BLOCKCHAIN - POWERED TRANSPARENCY: TRACKING AND DISSEMINATING DONATIONS FOR DISASTER-STRICKEN REGIONS

Abstract

This book chapter explores the pivotal role of supply chain management in facilitating the smooth flow of donations, while highlighting the persistent challenges of integrity compromise due to theft, fraud, and inefficiency. The chapter examines the transition from traditional approaches to modern technology adoption as a potential solution.

Historically, supply chain management struggled with authenticity verification and traceability, hindered by manual record-keeping and paper trails that led to errors, delays, and a lack of transparency. Counterfeit goods infiltrated inventories, impeding timely donations. Modern technologies, such as data analytics, IoT devices, and AI, brought real-time tracking and improved efficiencies, but data integrity remained a concern.

The emergence of blockchain, a decentralized and immutable ledger system, proved transformative. Its features like consensus mechanisms, smart contracts, and cryptographic security directly addressed supply chain challenges. Blockchain enabled stakeholders to verify product origin, track inventory, and ensure authenticity. It fostered collaboration, data sharing, and procedural enhancement among supply chain actors, ultimately reducing fraud risks and enhancing trust.

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The chapter proposes strategies including interoperability standards, public-private partnerships, and capacity-building efforts to overcome challenges. In summary, this comprehensive analysis highlights how blockchain integration can revolutionize humanitarian supply chain management, fostering more effective and ethical interventions.

Keywords: Supply chain, disaster management, Blockchain, Tamper-proof, Smart Contract

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I. INTRODUCTION

Humanitarian supply chains play a key role in delivering humanitarian aid and resources to people affected by crises. However, these supply chains often face challenges such as lack of transparency, inefficiencies and coordination issues. Blockchain technology has emerged as a potential solution to address these challenges by introducing transparency, accountability and efficiency. The report examines the benefits of blockchain in humanitarian supply chain management and highlights its potential to revolutionize the field.

Blockchain provides a transparent, immutable ledger that records all transactions and movement of goods within the supply chain. This feature allows stakeholders to track the movement of resources from source to end user. By verifying the origin of goods and services, blockchain helps prevent fraud, diversion and embezzlement of development aid. Enhanced traceability ensures that resources reach their intended beneficiaries effectively, increasing accountability and trust. Blockchain's decentralized and consensus-based approach facilitates real-time information sharing and collaboration between parties. By maintaining a common source of truth, blockchain eliminates information silos and improves coordination. This shared visibility improves your ability to respond quickly to crises, optimize logistics, and make informed decisions about resource allocation, inventory management, and distribution. This facilitates collaboration among organizations, agencies, donors and beneficiaries, leading to a more efficient and effective humanitarian response.

Blockchain streamlines and automates financial transactions within humanitarian supply chains through the use of smart contracts. Smart contracts are self-executing contracts that guarantee transparency and tamper resistance. Automate payment processes to reduce delays and administrative costs. By providing secure and efficient financial transactions, blockchain can get funds to their intended recipients faster, and help can be delivered in a timely manner.

Implementing blockchain in humanitarian supply chains reduces manual processes, paperwork and redundancies, improving overall efficiency. Real-time insights into the supply chain enable stakeholders to identify bottlenecks, optimize routes, and track inventory levels, resulting in faster delivery times and lower costs. Blockchain streamlines operations and reduces administrative burden by eliminating middlemen and reducing the need for voting. Blockchain technology increases transparency and accountability, thereby increasing trust of donors. Donors can access real-time data on the blockchain to verify the impact and effectiveness of their donations. This transparency reduces skepticism and encourages more donations. Donors are assured that their funds are used efficiently, foster trust and long-term partnerships with humanitarian organizations, and reach their intended recipients.

To conclude we can say that the benefits of blockchain in humanitarian supply chain management are significant and far-reaching. Improved traceability, enhanced coordination and collaboration, efficient financial transactions, increased efficiency and increased trust of donors are among the main benefits that blockchain brings to the field. By addressing challenges of transparency, accountability, and inefficiency, blockchain will revolutionize the management of humanitarian supply chains, effectively and ethically providing assistance to those in need. has the potential to ensure The use of blockchain technology in the

humanitarian field could lead to more efficient operations, better outcomes, and higher levels of trust between stakeholders.

II. OBJECTIVE

In traditional humanitarian aid logistics, a lack of trust and coordination among various stakeholders poses significant challenges to the efficient allocation of resources, with aid agencies, government agencies, donors and beneficiaries separated. They often operate in silos, leading to inefficiencies, delays and the risk of fraud or mismanagement of resources.

Trust is essential in humanitarian logistics, ensuring that resources are allocated and distributed fairly and efficiently to those in need. However, without a transparent and verifiable system, suspicion and mistrust can arise, leading to a loss of trust among parties. This lack of trust can lead to duplication of effort, delayed response, and mismatches between actual needs and allocated resources. Coordination is also an important factor in humanitarian logistics. With multiple organizations and agencies involved, each with their own processes and systems, seamless coordination is a challenge. Lack of coordination can create bottlenecks, redundancies and inefficiencies in the sales process. It becomes difficult to track the movement of resources, monitor their use, and ensure that aid reaches its intended recipients in a timely manner.

Additionally, the lack of coordination and information sharing in traditional humanitarian aid logistics hinders the ability to respond effectively to a rapidly evolving situation. In times of crisis, rapid and well-coordinated action is essential to save lives and reduce suffering. However, without a consistent and transparent system, stakeholders find it difficult to share critical information, leading to delays and inefficiencies in aid delivery.

Blockchain technology addresses these challenges by providing a decentralized and transparent platform for humanitarian aid logistics. Using distributed ledger technology, all transactions and resource movements are recorded in a tamper-proof and immutable manner. This transparency creates a common source of truth accessible to all parties involved in the supply chain. By using blockchain, it is possible to build trust between parties. The transparency of this technology makes all transactions and activities visible to authorized participants, eliminating any questions or doubts about resource allocation and utilization. Donors can be confident that their donations will be used appropriately, and beneficiaries can be confident that their aid will reach them fairly and in a timely manner.

Additionally, blockchain improves collaboration by providing an integrated platform for real-time data and information sharing. By implementing smart contracts, stakeholders can automate and streamline various processes such as procurement, inventory management, and distribution. By enforcing predefined rules and conditions, these smart contracts reduce the need for manual intervention and facilitate efficient decision-making.

Blockchain's shared visibility and real-time tracking capabilities allow stakeholders to monitor resource movements at every stage of the supply chain. This transparency enables better inventory management, identification of bottlenecks and optimization of logistics. In addition, stakeholders can respond quickly to changing needs and direct resources where they are needed most. Blockchain technology addresses the lack of trust and coordination in

traditional humanitarian aid logistics by providing transparency, accountability and real-time information sharing. By establishing a common source of truth and automating processes through smart contracts, blockchain improves the efficiency, effectiveness, and responsiveness of humanitarian relief efforts. Ultimately, this technology can help ensure that resources reach those in need quickly and effectively, making a significant impact on the lives of vulnerable people.

III. RELATED WORK

The article discusses how technological advances have increased supply chain efficiencies, but there are still problems to be solved. To meet this demand, the supply chain has been expanded by the Internet of Things (IoT) and other technologies [1].

Charitable groups play an important role in healthcare since they provide social services and rely on donations. Because the finest charities acknowledge that their donors' contributions have a significant influence, they strive to be honest. They make financial accounts, growth records, history, governance procedures, yearly reports, and updates on grant recipients' progress available to funders. These organisations are committed to demonstrating to donors that their money is being used effectively. Donors have the right to inquire about how their money are being used. Charities want their donors to understand where their money and efforts are going, as well as to feel respected and empowered to make a difference [2].

D. Ivanov discusses the importance of end-to-end visibility in supply chains and its potential to construct resilient supply systems. By performing case studies and analysing the corpus of current literature, the authors develops a paradigm for managing resilience during pandemic-related disruptions utilising digital technology. The essay provides conceptual guidance for appreciating potential benefits and implementing end-to-end visibility in supply chain resilience management [3].

The authors A.K.Pundir et.al investigates the significance of incorporating blockchain and IoT (Internet of Things) technologies into supply chain networks in order to boost efficiency and decision-making. Current supply chain information systems' lack of real-time and validated asset-specific information causes information asymmetry and inefficiencies. Stakeholders may get trustworthy and relevant data via IoT and blockchain technology, allowing them to make decisions swiftly and economically [4].

The researchers Ouafee etal, talks about the effects of digital supply chain integration for sustainable development. They try to determine the impact of digitization in supply chain effectiveness while taking into account social, economic, and environmental concerns. The goal is to provide decision-support tools to players in the agro-fishery logistics chain so that they may engage in a sustainable digitization process. The rise of digitalization has resulted in significant changes in logistics, transforming traditional logistics chains into digital supply chains [5].

A corporation is not an island in the modern business world; rather, it is a link in a longer supply chain. Supply chain management, however, has become increasingly challenging as a result of current issues like the COVID pandemic and trade disputes. The

supply chain is susceptible to disruptions because of its complexity and the unstable external environment. A supply chain that is weak can't operate correctly and can perhaps cease altogether. Managers must therefore devise strategies to lessen the supply chain's susceptibility [6].

The research study investigates the role of supply chain strategies in establishing a competitive advantage in the digital era. The author advises that companies alter their supply chain methods to take use of digital technology and meet evolving customer expectations, with the goal of increasing operational performance, lowering costs, and increasing customer happiness [7].

The authors stressed on the importance of the need of transparency, dependability and privacy for preserving consumer confidence and dealing with issues specific to the business, like food theft and safety worries. They suggested a system that makes use of blockchain technology and smart contracts to ensure to keep these elements important [8].

Blockchain technology in sustainable supply chain management with a focus on the fisheries industry specifically, "Case of the fisheries sector" investigated the potential of blockchain technology in enhancing sustainability in supply chain management. The authors emphasized the value of using blockchain to address problems including improper labeling, illegal fishing, and a lack of accountability in the industry. The study emphasized how blockchain technology has the potential to transform supply chain management procedures and advance sustainability in the fishing sector [9].

The paper explores how supply chains can employ blockchain technology, by capturing and validating transactions, blockchain, a decentralized and transparent digital ledger, has the potential to increase trust, transparency, and security in supply chains. It can increase process efficiency, decrease fraud, and offer real-time product visibility [10].

W.Zheng et.al,. created NutBaaS, which stands for Nutrient Blockchain as a Service is a platform that tracks and controls the supply chain for agricultural products using blockchain technology. By establishing a decentralized and open network where data regarding the production, processing, and distribution of food can be recorded and validated, the system seeks to address the issues of food safety and traceability. Smart contracts are used by NutBaaS to automate various procedures and increase effectiveness [11].

This paper investigates the interconnections between digitalization, sustainability, supply chain integration, and supply chains' overall performance. The purpose of the study is to lay out a research agenda for figuring out how these variables interact and affect the efficacy and efficiency of supply networks [12].

The development and distribution of fake medications have significantly expanded along with the surge in demand for better medications. Fake medications known as counterfeit meds may be contaminated or have the wrong components or dosages. This paper discusses how to have Blockchain as a solution to restrict fake medicine supply while tracking the origin of genuine medicines [13].

The world's population is growing, and there is a growing need for food, which is posing problems for the food supply system. Blockchain technology has been identified as a potential answer to these problems, ensuring food quality while lowering waste and carbon footprints. The usage of blockchain in the food supply chain is discussed in ensuring food quality reaching the end point of the delivery. Blockchain technology has been widely employed in logistics, finance, and product authenticity, according to the study. It has the potential to increase traceability, transparency, and confidence in the food supply chain, enhancing consumer confidence and providing evidence to back up product claims [14].

The authors cover the use of blockchain to produce an unchangeable and transparent record of food production, processing, and distribution, ensuring the accuracy and dependability of data regarding a food product's origin and journey. Customers may readily access specific information about the food they consume, such as its source, quality, and handling procedures, by utilizing blockchain. Furthermore, location fraud—the provision of incorrect information regarding the place of origin of a food product—can be detected and prevented with the aid of technology. The paper illustrates how blockchain technology could enhance food safety, lower fraud, and boost consumer confidence in the food industry [15].

The article discusses how the use of Internet of Things (IoT) and blockchain technologies (BCT) can increase transparency, public trust and collaboration in humanitarian logistics (HL). The study used data collected from humanitarian workers (HOs) to assess six research hypotheses and create a theoretical framework based on the concept of transactive memory systems. The results confirm the beneficial connections between IoT and BCT, as well as transparency, which in turn mediates the links between these technologies and public trust and collaboration. The study focuses on how transparency can improve public trust, coordination and the overall effectiveness of HL. The results provide stakeholders with insights into disaster risk management and significantly enrich the literature on IoT, BCT, transparency, public trust and coordination [16].

S.Malik et al. talks about the need to protect privacy and the possibilities of blockchain technology in supply chains. Blockchain can ensure the immutability, traceability, and provenance of supply chains, and the authors' proposed system called TradeChain seeks to solve these problems by compromising the privacy of sensitive information. It includes two separate logs: one for tracking identity and one for documenting trade movements. The reduction in execution times, latency and overall bandwidth costs is evident when TradeChain is implemented in Hyperledger Indy and Fabric. This privacy framework is designed to leverage the benefits of blockchain while maintaining privacy and traceability in supply chain systems [17].

Smart contracts need to build a digital system capable of facilitating, verifying and enforcing contract negotiations in the supply chain. The proposed approach from these authors seeks to address tracking this process, including loss of information, lack of reliable transaction tracking, and difficulty in investigating illegal activity or obtaining information about other players and build a more efficient and accountable supply chain structure [18].

Malik, et.al., which strive to protect the privacy of supply chain system participants by maintaining the accuracy of the data stored on the blockchain. The article details the

implementation and evaluation of the PrivChain system and highlights its potential to improve supply chain privacy through blockchain technology [19].

The paper written by S.Su et.al describes a platform named Smartsupply that makes use of smart contracts to verify transactions in a supply chain blockchain.
By integrating smart contracts that automatically check and approve transactions within the blockchain, Smartsupply seeks to address the issues of trust and transparency in supply chain management. By ensuring the validity and integrity of the supply chain data, the system helps to minimize the risk of fraud and mistakes. The paper emphasizes the potential advantages of adopting smart contracts in supply chain management while providing additional information and the findings of their research [20].

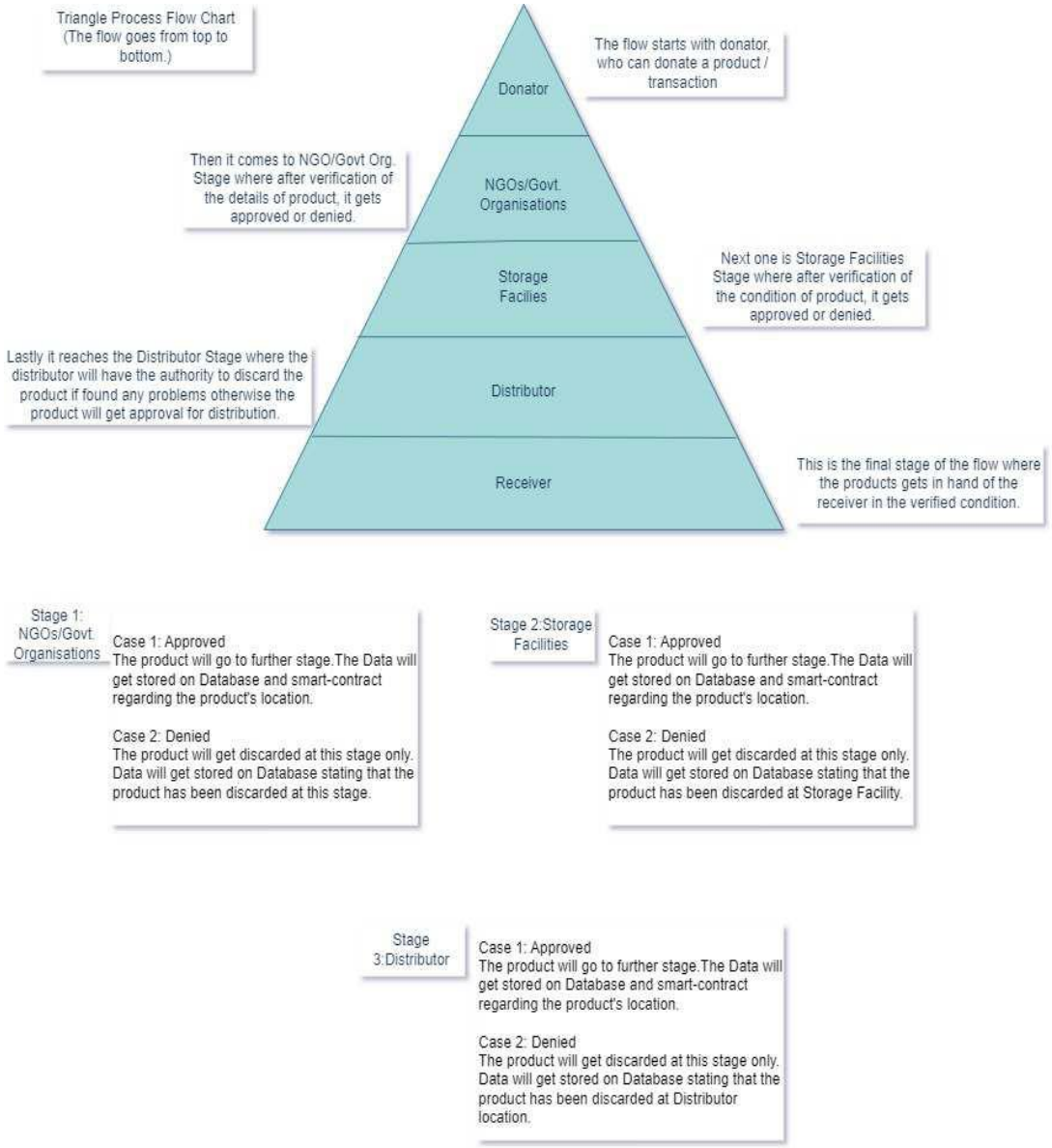

Figure 1: Process Methodology

IV. PROCESS AND METHODOLOGY

Our project focused on using blockchain technology to improve humanitarian supply chains. The chain of supply is divided into four stages. Donation stage, NGO/government stage, storage facility stage and final distribution to beneficiaries. The number of people who can participate in each stage varies, so anyone can contribute within the whole process. We have integrated several technologies to build a working solution.

1. **Figure 2: Process Methodology:** The following software and hardware have been used to build the solution:

   For front-end development, we used React, a JavaScript library that helps create dynamic and interactive user interfaces. Backend development was done using Express, a popular web application framework for Node.js for efficient handling of server-side logic and API integration.

   For the integration of the solution, we used Metamask, a widely used wallet provider that allows users to securely manage their transactions. Additionally, we used Solidity, a programming language specifically designed for Ethereum-based smart contracts. Solidity allows you to define and implement smart contracts that drive the functionality of your blockchain project. We used Polygon Mumbai's testnet to test and deploy smart contracts. This testnet provides a simulated environment where you can validate the functionality and behavior of your smart contracts before deploying them to the Ethereum mainnet.

   For Database we chose MongoDB, a flexible and scalable NoSQL database, to store and manage our supply chain related data. MongoDB allows you to efficiently store and retrieve information such as donation details, organizational records, and beneficiary details. During the development process, we extensively researched various academic papers and academic papers related to blockchain technology and humane supply chain management. This research provided valuable insight and guidance that enabled us to design and implement an effective solution for our project.

V. MATERIALS AND PROCESS

Our smart contract, was called "HumanitarianSupplyChain" to improve the transparency and efficiency of the humanitarian supply chain. The contract stored different types of data on the blockchain to facilitate the tracking and management of products, organizations, distributors, and storage facilities involved in the supply chain. For each product, we stored information such as its unique ID, name, quantity, and status. The status represents the current stage the product is in, and we use specific numbers to indicate if it has been registered, approved, denied, delivered, or not delivered. We also stored the address of the person or organization that owns the product, as well as additional details like the distributor's name, mobile number, and date associated with the product. Moreover, we keep track of codes that identify the organization, storage facility, and distributor related to each product.

To store data about organizations, we have a structure called "Org." It includes the name of the NGO or government organization, the type of organization (NGO or government), and a unique code assigned to it. Similarly, we have a structure called "distributor" that holds information about distributors, such as their names, organization type (e.g., army or volunteer), assigned codes, and their areas of operation. We also store data about storage facilities in a structure called "sFacility," which includes the facility's name and its assigned code.

To make it easier to access the stored data, we use mappings. The "products" mapping allows us to retrieve product information based on their unique IDs. The "ngoGovOrgs" mapping associates the addresses of NGOs or government organizations with their corresponding organization data. Similarly, the "distributors" mapping links distributor addresses with their respective details, and the "sFacilities" mapping connects storage facility addresses with their relevant information.

By storing this data on the blockchain, we create an immutable and transparent record of the humanitarian supply chain. This helps us track the movement of products, verify ownership, and ensure accountability at each stage of the process. It also enables us to provide real-time information to stakeholders, increasing trust and efficiency in humanitarian operations.

VI. BLOCK DIAGRAM

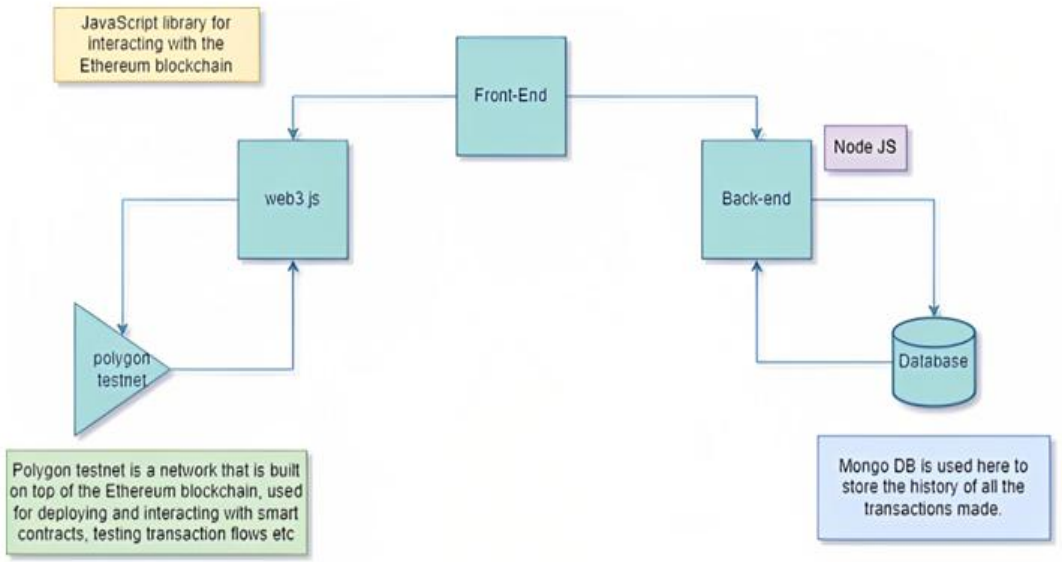

Figure 2: Block Diagram

In this workflow, we used React.js to create a front-end application. It allows to create user-friendly and dynamic interfaces for your humane supply chain solutions. To connect the frontend to blockchain functionality, we used web3.js, a JavaScript library that acts as a bridge between your application and the Ethereum blockchain. Web3.js allowed to interact with the Mumbai Polygon Testnet, a testnet specifically designed for Ethereum-based applications. The testnet simulates the behavior of a real blockchain network, but without the

costs and risks associated with deploying it on the main Ethereum network. This allowed to experiment, test and prove the functionality of our supply chain solution in a safe and controlled environment.

To connect the frontend to the Mumbai Polygon testnet, we used web3.js to connect to the network. One can specify a network endpoint or RPC (remote procedure call) URL that acts as a gateway to communicate with the testnet. This connection will allow the front-end application to interact with smart contracts deployed on the testnet, perform transactions, and retrieve data from the blockchain.

When a user interacts with the front-end application, such as submitting a product, approving or rejecting a product, or following the supply chain process, web3.js fulfilled these interactions by sending the necessary transactions to the Mumbai Polygon testnet making it easier. It also listens to events emitted by smart contracts, allowing applications to react in real time to changes and updates within the blockchain. In addition to connecting to blockchain, our front-end application interacts with MongoDB, a NoSQL database, to store and retrieve data related to our supply chain. MongoDB provides a flexible and scalable solution for managing the application's data requirements. We used web3.js in combination with libraries like Mongoose (an object data modeling library for MongoDB and Node.js) to interact with MongoDB databases from front-end application.

For example, when a user submits a product through the frontend, web3.js can be used to send the relevant data to a smart contract on the Mumbai Polygon testnet for processing. At the same time, the same product data can be stored in a MongoDB database using the Mongoose library. This allowed to store supply chain data centrally and permanently so that a query when needed can retrieve it later.

The frontend application interacts with web3.js to connect to the Mumbai Polygon testnet, allowing supply chain solutions to leverage blockchain capabilities. Facilitate transactions, wait for events, and retrieve data from the blockchain. Additionally, the frontend interacts with MongoDB and leverages libraries like Mongoose to store and retrieve data in a flexible and scalable way. This combination of technologies allowed us to seamlessly integrate blockchain and database capabilities into humanitarian supply chain solutions while creating user-friendly interfaces.

1. **Figure 3:** Detailed Flowchart

   On the application home page, the first step is to connect crypto wallet using Metamask. Metamask is a browser extension that allows users to manage their Ethereum wallets and interact with Ethereum-based applications. By connecting to a wallet, users can securely authorize transactions and access their funds. Once the wallet is connected, users can proceed to the donation section by entering all relevant product details. This information includes product name, quantity, owner name and mobile phone number. Users can submit this information for processing.

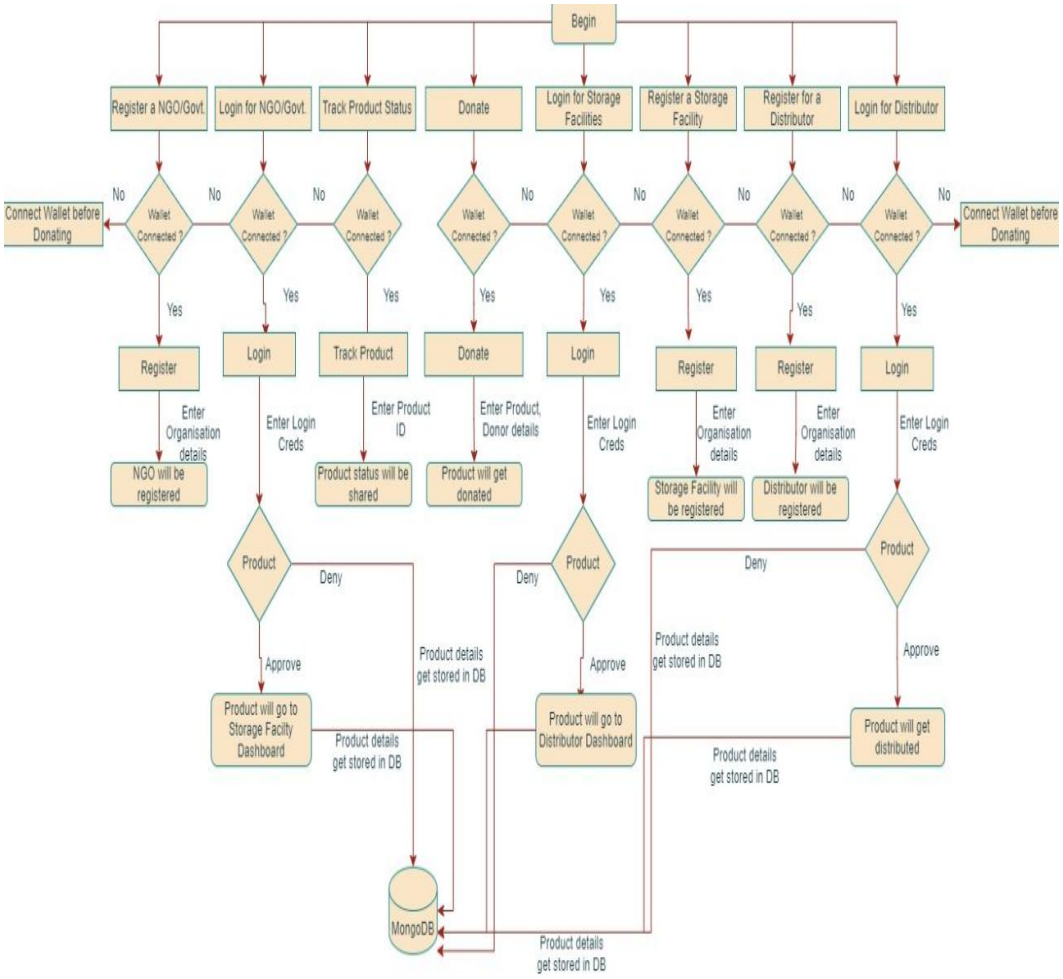

Figure 3: Detailed Flowchart

The registered NGO/Government Organization access the system and participate in the supply chain process. After registration, the NGO/Governmental Organization will have the opportunity to verify the donation received and can approve or reject donations based on the rating. If approved, donations will continue through the supply chain process. Appropriate action can be taken in the event of refusal. The donors will be notified, and feedback given for improvement.

In the next step, storage facilities must also be registered through the portal. This registration enables the storage facility to participate in the supply chain and handle the logistics of storing and managing donations. After a successful registration, the storage facility will evaluate available storage capacity, inventory management, and logistical needs and can approve or reject donations based on the rating.

The distribution stage is the final step in the supply chain process. Registered distributors also approve donations and control their distribution to beneficiaries. Distributors have the authority to review approved donations assigned to them and to make the final decision to approve or reject donations based on their evaluation.At every stage of the supply chain process, all transactions and actions must be approved by MetaMask. Metamask serves as a secure and convenient interface for confirming

transactions on the Ethereum blockchain. Ensure the integrity and transparency of your supply chain processes by requiring Metamask approval.

VII. CONCLUSION

The transparent, immutable and decentralized nature of blockchain creates a trustworthy and auditable system, inspires trust among stakeholders and reduces the risk of fraud and mismanagement. In addition, blockchain enables real-time information sharing, streamlined processes, and optimized resource allocation, enabling faster and more targeted responses to humanitarian crises.

The future scope of humanitarian aid management using blockchain is promising, with several potential advances and opportunities. Here are some of the key areas with great potential for the future of humanitarian aid management using blockchain.

The integration of blockchain and his IoT devices will enable real-time tracking and monitoring of aid shipments, ensuring transparency and accountability in the supply chain. IoT sensors can provide data on temperature, humidity, location, and condition of goods, which can be recorded on the blockchain to ensure the integrity and quality of auxiliary resources.

Artificial intelligence (AI) and data analytics: Combining blockchain with AI and data analytics can provide valuable insights into aid management. AI algorithms can analyze data recorded on the blockchain, recognize patterns, optimize sales channels, forecast demand, and improve decision-making processes. This integration allows for more effective resource allocation and relief planning.

VIII. LIMITATIONS

One of the main limitations of blockchain technology is its scalability. As the number of participants and transactions increases, the blockchain network may experience performance bottlenecks and slower transaction processing times. This can be a concern in humanitarian supply chains involving a large number of stakeholders and high volume of transactions in the event of an emergency or crisis.

Blockchain networks, especially those that use Proof-of-Work (PoW) consensus algorithms like Ethereum, require significant computing power, resulting in high power consumption. This can be an environmental concern and can raise ethical questions, especially in areas with unsustainable energy sources.

While the blockchain provides data immutability, the underlying data remains visible to all participants who have access to the network. In the context of humanitarian assistance, sensitive information of beneficiaries and donors must be protected from unauthorized access. Ensuring data privacy and security can be a complex challenge.

While blockchain technology improves transparency and accountability, human error in data entry or programming can still occur. In addition, governance models for decision-making and dispute resolution in blockchain networks must be carefully designed and managed to prevent centralization or abuse of power.

In some disasters or remote areas, the internet connection may be limited or unreliable. This can hinder the ability of blockchain-based systems to track and share real-time data.

IX. OUTCOMES

The paper introduces the concept of blockchain technology and its decentralized and transparent nature. It explains how blockchain works and how it can be applied in the humanitarian sector to address the challenges faced in supply chain management.

The article details the benefits of using blockchain in human supply chains, such as improved transparency, improved efficiency, transaction security, and accountability. It explains how these benefits contribute to improved aid delivery and resource allocation.

The paper acknowledges the limitations and challenges associated with blockchain implementation in a humanitarian context. It addresses issues such as scalability, power consumption, cost, data privacy, user acceptance, regulatory compliance, interoperability, and governance.

The paper describes a method to effectively implement blockchain in human supply chain management. This includes choosing the right technology, design considerations, user interface development, data management, and integration with existing systems.

Documentation includes real-life use cases or case studies showing successful applications of blockchain technology in humanitarian aid logistics. These examples can demonstrate the benefits and real-life outcomes of using blockchain in real-life humanitarian work.

The article explores the future scope and potential advancements of blockchain technology in human supply chain management. It can suggest areas for further research, improved scalability and sustainability, integration with emerging technologies, and collaborative efforts within the humanitarian community.

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