*),* 11.6 (Reduce the environmental impacts of cities), 13.1 (Strengthen resilience and adaptive capacity to climate-related *disasters),* 13.2 (Integrate climate change measures into policy and planning), 14.3 (Reduce ocean acidification), and 15.4 (Ensure conservation of mountain ecosystems) [13].

Table 1: Adverse impact analysis of blockchain applications on SDGs

Impact on		**Adverse impact on sustainability**	**Effect on SDG and its Targets [13]**
Environmental Pollution	Air	The planets become worm-like as the amount of CO_2 in the atmosphere rises, changing the temperature and ultimately harming people and other living things.	3 (3.9), 11 (11.6)
	Seawater	The concentration of CO_2 in the atmosphere increases the temperature and acidification of the ocean surface, rising sea levels, and melting glaciers which affect the safety and drinking water, ecosystem system, and aquatic life.	6 (6.3), 14 (14.3).
	Soil	Increasing CO_2 in the air influences to increase in the soil pH level which ultimately influences the rate of weathering and plant nutrients.	3 (3.9)
	Climate change	CO_2 is one of the main concerns of global warming and climate change where it functions as a greenhouse gas by heating the earth and increasing the temperature.	13 (13.1, 13.2)
	Ecosystem	The emission of CO_2 adverse impact on biodiversity and ecosystems. Increasing temperature disrupts and changes the distribution and behavior of species and the ecosystem like in polar regions as well as coral Islands.	15(15.4)
Social	Health	Once CO2 levels are high enough in the atmosphere, it affects temperature rise, which can cause climate change, heat waves, floods, storms, and fatalities.	3 (3.1,3.8, 3.9)
	Inequality	CO_2 emissions are not only affected by the atmosphere, but they also enhance to differentiation of low-income people, indigenous communities, and developing nations. It also leads to an increase in the poverty level and food scarcity in daily social life.	10 (10.2, 10.4)
	Migration tendency	The increase in CO_2 leads the changes in climate, sea levels, natural disasters, and weather which may insist on forced migration from different geographical locations to comparatively better geographical locations, and the overall result may be harmful to society.	10 (10.7)
Economical	Healthcare cost	Climate change may have an impact on diseases like malaria, cancer, dengue fever, and mental illness, among others, due to CO_2 emissions. On the other hand, breathing contaminated air can cause a variety of respiratory and cardiovascular conditions, which can increase the cost of medical care, insurance, and other related expenses.	3 (3.1, 3.8)
	Climate changes cost	Emissions of CO_2 lead to climate change which also exacerbates the extreme weather impacts such as floods, hurricanes, and draughts that may losses extra costs to recovery as well as resiliency costs. The extra budget needs to be allocated for these unseen events.	13 (13.1, 13.2)
	Industry cost	Emissions of CO_2 and climate change may interrupt the chemical industries directly. Due to climate changes, forestry, marine life, tourism, and other sectors. The production, maintenance, and employee health and safety costs will be increased significantly.	9 (9.1)

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It depicts the connections between negative effects and several SDGs because of the Proof-of-Work (PoW) blockchain protocol and excessive CO_2 emissions. Blockchain has many benefits for SDGs. It is critical to recognize and solve these unfavorable effects within the chemical business. Understanding and minimizing these negative effects are crucial for ensuring the ethical and long-lasting use of blockchain technology.

4. CONCLUSION

The analysis of the negative effects of blockchain applications on SDGs for the chemical production industry highlights the importance of taking a thorough and cautious approach. While blockchain technology may provide advantages like security and transparency, its implementation must consider the adverse impacts on sustainability such as environmental, social, and economic including their properties with continuous monitoring and adaptation of essential technology for maximizing its benefit.

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