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Blockchain Technology - Understanding Its Application in Humanitarian Supply Chains

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Abstract. This paper provides a holistic view of blockchain technology promises in humanitarian operations. Blockchain provides most value in the areas of trust, transparency, and visibility, yet it's still unregulated and its technical complexities compounded with a lack of knowledge, technical skills and training pose stringent challenges in its application. Our review offers valuable and unique insight for academic and supply chain practitioners on the extant status and its potential areas of application in humanitarian settings while laying a firm foundation for further research.

Keywords. Blockchain, Humanitarian Supply Chain, Systematic Literature Review.

1. Introduction

The frequency and severity of disasters are increasing worldwide, causing enormous disruptions and deaths [1]. Due to these effects, it's imperative to study the humanitarian or disaster mission of saving lives in the most efficient and effective way possible. To achieve this efficiency and effectiveness, supply chain processes need to be integrated as they account for 80% of disaster activities [2]. Humanitarian aid is needed across all the four disaster management stages of preparedness, mitigation, response, and recovery [3] and therefore, humanitarian supply chains (HSCs) deliver the aid in form of goods (food, water, medical supplies, shelter) and services to the victims. HSC studies the management of disaster operations across all the four stages and it includes the processes of material sourcing, procurement, transportation, storage, and timely delivery to the victims to diminish deaths, resources, and assets losses [4].

HSC involves many stakeholders like donors, aid agencies, governments, humanitarian organisations, business partners and coordinating these players is a big challenge especially due to lack of trust [5]. Information sharing gaps exists amongst partners and if effective communication is enhanced, that would improve collaboration, enhanced transparency, and efficiency of operations [6]. The governance of HSCs is characterised by centralised decision making that is time consuming and uncoordinated thus, clarity in accountability is minimal [4], which could lead to fraud and corruption of humanitarian aid [7]. Several authors have suggested that blockchain technology (BCT) in HSCs would help to minimise these challenges [8]; [9], thus leading to more efficient

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outcomes, but the development and implementation of BCT in HSCs are still young. Our contribution to this paradigm shift is twofold: 1) To identify the extant literature of blockchain application in HSCs and 2.) To reveal gaps for further research.

1.1. Blockchain Technology

Blockchain technology which is the technology behind cryptocurrencies like Bitcoin has revolved beyond its use in the financial industry to other industries such as the health, automotive and food supply chains. BCT is a public transaction digital ledger and a platform that allows everyone to know the truth [10]. Due to its key features of decentralisation where the ledgers are distributed across multiple nodes, immutability which makes data to remain unaltered, data provenance that enables tracking transactions from their source and anonymity as it conceals the real identity of individuals publicly but recognises them uniquely using pseudonyms [11]. Moreover, three concepts of blocks and hashing, mining and proof of work, and consensus, guarantee its functioning [12]. The attributes of BCT present numerous benefits of increased trust, transparency, privacy and security, disintermediation, and automation [13].

1.2. Application of blockchain in humanitarian supply chains

A few of BCT applications in HSCs contexts exist. These have been outlined in Table 1.

Table 1. Application areas of blockchain in HSCs

Organization(s)	Location	Application area
WFP Building blocks project	Pakistan pilot, Bangladesh, and Jordan project	Cash transfer, identity management, WASH transfers (water, sanitation, hygiene) & medicine
Start Network & Disberse	UK to Swaziland pilot, Global transfer projects	Cash transfer in response to humanitarian response
IFRC & Kenya Red Cross	Kenya pilot	Risks and benefits exploration
IFRC & Irish Red Cross & AID: Tech	Syrian refugees in Lebanon	Cash and in-kind donation transfers, and identity management
Akshaya Patra	India meal program	Integrate BCT with AI and IoT for automation of information sharing, food, and energy consumption predictions.
Finnish Immigration Service & MONI	Finland government project for Syrian refugees	Cash disbursals and Identity Management using a prepaid master card
Refunite & IOTA	Global proposed project	Identity management to help refugees reconnect with their families
Sikka	Nepal government & other HSCs players project	Digital asset transfers to financially marginalised communities
Oxfam Unblocked Cash project	Vanuatu project with extensions in Papua New Guinea & Solomon Islands	Cash and voucher disbursal
Fidelity charitable and other over 10 charities see [14]	American public charity	Cryptocurrencies donations acceptance and offering donations to humanitarian NGOs.

1.3. Potential roles of Blockchain application in Humanitarian Supply Chains

The following are areas in which blockchain would provide greater value for humanitarian supply chains.

1. Empowering beneficiaries - BCT provides a platform for efficient cash disbursals that helps in giving disaster victims freedom of choice while guaranteeing their privacy.
2. Funding and tracking donations - BCT offers a transparent contribution and disbursal point, thus eliminating fraud and corruption.
3. Efficiency in relief operations - BCT helps to reduce transaction costs during cash transfers.
4. Decision making tool - BCT enables the exchange of information in real-time, which enhances communication in emergencies and ensures quick implementation of action plans.
5. Data management - BCT enables management and protection of data of all humanitarian players, and it also helps to manage the identities of beneficiaries.
6. Social technology tool - BCT enhances trust that facilitate collaboration of all humanitarian players while offering a visual view of operations which enables proper understanding of individual roles.
7. Information sharing and control - BCT offers transparency and provenance. The central authority governing the network can also control the information that each humanitarian player can access without requiring a separate ledger.
8. Smart contracts - allow for automation of transaction processes thus reducing administrative work and risks arising from disputes.

2. Research Methodology

A systematic literature review (SLR) was carried out to answer the research questions above following [15] stages of planning, searching, screening and reporting as outlined in Table 2 below. SLR organises, synthesises and identify emerging paths and opportunities for developing a research agenda [16].

Table 2. Systematic Literature Review Process

Research Stage	Research Protocol	Detail description
Planning:	Research plan:	Developing two research questions
Searching:	Database:	Scopus and web of science
	Search field:	Title, Abstract, Keyword
	Search String:	Humanitarian* AND Supply Chain AND Blockchain*
Screening:	Inclusion criteria:	English and peer-reviewed journal articles only
	Exclusion criteria:	Articles outside scope of research questions & inclusion criteria
Reporting:	Data extraction:	Summary recording in a Microsoft Excel extraction form
	Data analysis:	Qualitative analysis

Our SLR was conducted between February 2022 and April 2022. From the search criteria above, 24 articles were identified from Scopus and 21 from Web of Science database. Duplicates were removed and 24 articles remained. After a thorough reading of the titles, abstracts and the article, we excluded 15 articles based on our exclusion criteria above and reviewed 9 journal articles.

3. Findings

Descriptive and content analysis was used. Based on our review, Turkey had the lead on publications of BCT in HSCs. The International Journal of Production Research also accounted for the biggest publications. For content analysis, papers were analysed based on their thematical focus and theories used for framework development. The key themes are as shown in **Table 3** below.

Table 3. Key Themes

Theme	Author
BCT Key Drivers	[17] [9] [18]
BCT Adoption Barriers	[17] [19] [20]
BCT Theories	[9] [21] [22] [8]
BCT integration with other technologies	[21] [8]
BCT design requirements	[23]

3.1. Blockchain adoption drivers and barriers in humanitarian supply chains

The drivers and barriers of BCT in HSCs are outlined in Table 4. The significant drivers were desirable due to the key features of blockchain and, if adopted, would bring potential benefits in this sector. Transparency was the most cited driver, followed by visibility and swift trust, while lack of knowledge, technical skills and training was the major barrier outlined by the authors followed by regulatory, governance and technology complexity issues.

Table 4. Drivers and barriers of BCT adoption in HSCs

Drivers	Barriers
Improved accountability, visibility, transparency, traceability, swift trust, trust, security, immutability, collaboration, time efficiency, automation, processing speed reduced administrative work, disintermediation, external pressures from donors and other HOs and minimal fraud disputes	Lack of knowledge, technical skills & training, lack of resources & funding, data privacy, ownership and security concerns, regulatory & engagement issues, governance & scalability issues, interoperability issues, high sustainability costs and technological complexities.

3.2. Blockchain Integration with other technologies

BCT integration with IoT improves transparency which enhances public trust and coordination, thus improving the overall performance in the humanitarian sector. BCT can be integrated with Artificial Intelligence and 3D printing to support the flow of information, finances and logistics across the HSC due to its immutable, distributed and smart contract features.

3.3. Theories used to develop humanitarian frameworks in the SLR

Authors grounded their frameworks from the theories illustrated in **Table 5** below.

Table 5. Theories and their application areas

Theory	Application Area	Explanation
Contigent resource-based theory	Empirical Framework: Trust, Transparency	As an extension of resource-based theory, it explains that resources value are dependent on the context and relationship between primary and complementary resources [24]

Organisational information processing theory	Empirical Framework: Operation Supply chain transparency capability, Swift trust	Explains the effective use of information especially when undertaking uncertain and interdependent tasks [25]
Relation view theory	Empirical Framework: Technological capability, organisation & people behaviour, swift trust, collaboration, resilience	Explains that an organisation relationship with its partners can improve its competitiveness [26]
Social exchange theory	Conceptual Framework: Resource sharing, Trust & Perceived benefits	Explains the interactions of people from an intangible benefit/cost perspective which facilitate reciprocity [27]
Transactive memory system theory	Empirical Framework: Information sharing, Coordination, Trust, Transparency	Explains the mechanism that groups mutually encode, store and retrieve knowledge [28]

3.4. Humanitarian blockchain project design requirements

Only one paper in our review addressed the design requirements of humanitarian BCT projects. Three categories of requirements were suggested; contextual, technological and organisational, while considering ethical guidelines of humanity, neutrality, impartiality, independence and dignity principles of HSCs.

4. Research Gaps

Our SLR revealed the following gaps for further research.

1. What are the influence of digital trust in coordination and cross-sector partnerships? Should collaboration efforts be minimised as a result?
2. Which BCT platforms should be used for HSCs? How should they be governed?
3. How can blockchain penetrate HSCs organisation cultures?
4. What end-users factors influence the intention to adopt BCT in HSCs?
5. How can humanitarian organisations collaborate with the government, banks and telecommunication companies to 'know your beneficiary' (KYB)? Just like financial institutions are using BCT for the know your customer (KYC) feature.
6. What are the major applications and legal challenges of smart contracts in HSCs?
7. What requirements should a blockchain maturity model in HSC meet to guide on the investment decision?

5. Conclusions and future work

Blockchain technology started as a 'hype' due to its unique features and vast application in cryptocurrencies. Despite research efforts on its drivers and adoption barriers, its application in humanitarian supply chains is still at an exploratory stage. Most articles offered a conceptual view of its enablers, and the barriers were empirically tested but primarily by expert opinions. More empirical studies are required to integrate all the humanitarian players in the design requirements, pilot projects to test their intention to adopt it, and performance measures of those actually implementing it.

While our systematic review focused on blockchain technology diffusion within humanitarian supply chains, we acknowledge that the search terms choice may have excluded certain articles for review. We also used only journal articles partly to allow for a standardised protocol and also due to time constraints and we suggest that future reviews can include conference proceedings, books and books chapters and gray articles to offer a more holistic view.

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