Blockchain Technology For Carbon Credit Management: Assessing Organizational and Cultural Implications

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction:

There is no question that the concerns of climate change are only becoming more pressing as time passes by. Many tools have been proposed as solutions to this global crisis, one of them being carbon credits. Carbon credits have grown as an instrument for limiting greenhouse gas emissions. The creation of carbon credits was rooted around the simple idea of being able to quantify the reduction of carbon emissions while allowing for tradeability. Not only does this incentivize businesses and individuals, but also allows them to invest in a cleaner future. Like any system however, the effectiveness relies on the strength of the system's framework. While this solution has tremendous potential, many challenges at its core, such as additionality, fraud, and inconsistent standards, must be addressed.

Carbon credit markets have seen significant adoption across different sectors, propelling forward global climate agendas. Despite their adoption and critical role, experts such as Chen (2021) have highlighted significant drawbacks which threaten the system's integrity. Chen argues "Without stringent verification, the authenticity of carbon credits remains questionable" (p. 18). Additionally, many reports, including one by Saraji (2020), have shed light on systemic fraud, showing the lack of trust in the carbon market system.

This paper proposes that blockchain technology, a distributed ledger technology that records transactions in a decentralized manner, can aid the failing carbon credit system. It can improve the current problems of the system, including transparency, consistency, accountability, and reliability. This research claims that the application of blockchain technology to carbon credit management can enhance the organizational and cultural aspects of the system, increasing its role in the fight against climate change.

Through a case study analysis of IBM Food Trust, this research draws parallels and extracts lessons about characteristics that make a reliable system. IBM Food Trust exemplifies the potential of blockchain in a complex socio-technical system, principles that can be applied to the carbon credit system. This paper dives into the organizational and cultural challenges hindering current carbon credit markets, and details how blockchain's properties, including immutability, smart contracts, decentralization, and transparency, can directly address these points.

Problem Description: Carbon Credits Are A Failing System

A carbon credit represents the avoidance of emitting one metric ton of carbon dioxide into the atmosphere. Companies and individuals can purchase these credits as a way to offset their own carbon emissions. By doing so, they are able to compensate for their emissions by funding projects that eliminate an equivalent amount of emissions elsewhere. The trading of carbon

credits through carbon markets creates a financial incentive for the reduction of emissions. According to Chen (2021), the carbon credit market is extremely large, with annual transactions reaching billions of dollars. He also points out how, "we can clearly notice that the three leading countries in issuing voluntary carbon offsets are India (25%), the USA (19.9%), and China (12.2%)" (p. 8). This indicates a significant engagement with carbon credits on a global scale, and further highlights the scope of the market within the US.

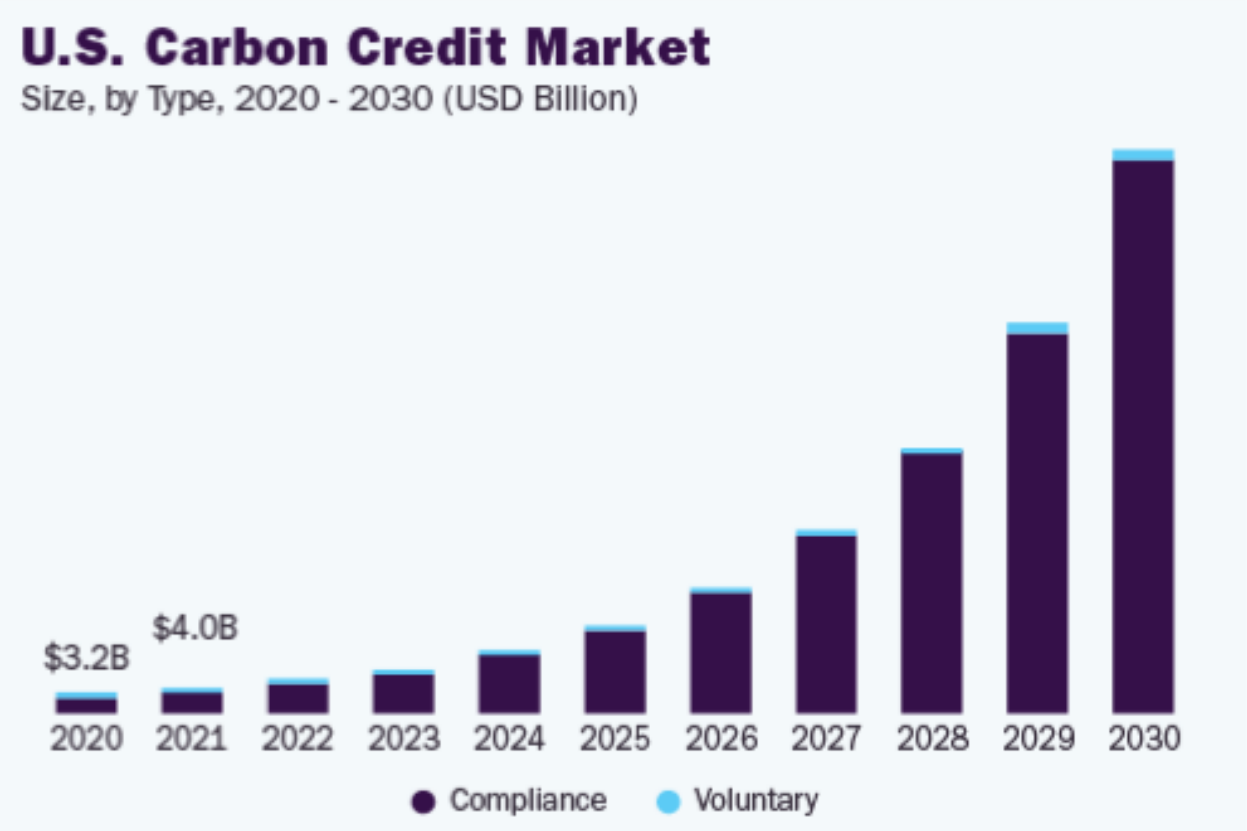

Figure 1: Growth of U.S. Carbon Credit Market (Grand View Research, (n.d.))

According to the World Bank Group (2021), various industries have been incorporating carbon credits into their sustainability strategies. For example, the energy sector has turned to carbon credits to offset emissions from fossil fuel power generation. Manufacturing companies have used them to reduce the carbon footprint associated with their production processes. Additionally, transportation companies have invested in carbon credits to promote cleaner modes of transport. Governments have also recognized the value of carbon credits, and their effectiveness in achieving international climate targets. Many countries have created regulatory frameworks that require the use of carbon credits as part of their emissions reduction strategies (Kim 2020). This widespread embracement of carbon credits highlights their significance in the global effort to fight against climate change.

Carbon credit systems, however, have several challenges that hinder their full effectiveness. One big concern surrounding carbon credits pertains to the concept of "additionality." Additionality determines whether emission reductions from a project would have occurred naturally, without any financial incentives provided by carbon credits. Individuals argue that certain projects funded through carbon credits might have transpired regardless of monetary incentives. This raises questions about the legitimacy of emissions reductions attributed to these projects. To address this concern, there should be a process to properly assess and verify that carbon credit projects are additional and would not have come about without financial incentives. Enhancing additionality and monitoring is essential to improve the credibility of carbon credit systems. Chen (2021) also adds that "Market participants feel that low quality carbon projects have no real positive impact on the climate; they do not actually lead to the removal or reduction of GHG emissions and can also have negative impacts on biodiversity, the integrity of local communities, and the health of the environment". (pg. 16) This statement notes the existence of low-quality projects, which fail to contribute meaningfully to greenhouse gas reductions. This leads to further questions about the true effectiveness of carbon credits in combating climate change.

Another challenge the carbon credit market faces is fraud. Numerous reports of fraudulent activities within the system have put a doubt on the authenticity of certain carbon credits (EEA, 2020). Examples of fraud might include the issuing of credits for projects that don’t deliver the expected emissions reductions, or double-counting emissions reductions across multiple projects. Chen notes that "Experts and stakeholders claim that verifying offsets in existing markets presents several challenges, with sellers of carbon offsets having little incentive to report information accurately, leading to issues like double counting and the use of

non-additional credits that do not go beyond business-as-usual". (p. 17) The lack of motivation for accurate reporting by sellers creates problems such as double counting and credits that fail to achieve actual emission reductions. These issues compromise the credibility of carbon credits, again showing a fundamental weakness in the current system. Such examples of fraud deteriorate the trust and integrity of the carbon credit market. To reduce this fraud, there is a need for increased transparency. Regulatory bodies must enforce some sort of an auditing and verification processes to ensure the legitimacy of these carbon credit projects.

The discrepancies in carbon credit standards across different certification bodies is another challenge. To improve transparency and credibility, the standards used by certification bodies must be consistent. Raizada writes that "The Taskforce for Scaling Voluntary Carbon Markets (TSVCM) has pointed out a number of issues with the voluntary carbon offsets market

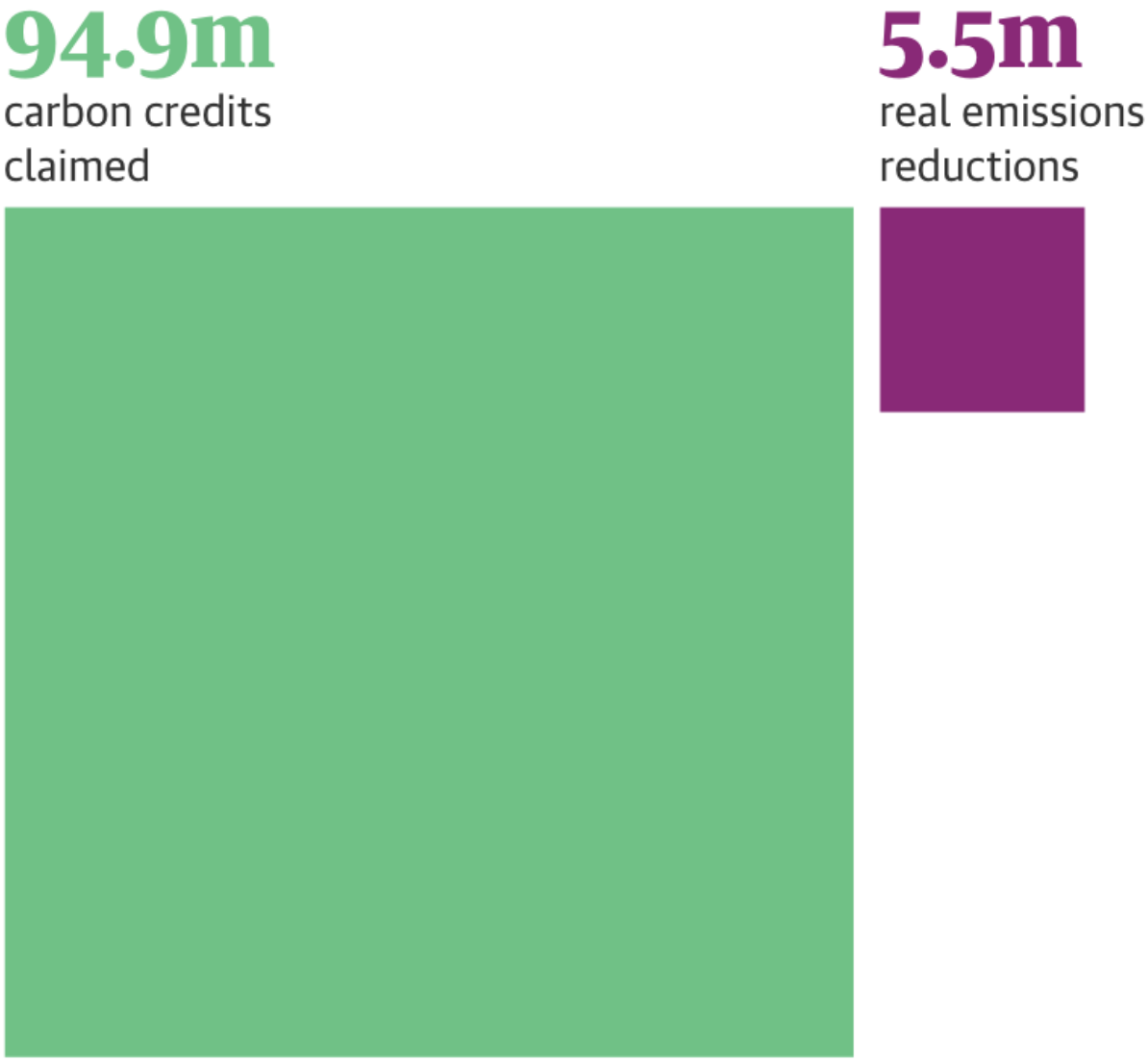

Figure 2: Difference in carbon credits claimed and real emission reductions for Verra's Rainforest Carbon Emission Project (The Guardian, 2023)

which must be addressed before it could scale, including lack of market integrity, weak validation and verification processes, and fragmentation of the carbon offset supply chain". (pg. 13) This quote highlights the inconsistent nature of the carbon credit market. The lack of a consistent approach to validate and verify processes causes trouble towards the market's effectiveness. It displays a significant challenge in scaling carbon credit systems globally. There needs to be some level of cooperation to establish a common framework for evaluating and

verifying carbon credit projects. This would allow for more accurate tracking and reporting of emissions reductions, making carbon credits more credible.

A proper system has several key characteristics that are important for full effectiveness. Such characteristics include transparency, consistency, accountability, and reliability. When evaluating the carbon credit system against these criteria, it becomes clear that it lacks many of these attributes. Transparency involves open and accessible information, as well as clear reporting, and disclosure. The carbon credit system fails to meet these properties as there is a lack of clarity behind project methodologies and specifics regarding emissions reductions which has led to doubts about the legitimacy of credits. Consistency is another critical attribute. A proper system should have uniform standards and criteria across the board. In the carbon credit market, there are discrepancies in certain standards and methodologies between different bodies, making it difficult to compare the environmental impact and validity of credits issued by different organizations. Accountability is also important for maintaining a system's integrity. It makes sure that parties responsible for negative actions are accountable for their choices. In the carbon credit market, there are accountability gaps when it comes to addressing instances of fraud and questionable credits. This lack of enforcement reduces the system's accountability. Reliability is another attribute, which involves the system's ability to deliver expected results.

Questions about additionality and instances of fraud have put doubt on the reliability of the carbon credit system. This raises concerns about whether the credits are truly contributing to meaningful emissions reductions. With these examples, is it clear the carbon credit system lacks several key characteristics that define a proper system. Addressing these shortcomings is crucial to enhance the system's credibility and its ability to provide a more substantial role in the fight against climate change.

In the global fight against climate change, carbon credits have emerged as the main way to reduce greenhouse gas emissions. However, diving deeper into the inner workings of carbon credits, we find many challenges that undermine their full potential. Questions about additionality, instances of fraud, and differences in standards have placed doubt in the credibility of carbon credits. The solution to these challenges involves an approach that can enhance the transparency and credibility of carbon credit programs. It requires standardizing carbon credit programs, improving the verification process, and establishing transparent platforms. By adapting these measures, we can improve the integrity of carbon credits and increase their capacity to fight climate change effectively.

Blockchain technology offers an innovative approach to address these exact issues. The decentralized, immutable ledger system that blockchain technology provides can bring a new

level of trust to the carbon credit market, ensuring that credits are earned and traded with proper integrity. Finck (2017) emphasizes the broader implications of blockchain for data sovereignty, stating that "blockchains offer the promise of the decentralized handling of data and data sovereignty, a concept that focuses on giving individuals control over their personal data and allowing them to share such information only with trusted parties" (p. 7). This principle can be extended to the carbon credit market, where the assurance of data integrity and control is

paramount. Through blockchain's capabilities, we can create a system where carbon credits fulfill their role as a powerful asset in the fight against climate change.

Methods: A Cultural and Organizational Analysis of IBM Food Trust

In this analysis, we explore the case of IBM Food Trust. IBM Food Trust encompasses a modern-day system built around blockchain technology. It properly utilizes organizational and cultural characteristics of a functioning socio-technical system to address issues in the global food supply chain. By offering a decentralized platform for data sharing and traceability, the IBM Food Trust aims to enhance the transparency, safety, and efficiency of food supply chains. The overarching goal of this being to address the areas of informed consumption and sustainability.

According to the IBM Supply Chain Intelligence Suite and Nguyen (2018), IBM Food Trust is a blockchain-powered platform designed to track the origins and journey of food products. Its primary objectives involve combating food fraud and ensuring food safety. Consumers can trace the journey of a food product from farm to table. Each participant in the supply chain, from farmers to distributors and retailers, record relevant information about the product on the blockchain. This includes details about the product's origin, production methods, and transportation. Once this information is recorded on the blockchain, it becomes immutable. This immutability ensures that the product's history remains unchanged, preventing any fraudulent attempts to manipulate information. Pilkington (2015) describes how "a shared, consensus-based and immutable ledger helps track the origin and the transformations undergone in the supply chain" (p. 29).

IBM Food Trust uses smart contracts, which are self-executing contracts with predefined rules. For example, a smart contract can specify that a product only moves to the next stage in the supply chain if certain criteria, like temperature conditions, are met. This reduces the potential for human error. Participants in the supply chain also have access to real-time data about the product's journey. This includes information such as temperature, humidity, and location.

IBM Food Trust's use of blockchain technology goes beyond just traceability. It redefines food safety standards on a large scale. For example, during an E. coli outbreak, the system enabled

exact tracking of the contamination within minutes, a process that typically can take weeks. The capability of quick response is important in preventing large scale health problems. IBM Food Trust has also facilitated collaborations between food retailers and suppliers to track and authenticate organic products, ensuring that consumers receive genuine organic food. This is

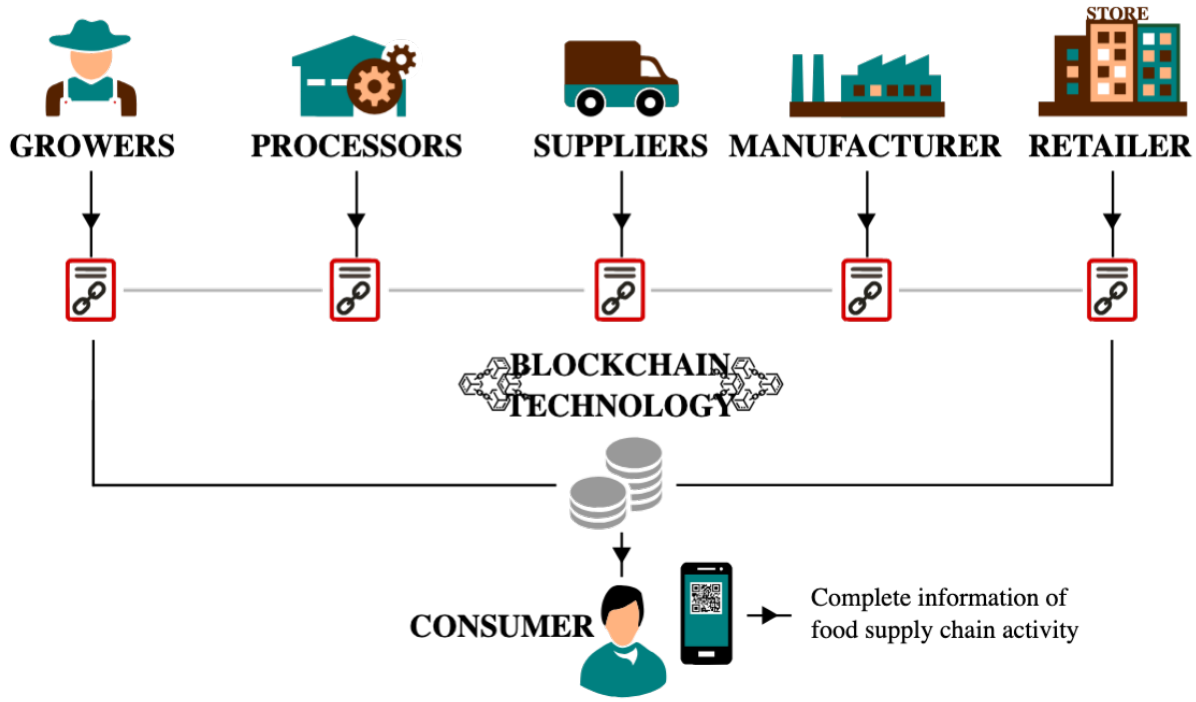

Figure 3: Simple visualization of the different actors that upload information to the blockchain, and the consumer interacting with the blockchain to view information. (SourceTrace, 2021)

important in protecting both consumer health and producer integrity. These examples show how blockchain's immutable record-keeping changes the entire lifecycle of food products from production, processing, to distribution.

The organizational framework of IBM Food Trust demonstrates the power of blockchain in addressing complex challenges. Its implementation of blockchain technology represents a significant change in the organizational layout within food supply chains. The platform operates as a collaborative network, with a wide range of stakeholders including farmers, processors, distributors, retailers, etc. This collaborative model is demonstrated by a shared commitment amongst the stakeholders to enhance transparency and accountability within the food supply chain. Through the use of blockchain, individuals within the system can access important data related to the food origin, processing, and shipping.

As Nguyen (2018) details, the platform uses smart contracts to drastically reduce lead times. These smart contracts are able to automate transactions and enforce agreements, streamlining the process from the grower to the consumer. This allows for informed decision-making and collective problem-solving by consumers of the data. For example, in an effort to limit food contamination, IBM collaborated with various food producers and retailers, using the shared data on the blockchain to pinpoint sources of contamination. This was addressed in the supply chain, as said issues were resolved by reaching out to the different contamination sources. Additionally, the organizational processes created by IBM Food Trust, including real-time data sharing and full transparency, play a huge role in improving the efficiency of the food supply chain.

The organizational impact of IBM Food Trust is far reaching. By creating a unified platform where all parties can share and access reliable data, it creates a sense of community.

This is helpful in an industry where timing and accuracy are important to maintaining reliability. The ability to trace a product back to its source and verify its quality represents a shift in how food safety and quality are managed.

IBM Food Trust also demonstrates the cultural aspects of a functioning socio-technical system. The heart of the problem being solved by IBM Food Trust is to foster an environment of greater transparency and trust. By allowing consumers to trace the origins of their food products, the platform aligns with the values of informed consumption and ethical sourcing. This improved transparency strives towards a culture of trust and accountability amongst stakeholders in the food supply chain, from farmers to retailers. Adding to this, Nguyen (2018) provides an analysis on how blockchain technology is driving a cultural shift within the food industry. Consumers are increasingly concerned about the origin, safety, and ethical aspects of their food. IBM Food Trust meets this demand by providing a transparent food supply chain. This aligns perfectly with the movement towards responsible consumption. The platform provides consumers with information about where their food comes from, how it was produced, and its journey through the supply chain. This level of transparency creates a greater sense of connection between consumers and the food they consume. It also encourages informed decision-making, where consumers can choose products that align with their values.

IBM Food Trust's role in this cultural shift goes beyond consumer behavior. They also have a role in influencing corporate policies and industry standards. Companies are recognizing the value of transparency and ethical practices, not only as a response to consumer demand but also as a competitive advantage. This is leading to a wider adoption of ethical practices across the industry.

Additionally, the focus on sustainability, as emphasized in the platform's objective to reduce food waste and enhance supply chain efficiency, aligns with global goals for improved sustainable practices. The cultural implications of IBM Food Trust pave a road beyond the food industry, setting the foundation for uses of modern technology to solve other socio-technical problems. The platform is becoming an influencer for a shift towards more responsible and sustainable food consumption. This cultural transformation is pivotal in addressing challenges such as environmental sustainability, food security, and public health.

The IBM Food Trust provides an example of how blockchain technology can combine organizational and cultural dynamics to address challenges in a socio-technical environment like the food supply chain. The platform highlights the potential of blockchain technology in solving real-world problems, but also demonstrates the importance of collaborative organizational frameworks and cultural shifts towards transparency, innovation, and sustainability. The principles of IBM Food Trust can serve as a blueprint for similar blockchain-based socio-technical systems.

Figure 4: Different characteristics of Cultural and Organizational Parts of a System

Results: Blockchain Can Improve the Failing Organizational and Cultural Characteristics in Carbon Credit Markets

Blockchain technology has the potential to culturally change the carbon credit system, impacting the level of trust and transparency within the system. Stakeholders within the carbon credit industry, which include government bodies, corporations, and even everyday citizens, hold doubt against the system. Over the years, the system has exemplified several instances of fraud, especially where credits are issued without actual emission reductions. The problem of double-counting, when a single emission reduction is counted multiple times, also decreases trust. This transparency that comes with blockchain technology is important, as it helps carbon credits to be recognized as legitimate instruments for environmental conservation. The immutability of blockchain can be used to ensure and validate every carbon credit transaction that occurs. The use of blockchain technology in carbon credit markets can have a similar effect such as what is seen in projects like IBM Food Trust, which has significantly increased trust and transparency in the food supply chain journey.

Blockchain can also create a cultural shift in environmental responsibility of corporate individuals. After companies gain more confidence in the authenticity and effectiveness of the carbon credit system, corporate entities can become motivated to integrate these credits into their sustainability strategies. This type of shift to substantial environmental habits is pivotal in the global fight against climate change. It mirrors what was observed in the food industry due to IBM Food Trust, where companies have started to emphasize the traceability and sustainability of their products. The improved trust and transparency that blockchain creates, as demonstrated by IBM Food Trust, encourages broader participation from various sectors, including businesses, governments, and individuals.

The organizational challenges facing the carbon credit system include issues related to standardization, verification, and real-time data accessibility. Blockchain technology addresses these challenges, by providing a platform that standardizes verification and validation processes across different regions. Smart contracts offer a way to automate the verification process in the carbon credit system. Smart contracts are digital protocols which execute automatically when they meet predefined conditions. This minimizes human errors and biases, improving efficiency. This efficiency replicates the achievements seen in IBM Food Trust, where smart contracts have been used to ensure compliance and quality standards in the food supply chain. IBM Food Trust's successful use of blockchain showcases how it can bring standardization and ensures consistency.

Additionally, having real-time access to data is extremely important. Blockchain allows stakeholders in the carbon credit market to access the most recent information, enabling them to make informed decisions and track the progress of projects. By offering a transparent and chronological record of transactions, blockchain gives stakeholders insights at any given point in time. This responsive nature of the system allows for quick identification and resolution of issues. The success of IBM Food Trust in providing real-time data access in the food supply chain highlights the potential of blockchain technology in improving the carbon credit system's responsiveness and decision-making processes.

Another organizational challenge in the current carbon credit system is varying regional regulations. Blockchain offers a solution through decentralization. Blockchain-based carbon credit systems would operate on a network where all stakeholders can govern the regulations involved with the carbon credit process. This collective oversight ensures that the system operates free of regional biases and inconsistencies.

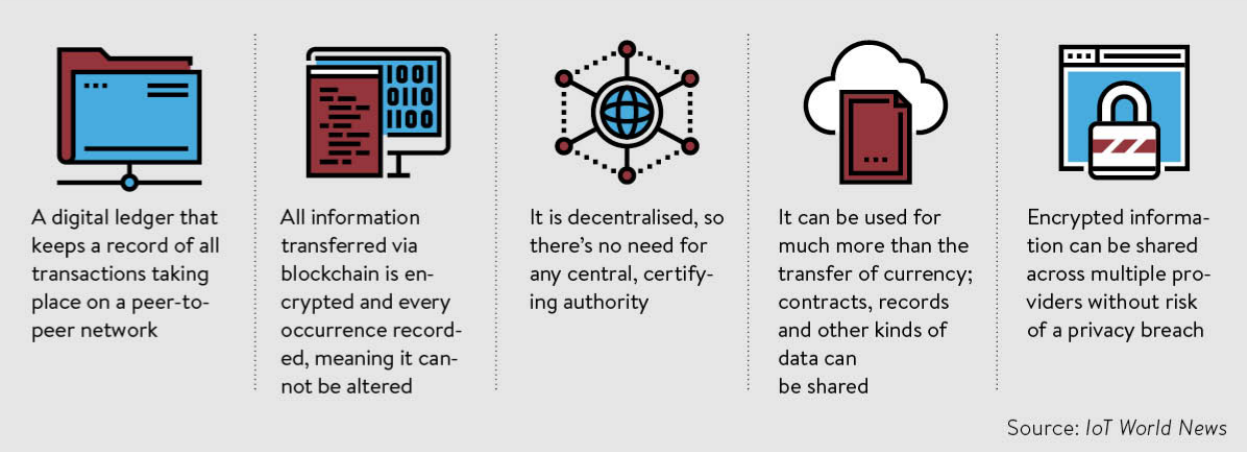

Figure 5: Different characteristics of blockchain technology visualized (IoT World News 2021)

With these solutions, blockchain technology can address the cultural and organizational challenges hindering the carbon credit system. By improving trust and transparency, blockchain can make carbon credits a powerful instrument in the global fight against climate change.

Conclusion:

As I conclude this paper, it is evident that blockchain technology could prove to be a central pillar in reinforcing the foundation of carbon credit systems. This research explores the capabilities of blockchain, highlighting its potential to improve the organizational and cultural discrepancies in carbon credit markets.

The significance of these findings present a strong argument for the practical implementation of a blockchain based carbon credit system. The implication of such a system could foster an environment where transparency, accountability, and integrity are guaranteed. This research acts as a call to action to policymakers, industry leaders, and environmental advocates, highlighting the tools that are at our disposal. These tools must be harnessed to achieve our global purpose of mitigating climate change. In summary, this paper advocates for the embracement of blockchain as a strategic enhancement to the carbon credit system.

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