Blockchain for International Development and Humanitarian Use Cases

A Deep Dive

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FRONTIER TECH HUB

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Executive Summary

Commissioned by the Frontier Tech Hub and executed by Impact Plus, this study explores the intersection of blockchain technology and the international development and humanitarian sectors. This research holds a dual aim: first and foremost, it aspires to expand the existing evidence concerning the added value of blockchain-based solutions in these sectors. Concurrently, it pinpoints essential pre-conditions and strategies that practitioners should be cognisant of when implementing, evaluating, and scaling blockchain solutions. It is hoped that this study will contribute to the research field, aiding in shaping optimal practices for the incorporation of blockchain technology in international development and humanitarian initiatives. Nestled within this broader aim, the study's objectives are encapsulated by two key research questions:

1. What evidence exists around the value-add of blockchain-based solutions for international development and humanitarian use cases?
2. What pre-conditions and/or approaches should practitioners be aware of in order to effectively test and scale blockchain solutions, and deliver value?

This study focused on early-stage innovations, specifically in the area of blockchain technology. Due to the inherent nature of investigating these early-stage developments, the scope for presenting a comprehensive array of well-evidenced value-adds was naturally more limited compared to research conducted on more established pilots. Even within these constraints, the research was successful in identifying and documenting key themes. These themes provide a preliminary yet informative look into the potential value-adds of blockchain technology, as seen by those who are actively working with the technology. It's important to bear in mind that the industry itself is in its early stages, further emphasising the relevance of these initial findings.

In response to the **first research question**, the study investigates ten potential benefits, or "value-adds," of blockchain technology, including trust, decentralisation, enhanced security and privacy, cost reduction, speed, visibility and traceability, immutability, individual control of data, tokenisation, as well as ethical considerations, sustainability, and accountability. Of these value-adds, trust, visibility/traceability, speed, and decentralisation are the most emphasised in the pilot studies. Notably, trust is rated the highest, signifying its pivotal role in the effectiveness of blockchain solutions.

These value-adds reveal a complex interplay of benefits resulting from the adoption of blockchain technology. The understanding of these interconnected benefits is essential to fully realise the advantages of blockchain solutions. For instance, the decentralised structure of blockchain inherently improves security and, simultaneously, enables cost efficiencies by reducing the dependence on intermediaries. This example underlines how blockchain's value-add dimensions can interrelate and mutually strengthen each other.

10 Value-add Dimensions

Trust

Visibility
& Traceability

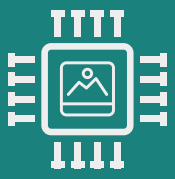
Speed

Decentralised
Structure

Reduced Costs

Improved Security
& Privacy

Immutability



Tokenisation

Improved Individual
Control of Data

Ethical Considerations,
Sustainability & Acccoutability

To capitalise on these interconnected benefits, we introduce the term 'context-specific prioritisation,' a process that involves identifying the potential benefits of blockchain that are most relevant or impactful within a particular setting. Depending on an organisation's specific needs and objectives, some value-adds may take precedence over others. For instance, an organisation handling sensitive data may prioritise 'improved security,' while an organisation seeking operational efficiency might focus more on 'speed' and 'cost reduction.'

Moreover, inherent features of blockchain technology, such as smart contracts, can enhance these value-adds. They can increase cost savings and speed by automating transactions and enforcing agreements without the necessity for third-party intermediaries.

Lastly, an area of concern raised by this study is the apparent de-emphasis on ethical considerations in blockchain initiatives within the sector, despite its strong emphasis in international development and humanitarian work. The apparent preference for operational efficiency and innovation over ethical considerations is troubling and may indicate a systemic issue. Therefore, it's crucial to integrate ethical considerations into all stages of blockchain project design and implementation, especially given the sector's work with vulnerable populations and the profound implications of these decisions.

Regarding the **second research question**, several conclusions were drawn. The primary lesson learned is that a holistic approach integrating Social Impact, Blockchain Design and Token Diagnosis to designing applications (such as the Enabling Factor Framework), can help navigate challenges and maximise the potential of blockchain technology. These frameworks consider a number of variables, such as technological readiness, stakeholder engagement, regulatory environment, resource allocation, and risk management. Many pilot programs faced challenges in identifying critical risks, including the integration of blockchain technology into existing legacy systems. However, when minimal requirements for pre-existing data management systems were met and key stakeholders were actively engaged, this integration became more manageable.

It is important to note that even simple solutions require careful planning to achieve desired outcomes. Notably, the elimination of third-party functions by blockchain can create resistance from legacy intermediaries. To overcome these social and technological challenges, identifying relevant ecosystem stakeholders and developing effective engagement strategies are essential. Building alliances among governments, private entities, and NGOs can drive innovation and help overcome regulatory and operational obstacles.

Additionally, it is worth mentioning that start-ups funded by traditional organisations generally had a lower technical understanding of blockchain compared to native Web 3.0 start-ups. These actors demonstrated greater proficiency in utilising professional networks, platforms like GitHub and Discord, and other blockchain-centric resources to meet their needs.

This discrepancy in knowledge and resource utilisation highlights the importance of providing targeted guidance and support to bridge the gap. The survey respondents pointed out five

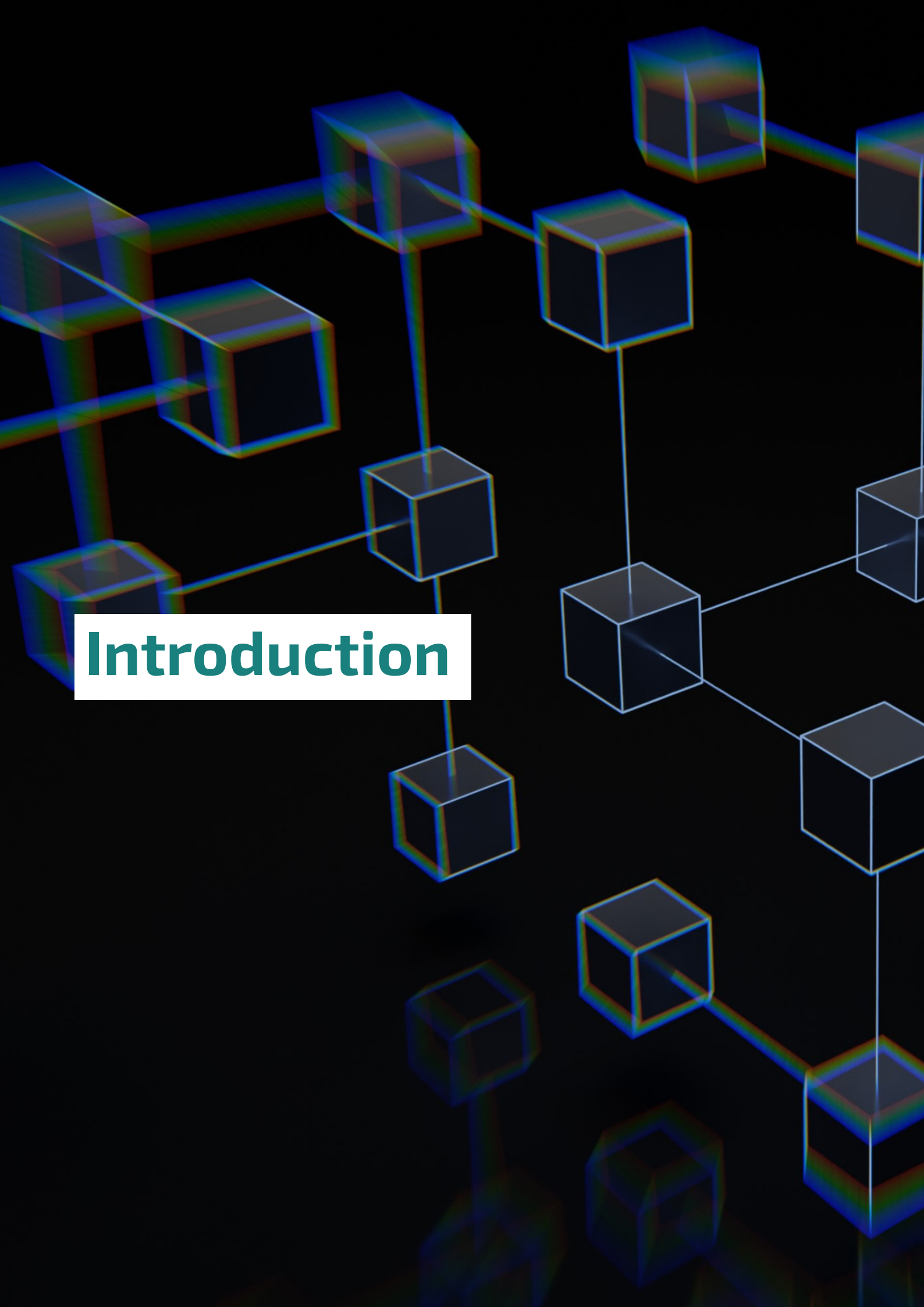
lessons to achieve successful outcomes in blockchain initiatives that are worth mentioning: it is important to expect delays and cost overruns, the need to maintain focus on specific problem areas, engage and educate stakeholders, have a thorough understanding of the problems, and prioritise education of the ecosystem and user experience.

Blockchain holds great promise for bolstering the efficiency of international development and humanitarian initiatives. A range of strategic recommendations emerge from our analysis, aimed at facilitating successful adoption and management of blockchain technology in these sectors. As mentioned, measurement models such as the Lean Impact Approach, Blockchain Adoption Model, and Capabilities, Opportunity, and Motivation (COM-B) model are powerful tools for optimising adoption. They offer insights into behavioural, technological, organisational, and environmental contexts that can shape the successful deployment of blockchain.

Equally important is mitigating data integrity risks through structured data management protocols. The nature of the blockchain used, the fostering of collaboration, and the prioritisation of user experience are central to successful implementation. The iterative testing of assumptions, planning for scalability and sustainability, and incorporation of behavioural insights are also essential to build robust blockchain solutions.

Additionally, viewing blockchain as a trust tool and incorporating risk management strategies, alongside addressing ethical and social considerations, and building governance and capacity, can foster effective and ethical implementations. By taking these recommendations to heart, we can drive innovation, navigate challenges, and ultimately enhance the impact of blockchain initiatives in the international development and humanitarian sectors.

This executive summary closes with a note of caution. Blockchain technology should not be used for the sake of using cutting-edge tech. It should provide clear, substantial advantages over existing solutions. If the blockchain solution in question does not enhance any other key metric relevant to the specific application to a degree that justifies its implementation and maintenance costs, then it may indeed fail to provide sufficient value.



Introduction

The Frontier Tech Hub, managed by Results for Development (R4D), DT Global (formerly IMC Worldwide) and Brink is a dynamic collaboration that intersects technology, innovation, and global development sponsored by the UK Foreign Commonwealth and Development Office (FCDO). Its activities revolve around three principal domains:

- ***Livestreaming*** explores the use of frontier technologies by working with partners all over the world to test and scale tech with the potential for positive social impact.
- ***Futures*** connects FCDO employees with one another and the world of tech, equipping them to apply frontier technologies in their programmes.
- ***Hub Research*** gathers and shares what is learned and dives deeper into areas where technology has the greatest potential for doing good.

The Frontier Tech Hub has a growing body of evidence from pilots that are attempting to use blockchain in international development and humanitarian use cases. Blockchain technology, while still in its early stages, is receiving increased attention, and the literature validating its effectiveness in resolving real-world problems continues to expand.[1] However, despite this increased interest, its application in international development and humanitarian sectors remains poorly documented.[2] While some progress has been made in mapping research across different sectors and analysing individual case studies, there still exists a noticeable lack of systematic reviews, initial evidence gap maps,[3] and other comprehensive research methodologies on the subject.[4]

The objective of this collaboration is to fill this gap by researching blockchain's value-add within humanitarian and developmental contexts. Additionally, it aims to determine the essential conditions for effectively testing and scaling such solutions. These factors form the heart of the two Study Questions driving this research:

Study Question 1: *What evidence exists around the value-add of blockchain-based solutions for international development and humanitarian use cases?*

The accurate identification and measurement of the value-adds are a critical component of any successful use of a blockchain. Knowing the potential value-add of using a blockchain as a tool for specific types of problems and developing performance measurement frameworks around these value-adds helps to assess their applicability. A significant portion of this study aims to identify the possible types of value-added benefits that could be derived from using blockchain technology. The value-adds were identified and selected upon completing a literature review.

Study Question 2: *What pre-conditions and/or approaches should practitioners be aware of in order to effectively test and scale blockchain solutions and deliver value?*

Enabling conditions refer to the contributing factors and strategies that optimise the value-adds of the start-ups. These conditions include pre-existing internal aspects such as workflows, skill sets, financial resources, and contextual factors like market demand and regulations. The understanding and management of these conditions by the pilot projects play a crucial role in

improving their performance. In this study, we use the term "pilots" to describe all the interventions and activities.

The term "pilots" has been chosen because all the included interventions are still in their early stages, where they are testing foundational value propositions and business models.

The research paper is structured as follows: it begins with a brief introduction to the methodology , explains how the pilots were selected and the limitations of the research. The study findings section presents the outcomes of the research, addressing two key study questions: the evidence of the value-add of blockchain-based solutions for international development and humanitarian use cases, and the pre-conditions and approaches for effectively testing, scaling, and delivering value with blockchain solutions. The paper also includes a literature review on evidence from sector applications, covering supply chains, decentralised funding, and land rights that informed and complemented the findings. Finally, we conclude by offering key findings and recommendations.

Methodology, pilot selections and limitations

The research design encompassed a multifaceted approach to examine the goals, implementation processes, challenges, enabling factors and success metrics of the pilots. A literature review, document review, Key Informant Interviews (KIIs), discussions with project staff, and an electronic survey were conducted, allowing for a triangulated analysis of the data. To assess the value-added by blockchain technology and identify key enabling factors, two analytical frameworks, namely the value-add Framework and the Enabling Factors Framework, were employed. The Consultative Committee, comprising experts in relevant fields, provided invaluable technical feedback on the findings. The full description of research methodology, including pilot sampling, data collection and analysis methodology are included in Annex 9.1.

The fifteen pilots included in this study spanned multiple sectors such as finance, agriculture, land titling, supply chain and decentralised funding, and also varied in terms of amount funding received and types of implementing partners. Nine of these pilots were funded by Frontier Tech Hub. However, to enrich the findings, the sampling pool was expanded to include pilots from other funders such as Mercy Corps, UNICEF Venture Fund, and others.

Table 1: Pilots included in study

<table>
<tr><th>Pilot</th><th>Funders</th><th>Sector</th></tr>
<tr><td>High Tech Solutions for supply chain and distribution (link)</td><td rowspan="3">Frontier Tech Hub</td><td rowspan="4">Supply chain</td></tr>
<tr><td>Blockchain Certified Digital Payments for Miners (link)</td></tr>
<tr><td>Blockchain Technology for the Humanitarian Supply Chain (link)</td></tr>
<tr><td>Statwig (link)</td><td>UNICEF Venture Fund</td></tr>
<tr><td>Improving Land Records in Karnataka through Blockchain (link)</td><td rowspan="6">Frontier Tech Hub</td><td rowspan="2">Land records management and land rights protection</td></tr>
<tr><td>Protecting land rights forest in Ghana with blockchain (link)</td></tr>
<tr><td>A blockchain-enhanced platform to support the humanitarian crisis in Venezuela (link)</td><td rowspan="3">Decentralised funding. Coordination of aid distribution</td></tr>
<tr><td>Tracking UKAid Payments on the Blockchain (link)</td></tr>
<tr><td>De-duplicating aid to enhance the impact of humanitarian assistance (link)</td></tr>
</table>

Pilot	Funders	Sector
Glo (link)	Private	Financial technology (FinTech), digital currency, and philanthropy
AGRIFIN_MercyCorps (link)	Mercy Corps	Agriculture
Stellar (link)	Private	Financial Inclusion
RAHAT (link)	UNICEF Venture Fund	
Xcapit (link)		
Os City (link)		Identity

As detailed in the Sampling section (see Annex 9.1.1), the technical limitations of this study primarily stem from the limited quantity and variety of applications. Although the study incorporated results from literature reviews, it primarily relied on data from the pilot projects included in the research. Furthermore, there was a significant disparity in the type and quality of data available for each pilot project, leading to a degree of variance in the research outcomes. The specifics of this disparity are outlined in Table 3 below.

Nonetheless, a substantial portion of the findings align with external evidence, hinting at a wider representativeness. This correlation could be attributed to the predominantly qualitative nature of the findings, which generally lend themselves to broader interpretation. For instance, the array of value-added benefits and enabling factors are defined somewhat loosely, allowing for extensive applicability across different contexts and use cases.

To conclude, it is important to bear in mind that while the study's findings do offer valuable insights, their applicability might be contingent upon the specific contexts and characteristics of different pilot projects. The study's findings should be interpreted and applied with due consideration for these limitations.

Table 2: Types of data available for each pilot

Pilot names		Application	Frontier Tech Hub Video Interview	Sprint Reports	Pilot Log	KII	Survey
1	Tracking UKAid Payments on the Blockchain	Yes	No	Yes	Yes	No	No
2	High Tech Solutions for supply chain and distribution	Yes	Yes	No	Yes	No	No
3	Blockchain Technology for the Humanitarian Supply Chain	Yes	No	Yes	Yes	No	No
4	Blockchain Certified Digital Payments for Miners	Yes	Yes	Yes	Yes	No	No
5	Improving Land Records in Karnataka through Blockchain	Yes	No	No	Yes	Yes	No
6	A blockchain-enhanced platform to support the humanitarian crisis in Venezuela	Yes	No	Yes	Yes	Yes	Yes
7	De-duplicating aid to enhance the impact of humanitarian assistance	Yes	No	Yes	Yes	Yes	Yes
8	Protecting land rights forest in Ghana with blockchain	Yes	No	No	No	No	No
9	Glo	N/A	N/A	N/A	No	Yes	Yes
10	Stellar	N/A	N/A	N/A	No	Yes	Yes
11	AGRIFIN MercyCorps	N/A	N/A	N/A	No	Yes	No
12	Rahat	N/A	N/A	N/A	No	Yes	No
13	Xcapit	N/A	N/A	N/A	No	Yes	Yes
14	Os City	N/A	N/A	N/A	No	Yes	Yes
15	Statwig	N/A	N/A	N/A	No	Yes	No

Findings

The findings of the study are structured as follows: First, we address the two study questions individually. Blockchain has the potential to create efficiencies, which is attributable to two critical factors. The first factor is the inherent design attributes of the blockchain itself (the value-adds –Study Question 1), and the second is the capacity to maximise these value-adds through effective practices, terms we define as 'enabling factors' in Study Question 2 of this report. The answers to the study questions are followed by a literature review of three priority application sectors, namely Supply Chains, Land Rights, and Decentralised Funding, which serves to reinforce the findings and provide context. Finally, we present general conclusions derived from the study findings. This structured approach allows for a comprehensive understanding of the study outcomes within specific contexts, as well as broader implications.

4.1 Study Question 1: Evidence around the value-add of blockchain-based solutions

The structure of the findings for Study Question 1 begins with a comprehensive overview of the types of value-add facilitated by the use of blockchain technology, which were determined through a literature review. These formed the basis of the Value-add Assessment Framework (see annex 9.4), a framework which was constructed to provide guidance on how the value-adds translate into tangible benefits. Success metrics and a survey were utilised to validate and triangulate the findings. Having introduced the methodology and framework, we now turn our attention to Study Question 1.

Blockchain, at its core, can be understood as a form of code. It relies on cryptographic algorithms and distributed ledger technology to create a decentralised and immutable system for recording and verifying transactions. The value-adds arise when this code is deployed to achieve specific objectives in the international development and humanitarian space more efficiently.

The categorization of value-adds from 1 to 10 is derived from a comprehensive analysis of the pilots' documentation, KIIs, and the survey conducted during this study (Table 5: Relevant value-adds of the Study Pilots based on their level of contribution to envisioned pilot objectives). Furthermore, the analysis was informed by the survey results (Graphic 1: Measures of Success), which provided additional perspectives on the value-adds. These were identified and ranked based on their perceived significance and contribution to the pilot objectives. This ranking is valuable as it provides insights into the relative importance and relevance of each value-add within the study's context.

However, it is essential to acknowledge that this categorization is subjective rather than objective, as it represents the perspectives and experiences of the pilots, KIIs and survey respondents. It is also important to note that this categorization is based on a limited sample size, which may impact its generalizability. The prioritisation of value-adds may also vary depending on specific contexts and the perspectives of different stakeholders involved.

Table 3: The value-adds of Blockchain

Value-adds	How the Blockchain Achieves the value-add
Decentralised Structure	Decentralisation enhances security by eliminating single points of failure and makes networks more resilient to failures and attacks. Even if some nodes in the network go offline or are compromised, the blockchain remains operational as long as a sufficient number of nodes are still functioning.[5]
Ethical Considerations, Sustainability & Accountability	Ethics can be defined as a collection of moral principles or values that steer behaviour and decision-making, typically with the intention of fostering the welfare of individuals and society at large. Various ethical frameworks may uphold different values or principles, such as augmenting benefits, honouring rights, advocating fairness, or advancing the collective good.[6] . Sustainability in the context of blockchain refers to the consideration of environmental, economic, and social factors in the design, implementation, and operation of blockchain systems. It involves minimising the carbon footprint and energy consumption of blockchain networks, ensuring economic viability and long-term viability of the technology, and promoting equitable and inclusive outcomes.[7] Accountability refers to the responsibility of organisations and individuals to provide transparent and accurate information about their actions and decisions, and to be held accountable for their impact.
Immutability	The immutability of the blockchain is achieved through the combination of cryptographic hashing and the distributed nature of the network.[8]
Improved Security and Privacy	Transactions are permanent and unchangeable once they are entered on the ledger. Each transaction is linked to the previous one through cryptographic hashes, creating a chain of blocks where any attempt to alter or tamper with a transaction would require modifying all previous blocks which is computationally infeasible.[9]
Individual Control of Data	Through the use of cryptographic keys, individuals , organisations, institutions, etc. can securely access and manage their data on a blockchain. They can choose which data to share and with whom, granting permission through smart contracts or digital signatures.[10]

Reduced Costs	The decentralised and distributed nature of blockchain enables faster and more efficient transactions by reducing settlement times and eliminating unnecessary manual processes and inefficiencies caused by delays.[11]
Speed	Blockchain technology facilitates direct peer-to-peer transactions, eliminating the necessity for intermediaries. It also diminishes the reliance on intermediaries for tasks such as reconciliation processes and multiple layers of verification.[12]
Tokenization	Tokenization is the representation of rights and permissions for real-world assets on a blockchain as digital tokens.[13]
Trust	Blockchain provides trust through its consensus mechanisms, decentralisation, immutability, transparency, and cryptology. These features work together to create a secure platform for parties who do not know each other to transact in some way shape or form.[14]
Visibility and Traceability	Blockchain maintains a complete history of all transactions that have occurred on the network.[15] This provides visibility into the transaction history and allows for traceability of any data or asset that has been recorded on the blockchain. It enables a secure and transparent tracking of all transactions, providing a tamper-proof log of sensitive activity. This visibility is crucial in industries such as supply chain management, where the ability to track and trace products is critical.[16]

All of the value-additions were relevant to the pilots included in this study. It is worth noting, as per the literature review, that the selected value-additions for development and humanitarian applications are comparable to the benefits observed in the broader context of blockchain technology. This insight reinforces the credibility of the Value-add Assessment Framework as a useful tool for two primary functions.

Firstly, it measures the relative contribution of different types of value-add to the objectives of the application in a way consistent with the key characteristics of blockchain. Secondly, it serves as a foundation for constructing pilot design and management tools. These tools can include problem diagnostic instruments, decision trees for assessing the utility of a blockchain solution, feasibility assessments, key performance indicators, and so forth.

Each pilot was requested to cite what it considered to be their most important value-add. For clarity, the following table only shows the four most important value-adds.

Table 4: Relevant value-adds of the Study Pilots (the top four value-adds based on their level of contribution to envisioned pilot objectives)

Value Adds	Trust	Visibility/ traceability	Speed	Decentrali-sation	Reduced Costs	Security/ Privacy	Immutability	Tokeni-sation	Individual Control of Data	Ethical Sustainability & Accountability
Tracking UKAid Payments	✓	✓	✓		✓					
High Tech Solutions for supply chain and distribution	✓	✓	✓		✓					
Blockchain Technology for the Humanitarian Supply Chain	✓	✓	✓		✓					
Blockchain Certified Digital Payments for Miners	✓	✓	✓				✓			
Support the Humanitarian crisis in Venezuela	✓		✓		✓	✓				
Support the Humanitarian crisis in Venezuela	✓	✓	✓		✓					
Protecting land rights forest in Ghana	✓			✓		✓		✓		
Improving Land Records in Karnataka through Blockchain	✓			✓		✓		✓		
Glo	✓	✓		✓		✓				
Stellar	✓			✓		✓	✓			
AGRIFIN MercyCorps	✓	✓	✓		✓					
Rahat	✓	✓	✓	✓						
Xcapit	✓	✓		✓			✓			
Os City	✓	✓		✓						
Statwig	✓		✓	✓	✓					
TOTAL	15	10	9	8	8	5	3	2	0	0

All fifteen pilots unanimously identified "**Trust**" as a key value-add, emphasising its paramount importance. Therefore, the value of trust will be a recurring theme throughout the research paper. "**Visibility and Traceability**" emerged as the second most prevalent value-add, acknowledged in all pilots except one, resulting in the highest total score of 10 out of 15 (out of the top 4). This value-add played a crucial role in projects such as "Tracking UKAid Payments," "High Tech Solutions for Supply Chain and Distribution," and "Blockchain Certified Digital Payments for Miners," where transparent tracking and recording of transactions were vital. "**Speed**" followed closely, receiving a score of 9. Its significance was particularly noticeable in pilots like "Rahat" and "AGRIFIN MercyCorps," where the efficiency of blockchain transactions was of utmost importance.

"**Decentralization**" and "**Reduced Costs**" both received a score of 8. Projects like "Glo," "Stellar," "Os City," and initiatives like "Support the Humanitarian Crisis in Venezuela" and "De-duplicating Aid Nigeria" notably benefited from the decentralised structure of blockchain and recognized the potential cost-saving advantages. The first five identified elements that contribute to the overall value of a blockchain solution appear to be of significant importance, as suggested by the results. Whilst other features may also enhance the solution, they have received less attention,

implying that these primary five elements are important components in the foundation of any blockchain application.

With a score of 5, "**Improved Security and Privacy**" was cited by projects such as "Os City" and "Statwig," which required robust security measures. "Immutability," although relatively less acknowledged with a score of 3, played a critical role in the "Safeguarding land-based climate investments in Ghana with blockchain" project, necessitating permanent and unalterable record-keeping.

While not explicitly mentioned in the listed pilots, "**Individual Control of Data**" is a noteworthy value-add that could potentially offer significant benefits in projects where secure and personal data management is a primary concern. "**Tokenization**," scoring 2, was recognized in the "Blockchain Certified Digital Payments for Miners" and "Xcapit" pilots, where the digital representation of real-world assets on a blockchain was of utmost importance. Despite the significant prominence of tokenization as a flagship feature of blockchain technology, it is notable that a majority of respondents in the KIIs did not identify it as a key value-add.

This raises the question of several potential factors that may account for this observation. Respondents may lack a comprehensive understanding of tokenization due to its complex nature (as a matter of fact only a fraction of the pilots tokenized their solutions. Additionally, its relevance might not be apparent in specific use cases where other aspects of blockchain, such as transparency and efficiency, are prioritised. Regulatory concerns and legal uncertainties surrounding tokenization could further deter its recognition as a value-add. Moreover, the feasibility of implementing tokenization, especially given the necessity for systemic changes and user education, might be questioned. Lastly, perceived risks associated with tokens, including volatility and security issues, might overshadow its potential benefits. These perspectives suggest a need for more in-depth exploration of blockchain's perceived value-adds in this context.

Despite no pilot projects in the international development and humanitarian sector highlighting **ethical considerations** as their top value-add, the importance of these considerations, as emphasised in Blockchain Ethical Design Framework[17], cannot be understated. This framework suggests that ethical considerations, intentional design, and an ethical decision-making process are vital to effectively utilise Blockchain technology for social impact.

This is rather disconcerting given the substantial attention accorded to ethics in the literature review. Working in this field inherently involves addressing some of the most vulnerable populations, and decisions made can have profound impacts on their lives. Ethical considerations should, therefore, form a cornerstone of any initiative. They ensure that the solutions provided are not only effective but also respectful of human dignity, rights, cultural differences, and societal structures. Surprisingly, these pilots appear to not prioritise ethical considerations, which may point to a broader issue within the sector - a tendency to prioritise

operational efficacy and innovation at the expense of ethical prudence. This lack of ethical framing in the implementation of blockchain solutions is a point of concern that demands urgent attention.

It underlines the need for an in-depth dialogue on how best to integrate ethical considerations at every stage of blockchain project design and implementation in international development and humanitarian contexts.

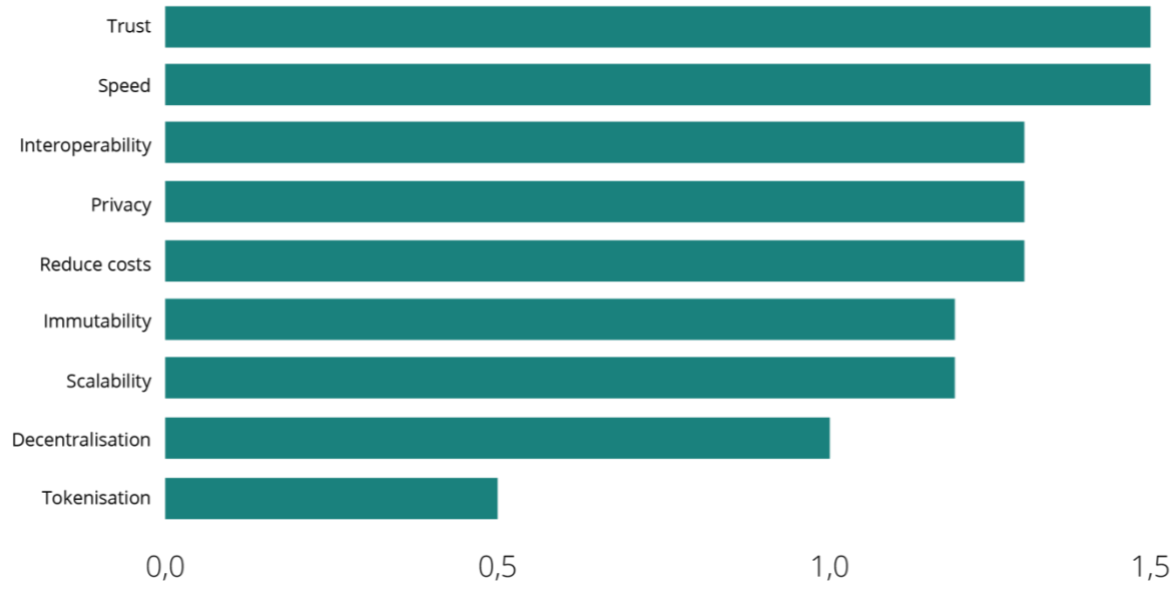
To conclude this subsection, this framework provides a current snapshot, but it may not effectively capture changes in value-adds over time, which is particularly relevant due to the experimental nature of many blockchain pilots. Each pilot operates within a unique context, including varying scales, target populations, and objectives. As a result, a value-add that proves beneficial in one context may not be equally effective in another. In the table, all value-adds are treated equally without indicating their relative importance or impact on the overall success of the pilot.

Some value-adds may hold more significant influence on the pilot's objectives than others. The methodology does not fully account for these contextual differences. Furthermore, given the overlapping and interdependent nature of these value-adds, the results should not be interpreted as statistical, objective, or conclusive. Despite these limitations, the results obtained from the value-add assessment framework still offer valuable insights and can serve as a starting point for developing pilot design, adaptive management strategies, and measurement tools. The identified value-adds can inform decision-making processes and help stakeholders understand the potential benefits and considerations associated with blockchain technology in international development and humanitarian contexts.

To triangulate the findings from the KIIs, we utilised a survey as an additional research method. First, we asked the pilots to rank the value-adds, providing an additional perspective on their perceived significance. Second, we inquired about their success metrics as a proxy to gauge the value-adds, further strengthening the validity of the findings.

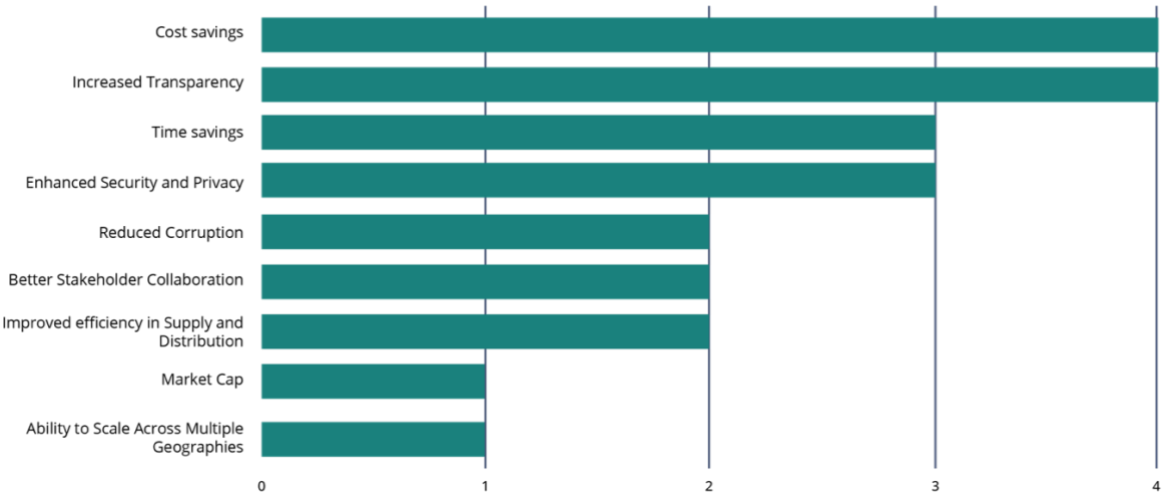
The survey directly highlighted the importance the start-ups and pilots saw in the value-adds. While the survey sample size was limited to six responses, the participants represented a diverse range of projects and initiatives. Each participant was asked to score the value dimensions on a scale of 0-2.[18] Trust and Speed were the highest-scoring categories, each averaging 1.5. Other notable dimensions were Interoperability, Privacy, Reduced Costs, Immutability, and Scalability, all scoring over 1. Decentralisation scored a 1, and Tokenization was the least prevalent with a score of 0.5.

Graphic 1: Average Scores on a 0-2 scale of Important for Value-add Dimensions (Survey Results)



The survey also included a section where respondents were asked to indicate what they thought were their primary measures of success. This additional information helped to assess the accuracy and relevance of the identified value-adds in the context of the pilots.[19]

Graphic 2: Success Metrics (Survey Results)



The survey results, in alignment with KIIs and document reviews, reinforced the validity of the key value-add dimensions included in the Value-add Assessment Framework. Notably, there was limited variation observed between the success measures reported by individual pilot teams and the value-adds identified through qualitative data collection. This indicates a significant overlap between the performance measurements prioritised by different pilot teams and the ten value-adds established in the study. Notably, several metrics align directly with specific value-adds:

- Cost Savings, which was used as a success metric in four out of six projects, corresponds to the "Reduced Costs" value-add. This highlights the pilots' focus on leveraging blockchain for cost efficiencies.
- Increased Transparency, referred to in four projects, relates to the "Visibility/Traceability" value-add. This underscores the importance of trust and accountability in these projects.
- Time Savings, mentioned in three projects, is linked to the "Speed" value-add, showcasing blockchain's ability to streamline processes.
- Enhanced Security and Privacy, also mentioned in three projects, aligns with the "Security/Privacy" value-add, emphasising blockchain's role in safeguarding data.
- Reduced Corruption and Better Stakeholder Collaboration, each mentioned in two projects, can be attributed to the "Decentralisation" value-add. Blockchain's decentralised nature promotes transparency and trust among stakeholders, potentially reducing corruption.
- Improved Efficiency in Supply and Distribution, mentioned in two projects, encompasses value-adds such as "Speed," "Reduced Costs," and "Visibility/Traceability." This highlights the multifaceted benefits of blockchain in supply chain management.

Informed by insights from the literature review, KIIs, and survey data, we then established a ranking system for the value-adds of blockchain technology. These rankings, as presented in Table 5, are based on an analysis of fifteen pilot programs and offer an understanding of the prominence and relevance of each value-add dimension.

By demonstrating the numerous benefits that blockchain brings across different sectors, these rankings serve as a guide to the key areas of impact. They will also shape the final conclusions and recommendations of the study regarding the potential of blockchain for transformative social outcomes.

Table 5: Ranking of value-add Dimensions as Manifested in the Pilots (Based on the Three Most Significant value-adds Manifested in Each Pilot)

1. Trust

Trust emerges as the highest-rated value-add dimension in both the Value-Add Assessment Framework (score of 15) and the survey (average score of 1.5). This indicates that establishing trust in blockchain-based solutions is considered crucial across the evaluated pilots.

While there was no standardised causal pathway identified across the pilots to achieve trust, it was consistently recognized as a higher-level objective or overall goal. Each pilot aimed to establish trust among participants and levels, whether it was in the context of supply chain management, financial transactions, or land rights.

Blockchain technology was seen as a means to enhance trust by providing transparent and immutable records, reducing the need for intermediaries, and ensuring the integrity of data. The significance of trust as a value-add underscores its essential role in building confidence and fostering cooperation within the blockchain-enabled solutions studied.

2. Visibility and Traceability

Visibility and traceability are consistently identified as important value-add dimensions in both the Value-Add Assessment Framework (score of 10 out fifteen pilots) and the survey results. This highlights the significance of transparent and traceable transactions in the context of the evaluated pilots.

The pilots where this value-add was prominent include "Tracking UKAid Payments," which aimed to ensure transparency in aid distribution; "High Tech Solutions for supply chain and distribution," which focused on improving transparency in the Public Distribution System; and "De-duplicating aid Nigeria," which aimed to prevent aid duplication and enhance resource distribution.

In these pilots, visibility and traceability provided transparency, accountability, and efficient resource allocation, contributing to the overall success of the projects.

3. Speed

Speed received a score of 9 in the Value-Add Assessment Framework (score of 9 out fifteen pilots) and average score of 15 in the survey. The efficiency and quick transaction processing capabilities of blockchain technology are highly regarded by the pilots, demonstrating its relevance in a wide range of blockchain-based solutions. The following pilots exemplify the benefits of speed in their respective contexts:

"Tracking UKAid Payments" experienced accelerated transaction times enabled by blockchain technology. This real-time tracking of aid payments significantly increased the speed of the process compared to traditional methods.

The "High Tech Solutions for supply chain and distribution" project harnessed the rapid, transparent transaction capabilities of blockchain to optimise their supply chain processes.

This resulted in quicker movement of goods, faster resolution of discrepancies, and enhanced operational efficiency.

The "De-duplicating Aid in Nigeria" project leveraged blockchain to promptly detect and eliminate duplicate entries in their aid distribution system. This efficiency not only saved time but also ensured that aid reached its intended recipients more expediently.

The "Blockchain Technology for the Humanitarian Supply Chain" pilot demonstrated improved speed by streamlining processes and reducing the reliance on intermediaries. This enabled faster and more efficient interactions within the supply chain.

"AGRIFIN MercyCorps," "Rahat," "Statwig," "Blockchain Certified Digital Payments for Miners," and "Support the Humanitarian crisis in Venezuela" also recognized significant enhancements in speed through the implementation of blockchain. These projects replaced manual verification processes with automatic and transparent blockchain verification, resulting in quicker execution times and improved overall productivity.

4. Decentralised Structure

Decentralisation emerged as a significant value-add in eight of the fifteen pilots as an important value-add dimension in the Value-Add Assessment Framework (score of 8) and is also mentioned in the survey results. While it may not receive a high average score in the survey, its consistent mention indicates its relevance in the pilots' considerations. Showcasing its relevance in various blockchain-based solutions. The following projects exemplify the benefits of decentralised structure:

"Protecting land rights forest in Ghana" and "Improving Land Records in Karnataka through Blockchain" initiatives both utilised decentralisation to eliminate the reliance on a centralised authority for land-related transactions. By leveraging blockchain technology, these projects ensured transparent and efficient processes while empowering stakeholders with greater control over their land rights.

"Glo" and "Stellar" projects embraced decentralisation to create a network that operates without a central authority. By distributing control and decision-making across participants, these projects fostered transparency, trust, and inclusivity.

"Rahat," "Xcapit," "Os City," and "Statwig" recognised the value of decentralisation in their respective sectors. By eliminating the need for intermediaries and centralised control, these projects enhanced transparency, efficiency, and data control, promoting trust and empowering individuals.

5. Reduced Costs

Eight projects identified reduced costs as a significant value-add, highlighting the financial benefits that blockchain technology can bring. These projects include:

"Tracking UKAid Payments" leveraged blockchain's automation capabilities and eliminated intermediaries, resulting in cost savings throughout the aid delivery process.

"High Tech Solutions for supply chain and distribution" optimised supply chain processes, reducing costs associated with manual reconciliation and improving overall operational efficiency.

"Support the Humanitarian crisis in Venezuela" implemented blockchain to enhance transparency and accountability in aid distribution, leading to cost savings by reducing inefficiencies and ensuring resources reach those in need more effectively.

"De-duplicating aid Nigeria" utilised blockchain to eliminate duplicate entries in aid distribution, reducing administrative costs and ensuring aid reaches the intended recipients efficiently.

"Protecting land rights forest in Ghana" and "Improving Land Records in Karnataka through Blockchain" projects applied blockchain to streamline land-related transactions, reducing costs associated with paperwork, intermediaries, and administrative inefficiencies.

"AGRIFIN Mercy Corps" focused on leveraging blockchain to enhance financial inclusion in agriculture, reducing costs associated with traditional financial intermediaries and improving access to financial services for smallholder farmers.

"Os City" and "Statwig" projects harnessed blockchain to improve supply chain management and data authenticity, reducing costs related to fraud, counterfeiting, and inefficiencies in the supply chain.

6. Improved Security & Privacy

Five pilots, including "Support the Humanitarian crisis in Venezuela," "Protecting land rights forest in Ghana," "Improving Land Records in Karnataka through Blockchain," "Glo," and "Stellar," demonstrated the value-add of improved security and privacy through the use of blockchain technology.

These pilots recognized the significance of blockchain in enhancing security and privacy aspects. By leveraging the decentralised and tamper-resistant nature of blockchain, they addressed security concerns and protected sensitive information, such as personal data of individuals involved. The adoption of blockchain technology in these pilots showcased its potential in ensuring secure and private transactions in diverse contexts.

The use of blockchain technology provided a robust security framework by linking transactions with cryptographic hashes and creating an immutable and transparent record. This increased the trust and integrity of the data, mitigating the risks of data tampering, unauthorised access, and fraud. Furthermore, as no single entity had control over the data, the blockchain enhanced the privacy and data ownership for individuals and organisations involved.

By prioritising improved security and privacy, these pilots demonstrated a commitment to safeguarding sensitive information and maintaining the confidentiality and integrity of transactions.

7. Immutability

The value-add of immutability was observed in several pilots, including "Blockchain Certified Digital Payments for Miners," "Stellar," and "Xcapit."

These pilots recognized the importance of immutability in mitigating risks associated with corruption and fraudulent activities. By leveraging the immutability of blockchain technology, they established transparent and tamper-proof record-keeping systems, ensuring the integrity and reliability of their transactions.

In the case of the Land Titling pilots, immutability played a crucial role in creating a secure and transparent system for recording land titles. This significantly reduced the potential for fraudulent activities and corruption, as the records could not be altered without detection.

The Aid Coordination pilots also benefited from immutability by maintaining unalterable records. This made their transactions and activities "audit ready," ensuring transparency and accountability in the distribution of aid.

8. Tokenization

Despite the pilots manifesting an interest, tokenization rarely fell within the first four most important value adds. Nonetheless, the value-add of tokenization was evident in Glo and Stellar and in two specific Frontier Tech Hub projects: Protecting land rights forest in Ghana and Improving Land Records in Karnataka through Blockchain.

The Protecting land rights forest in Ghana project, showcased the transformative potential of tokenization. By leveraging tokens, this initiative created a unique opportunity for participants to establish rights and access the global carbon market. This breakthrough allowed individuals and communities to tap into a previously inaccessible market, enabling them to unlock new economic possibilities and potential benefits.

Similarly, the Improving Land Records in Karnataka through Blockchain project utilised tokens to enhance land record management. Through tokenization, this pilot aimed to streamline the process of recording and verifying land ownership, making it more efficient, transparent, and resistant to tampering. By representing land rights through tokens, the project sought to establish a secure and immutable system that could facilitate seamless property transactions and reduce disputes.

9. Improved Individual Control of Data

None of the projects included in the study were explicitly evaluated with the value-add of "Improved Individual Control of Data" as one of the top three priorities. However, while this specific value-add was not a primary objective for many pilots, several projects in the categories of Land Titling, Aid Coordination, and Digital Payments did focus on empowering individuals with better control over their assets.

Although individual control of data was not explicitly highlighted, it is important to note that blockchain technology inherently provides individuals with greater control over their assets. These pilots aimed to create systems that enable individuals to have direct ownership and control over their digital assets, such as land rights, financial transactions, and aid distribution.

While the focus of individual control of data was not explicitly stated, it is crucial to recognize that blockchain's decentralised and immutable nature allows individuals to have a higher degree of control and ownership over their digital assets. This expanded perspective of individual control encompasses a wider range of use cases and potential advantages beyond just identity data, making it a valuable aspect to consider in the evaluation and implementation of blockchain solutions.

10. Ethical Considerations, Sustainability & Accountability

Although the value-add of Ethical Sustainability & Accountability was not specifically highlighted in the pilot projects, despite being mentioned during the KIIs. Several pilots, including Statwig, Rahat, Xcapit, De-duplicating aid in Nigeria, and Blockchain Certified Digital Payments for Miners, recognized the significance of incorporating real-time feedback mechanisms in their initiatives.

These pilots acknowledged the need for continuous improvement and the identification of potential issues or bugs through real-time feedback from users. By actively collecting feedback, they aimed to enhance the user experience and address any concerns promptly, ensuring the ethical and sustainable operation of their platforms.

Furthermore, the KIIs emphasised the importance of protecting individuals and promoting transparency in the initiatives. By sharing information about the projects and encouraging participation, the pilots aimed to establish a sense of accountability. They recognized that involving stakeholders and ensuring transparency fosters trust and increases the overall effectiveness of their initiatives.

Trust as the primary goal: Trust is exceptionally difficult to measure[20] and yet there is compelling evidence that it is the top value-add from using a blockchain.[21] The results of the document review and KII's found that Trust was also the overall goal for using a blockchain within the applications assessed in the study. Many respondents noted other value-add dimensions as the primary reasons for using a blockchain (security, cost savings, etc.) because they addressed the root causes of their problem of interest. However, the underlying cause of addressing these root issues was to establish the necessary conditions for fostering trust among participants. Trust was essential for facilitating interactions, whether it involved exchanging financial data, engaging in supply chain operations, or any other form of transaction. This could mean that:

- Trust problems were the primary area where participants envisioned blockchain could add value, but other value-add dimensions were the tools used to achieve the desired level of trust
- Trust was often a nebulous objective that was loosely defined, where the other value-add dimensions had more clarity and better operational definitions.

These findings are in line with other development/humanitarian guidance on using a blockchain as a primary tool for fostering Trust.[22] They highlight opportunities for the development of tools that can facilitate the diagnosis of trust-related problems, improve pilot design, and enhance assumption testing and risk management for scaling trust solutions. Given that trust is a behavioural concept, there is potential to integrate evidence and methods from behavioural science into these tools to enhance their utility and effectiveness. Further discussion on this topic is provided in the Conclusions section.

Interdependency of value-add dimensions: The qualitative analysis, survey results, and KIIs consistently revealed that multiple value-add dimensions were relevant for each other, forming a complex network of relationships. For example, security can be achieved through the combined effects of decentralisation and immutability. Similarly, reduced management costs can be a result of faster transaction speeds enabled by blockchain technology.

Correlation: The survey results revealed a correlation between various value adds, as was the case between Speed and Cost savings. This correlation suggests that an increase in speed is often associated with cost savings in blockchain-based solutions. However, this correlation does not imply a direct causal relationship between the two dimensions. It simply indicates that there is a tendency for projects that prioritise speed to also experience cost savings, and vice versa.

The interdependency and correlation of value-add dimensions underscore the complexity and interconnected nature of blockchain technology. While certain dimensions may exhibit stronger relationships, it is crucial to consider all dimensions collectively for effective blockchain solution design and implementation. This can help organisations maximise the value potential of blockchain technology and achieve their desired objectives.

Context-specific prioritisation: Highlighting the theme of context-specific prioritisation within blockchain applications, certain pilots, despite their varied objectives, shared common prioritised value-add dimensions. For example, the Deduplicating Aid and High-Tech Solution for Supply Chain pilots had similar problem statements and objectives related to building trust among actors. Despite their differences, they shared the same prioritised value-add dimensions (Visibility/ Traceability, Speed and Reduced Cost) as the AGRIFIN pilot, which had different objectives. This highlights the context-specific nature of value-add prioritisation.

Smart contracts as a value-add multiplier: Many of the value-add dimensions are magnified when using smart contracts, particularly in terms of reduced costs and increased speed. Out of the six pilots covered in the electronic survey, three utilised smart contracts: Glo Dollar, Blockchain technology for addressing humanitarian aid duplication and Xcapit. For Glo Dollar the smart contract is the core of the project. For De-duplicating aid Nigeria utilised smart contracts to log beneficiary registrations and validate duplicate humanitarian aid, illustrating the use of blockchain and smart contracts for enhancing accountability and preventing fraud in humanitarian contexts. Xcapit employed a smart contract as an escrow to function as a self-executable guarantee for borrowers who lack sufficient credit scores against lenders.

Smart contract rigidity: Smart contracts have the potential to enhance cost savings and speed in various applications by eliminating resource-intensive tasks. However, their deterministic nature creates limitations in managing complex and unpredictable transactions. Smart contracts are best suited for simpler transactions with elevated levels of certainty, such as supply chain operations. Until there are advancements in smart contract capabilities for handling complexity, it is advisable to focus their use on transactions with greater certainty.

Data integrity risks: The immutability of blockchain poses a potential challenge known as "Garbage In, Garbage Out." When inaccurate or unreliable data is entered into the blockchain, it becomes permanently recorded, leading to negative cascading effects. This risk is particularly pronounced in applications involving vulnerable individuals, such as when personal assets like land titles are registered on the blockchain or when these risks affect those below the poverty line. At-risk populations often have limited resources or capacities to recover from the adverse effects of data breaches or manipulation. Inaccurate, altered, or improperly accessed data can lead to misinformation, identity theft, discrimination, and other forms of exploitation.

Furthermore, these individuals often rely heavily on the services provided by entities that handle their data. Any compromise to data integrity can disrupt these vital services, worsening their already precarious circumstances. To mitigate this risk, effective protocols for protecting personally identifiable information (PII) should be implemented. Surprisingly, none of the pilots included in this study had structured data management protocols in place to address this risk. Thus, there is a pressing need to develop guidance, protocols, and tools to ensure data integrity and accuracy in blockchain applications. By incorporating data management protocols as a value-add dimension, practitioners can enhance the overall effectiveness and reliability of blockchain solutions.

Ethics in blockchain: Despite the strong emphasis on ethics in international development and humanitarian work, the pilots under review rarely highlighted ethical considerations in their blockchain initiatives as their main priority. This is concerning given the sector's involvement with vulnerable populations and the profound impact of these decisions. The apparent prioritisation of operational efficiency and innovation over ethical considerations is worrisome, signalling a potential systemic issue within the sector.

4.2 Study Question 2: Pre-conditions and/or approaches that test and scale blockchain solutions and deliver value.

Similarly, to Study Question 1, a specific framework was built to answer Study Question 2. The Enabling Factor Framework measures the contribution of different enabling factors on the overall design, management, and success of the various pilots. The factors were structured into various dimensions and subdimensions based on a literature review that examined the most crucial factors in humanitarian/development activities and the highest risk factors associated with blockchain usage.[23]

Using the framework to guide the qualitative analysis of document review materials, KII transcripts and the literature review resulted in identifying lessons around key risks/assumptions. Frontier Tech Hub employs a Lean Impact approach where pilots are matured through assumptions testing organised into Sprints that iteratively test the most critical assumption for the relevant stage of scale.[24] The underlying hypothesis was that the extent to which a pilot accounted for and integrated these factors into its design and management would

positively influence its ability to sustain the benefits (i.e., the value-add) derived from using a blockchain. In other words, the more effectively the pilot addressed these factors, the greater its potential to benefit from blockchain implementation.

As was the case with the findings of Study Question 1, Study Question 2 also faces some methodological limitations. The scoring criteria for the subdimensions were refined throughout the study, but there may still be some redundancy in the criteria. Additionally, the framework served as a qualitative code book for analysing KII transcripts, document reviews, and other data sources. Therefore, while the results are presented as statistical calculations, it is essential to recognize that the scoring criteria were subjectively applied to several types of data. Despite these limitations, several key findings are supported by the available evidence, providing insights into the effectiveness and impact of the pilot projects.

Having said this, the Enabling Factor Framework consists of three dimensions: Social Problem, Blockchain Design Assessment, and Token Diagnosis, each containing specific subdimensions/assessments and considerations (see Annex 9.5).

Table 6: Dimensions and sub-dimensions of the Enabling Factor Framework

DIMENSION	Sub-dimension	Description
Social Impact	Theory of Change and Outcome Assessment Needs assessment. Target population analysis Community Impact Accountability	In this dimension, the tool helps practitioners define and understand the social problem being addressed, propose blockchain solutions, identify assumptions and risks linked to the ToC, establish indicators of success, evaluate the scope of the problem and existing gaps, analyse the target population's characteristics and vulnerabilities, assess accessibility, and determine the direct and indirect benefits of the initiative, including economic, social, and environmental impacts.
Blockchain Design Assessment	Outlining the type of blockchain Assumptions/Risks	This dimension plays a crucial role in evaluating the type of blockchain being used, the consensus mechanism employed, interoperability with other systems, and scalability. It also examines key assumptions and risks related to spoilers, data privacy, regulatory compliance, data control, interoperability, and participant awareness. By addressing these critical factors, the Blockchain Design Assessment dimension ensures that the blockchain solution is designed and implemented effectively, considering technical considerations, regulatory requirements, and potential challenges. This dimension's significance underscores the importance of thorough and comprehensive assessment when deploying blockchain initiatives, enabling practitioners to make informed decisions and optimise the design and implementation of their blockchain solutions.
Token Diagnosis	Type of token	This dimension focuses on the type of token being utilised, its classification (e.g., utility, security, payment), token standards compatibility with existing infrastructure, and the process of token issuance and distribution. It considers the implications of token classification for regulatory compliance and use cases, the selection of appropriate token standards, and the impact of token issuance and distribution on accessibility and adoption.

Social Impact

For the first dimension on Social Impact the analysis (see Annex 9.6 Enabling Factor Framework Calculations) reveals that the Theory of Change and Outcome Assessment are the strongest aspects. However, there are several areas that require improvement to maximise the positive social impact of the blockchain initiatives. Stakeholder involvement emerged as a consistent concern in all KIs, highlighting its importance as both a priority and a barrier to progress in the pilots. It is crucial to address this issue and prioritise efforts in defining indicators of success, assessing assumptions and risks, conducting comprehensive gap analysis, evaluating vulnerabilities, promoting social cohesion, addressing environmental impact, enhancing capacity-building, and strengthening reporting, inclusivity, and evaluation processes. By actively involving stakeholders, these areas can be effectively addressed.

Blockchain Design Assessment

The analysis of the data from the Blockchain Design Assessment Dimension (the second dimension) reveals that most pilots tend to use permissioned blockchains developed on top of Ethereum or are private blockchains (meaning the blockchain was created specifically for the pilot). Permissioned chains are often used in these pilots given the low levels of digital literacy (especially around the safeguarding of private keys) amongst ecosystem actors, the need to implement solutions quickly, or to ensure compliance with donor requirements. Building on Ethereum offers many advantages given the scope of open-source code and access to technical solutions within the Ethereum ecosystem over many other Layer 1 chains. A takeaway from this is that it could be that more centralised and permissioned protocols are needed during initial pilot testing, but higher levels of decentralisation could be built into the scale up pathway planning for pilots as appropriate.

In relation to the category assumptions and risks within the same dimension, the pilots demonstrated a moderate level of achievement in these areas, indicating the need for further development and refinement. Specifically, the initiatives showed partial compliance with the standards for blockchain type, consensus mechanism, interoperability, spoilers, regulatory compliance, data control, and participant awareness. Data privacy received a lower score, suggesting the need for increased attention in protecting sensitive information. These findings highlight the importance of addressing these areas to enhance the effectiveness and sustainability of blockchain initiatives.

More specifically, the data and analysis on the Risk & Assumption Sub-dimension allowed us to identify the following blockchain specific assumptions/risks:

- *Spoilers*: Resistance from disintermediated third parties or other entities who may be disincentivized from using blockchain technology.
- *Data Privacy*: PII or other sensitive information not being protected or individuals not having adequate permissions over their own data.
- *Regulation*: The risk of violating local, regional, or national regulations.
- *Data Contro*l: Data management rights and permissions not adequately defined and managed.

- *Interoperability*: The lack of ability of the blockchain to be integrated into legacy social and technological systems.
- *Participant Awareness*: The level of awareness, technical knowledge and other capacity needed amongst different actors to enable them to buy into the blockchain solution.

The assumptions/risks were identified through a combination of a literature review[25] and emerging results from qualitative analysis conducted during the study. These assumptions were then tested by reviewing the sprint reports of the Frontier Tech Hub pilots to determine if the assumptions tested during relevant pilot sprints aligned with the general risk areas outlined above. We included "other" category as a catchall for sprint assumptions that did not fit in the predetermined risk area and captured our results in Table 7.

Table 7: Assumption Areas for Pilot Sprints

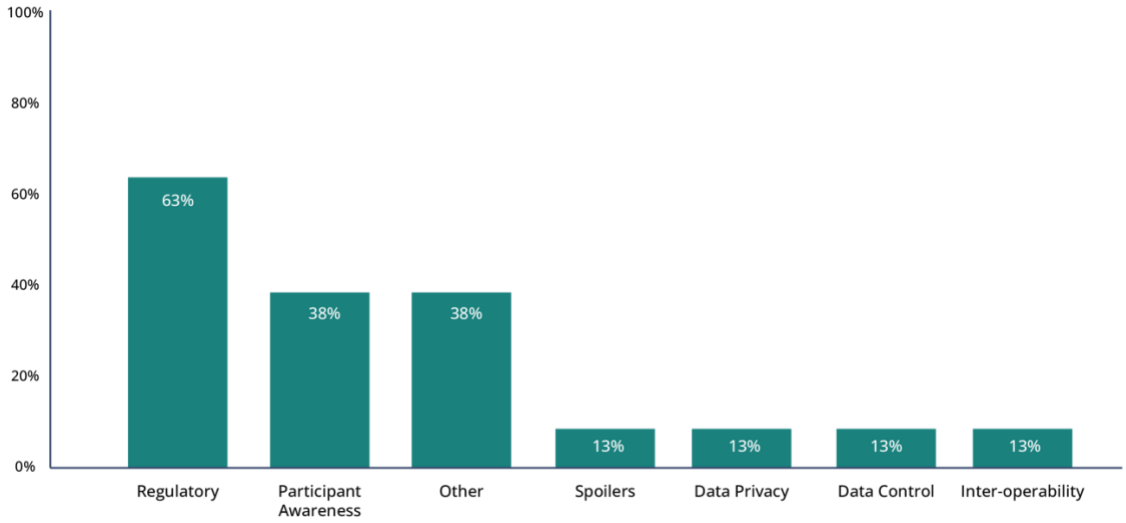
Pilot	Blockchain Specific Risk Factors						
	Spoilers	Data Privacy	Regulatory	Data Control	Interoperability	Participant Awareness	Other
Tracking UKAid Payments		✓	✓			✓	
High Tech Supply Chain/ Distribution			✓			✓	
Blockchain in Humanitarian Supply Chain							✓
Certified Digital Payments for Miners							✓
Karnataka Land Titling			✓		✓		
Humanitarian Response in Venezuela			✓				✓
De-duplicating Aid	✓		✓	✓		✓	
Ghana Land Rights	No sprint materials available						

The results from the assumption areas for the Pilot Sprints in the Frontier Tech Hub projects can be summarised as follows, as depicted in Graphic 3:

- Regulatory (63%): This factor was identified as a significant risk for the pilots "Tracking UKAid Payments," "High Tech Supply Chain/Distribution," "Karnataka Land Titling," "Humanitarian Response in Venezuela," and "De-duplicating Aid." It suggests that these pilots need to carefully navigate and comply with relevant regulations and legal requirements associated with blockchain implementation.
- Participant Awareness (38%): This factor was highlighted as a risk for the pilots "Tracking UKAid Payments," "High Tech Supply Chain/Distribution," and "De-duplicating Aid." It implies that these initiatives may require efforts to increase awareness and understanding among different actors involved in the pilot, such as implementers and users, to effectively achieve their objectives.

- Other (38%): This category includes the pilots "Blockchain in Humanitarian Supply Chain," "Certified Digital Payments for Miners," and "Humanitarian Response in Venezuela." While not specified, it suggests that there may be additional risks or challenges specific to these pilots that require attention or mitigation measures.
- The rest of the identified risk factors - spoilers, data privacy, data control, and interoperability - each emerged at a relatively low frequency, each accounting for only 13% of the total risks in blockchain initiatives. The "De-duplicating Aid" pilot exposed risks related to spoilers and data control, while data privacy was a concern in the "Tracking UKAid Payments" pilot. The "Karnataka Land Titling" pilot revealed interoperability as a potential challenge.

Graphic 3: Risk specific factor compiled results



The findings from this study reflect a common trend. Most pilots preferred to utilise permissioned blockchains built on top of Ethereum or private blockchains specifically designed for the pilot. Permissioned chains are preferred due to reasons such as the limited digital literacy among ecosystem actors, the need for quick solution implementation, or compliance with donor requirements. Leveraging Ethereum provides numerous advantages, including access to a vast array of open-source code and technical solutions within the Ethereum ecosystem compared to other Layer 1 chains.

It is noteworthy that while more centralised and permissioned protocols may be suitable for initial pilot testing, there is a potential to incorporate higher levels of decentralisation into the pathway planning for pilot scaling, as deemed appropriate.

Based on the aforementioned insights and observations, several key recommendations emerge for the successful implementation and management of blockchain technology in the international humanitarian and development sector.

Token Dimension

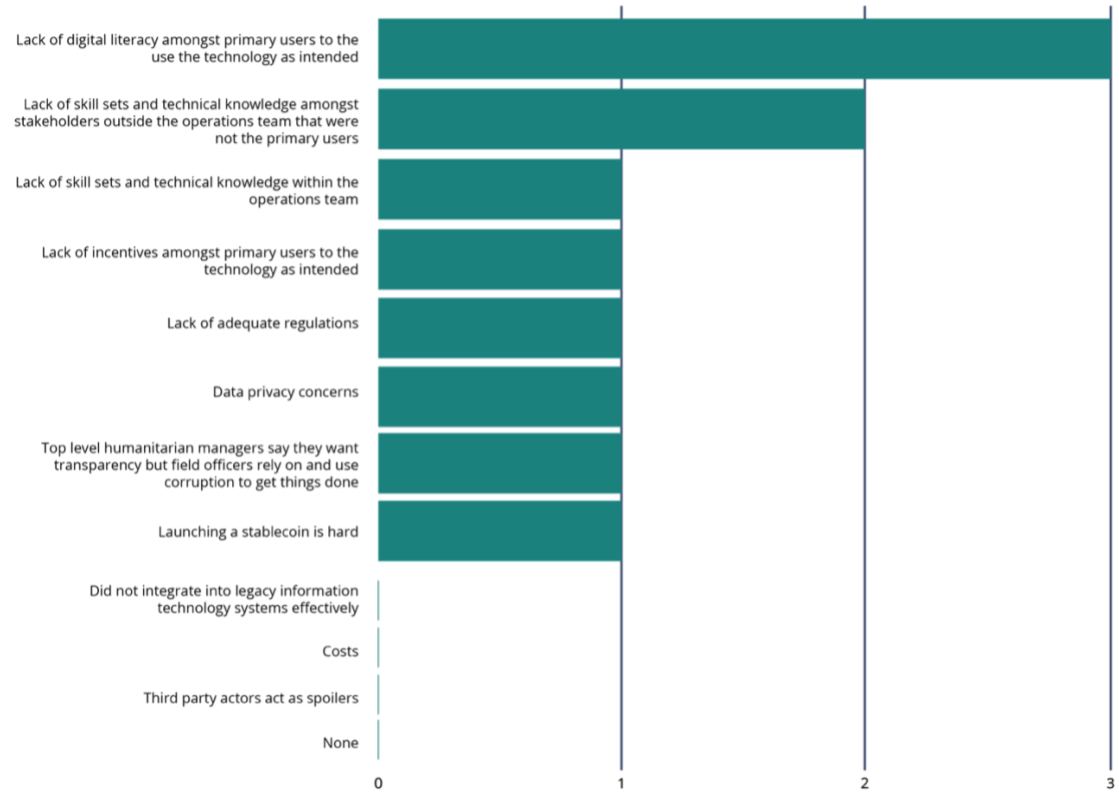
Our analysis of the 'Type of Token' data (the third dimension) suggests a need for enhancement in token classification, standards, and issuance and distribution processes. Observations from the pilot programs revealed a modest level of compliance in these areas, indicating areas for growth and refinement. Interestingly, only a third of the initiatives actively utilised tokens, signifying untapped potential for broader token application within blockchain initiatives, as discussed in Study Question 1.

An ultimate point, which impacts all three dimensions of the Enabling Factor Framework are the barriers that hinder the progress or implementation of a blockchain project. These can be organisational, technological, regulatory, or social in nature and can impede the adoption and scalability of blockchain solutions.[26]

These have been prominently acknowledged in the KIIs and the surveys. Survey respondents ranked their primary barriers to success as outlined in Graphic 4. They identified several barriers that could potentially hinder the successful implementation of blockchain initiatives. Lack of digital literacy among primary users and stakeholders, along with a lack of technical knowledge and skill sets, were mentioned as significant challenges.

This highlights the importance of providing adequate training and support to ensure users can effectively utilise the technology. The respondents also noted concerns regarding data privacy, the need for adequate regulations, and the existence of corruption in certain operational contexts. These findings emphasise the need for strong governance frameworks and transparent processes to address these issues.

Graphic 4: Barriers (Survey Results)



The assessment of the assumption areas for the pilot sprints in the Frontier Tech Hub projects, along with the identification of barriers by the survey respondents, sheds light on the critical factors that can impact the success of blockchain initiatives. It is evident that regulatory compliance, participant awareness, and other specific risks play significant roles in the implementation and adoption of blockchain technology. These findings highlight the importance of navigating regulatory frameworks,[27] increasing awareness among stakeholders, and addressing potential risks to ensure the effective deployment and scalability of blockchain solutions. By understanding and proactively addressing these factors, practitioners can better strategize and mitigate potential challenges, paving the way for successful blockchain implementations that deliver value and contribute to positive social impact.

From the above analysis, several general conclusions can be drawn. These are derived from the comprehensive examination of the literature review, KIIs and survey data.

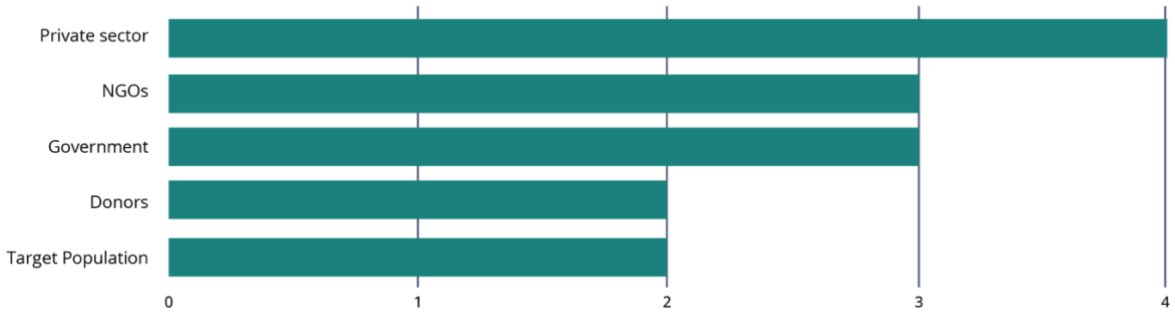
Using a framework. The primary takeaway underscores the importance of a holistic approach to designing blockchain applications, an example of which is the Enabling Factor Framework. Such a methodology offers a comprehensive and structured way to address a variety of factors contributing to success, including technological readiness, stakeholder engagement, regulatory considerations, resource allocation, and risk management. Using a framework like this, stakeholders can systematically identify, assess, and address critical elements, helping to align efforts, make informed decisions, and effectively allocate resources, thus maximising the

potential of blockchain technology and increasing the likelihood of achieving desired outcomes. Indeed, nine pilots reported significant difficulty in identifying their critical risks/assumptions and developing tests for them during the sprints. But there was a consensus that testing assumptions in the sprints was a critical component for their success. A possible explanation for this difficulty could be the lack of technical knowledge of blockchain technology by Frontier Tech Hub pilot coaches and implementing partners.

Improving the integration of blockchain technology into legacy technology and social systems: The ease of integrating blockchain technology with existing legacy information technology systems varied amongst the pilots. Two of the six pilots that completed the survey reported a smooth integration process requiring minimal effort. One pilot faced significant challenges during integration, requiring substantial modifications or workarounds. De-duplicating Aid in Nigeria and Improving Land Records in Karnataka through Blockchain both used the chain precisely because it was easier to integrate into legacy systems (meaning it had minimal requirements for pre-existing data management systems which makes the uptake onto the chain easier).

The process of integrating blockchain technology into existing social systems, such as economic and political structures, necessitates active engagement with stakeholders, as demonstrated in Graphic 4. The graphic presented below illustrates the frequency with which each stakeholder was selected in response to a multiple-choice question, providing insight into the extent of stakeholder involvement.

Graphic 5: Key stakeholder involvement (Survey Results)



No Such Thing as Plug and Play: The consensus among the study participants was that there are no "low hanging fruit" or "plug and play solutions" when it comes to blockchain implementation. While there may be "simpler" applications that require less effort and oversight, they still demand a significant amount of due diligence to ensure success. It is important to recognize that successful blockchain solutions, even if relatively straightforward, still necessitate careful consideration and thorough implementation strategies to achieve desired outcomes. Additionally, solutions that involve higher levels of participant awareness or have the potential to disrupt established third parties tend to require more significant behaviour change efforts and, consequently, more complex, and resource-intensive pilot projects. In other words, it appears that solutions with disruptive impacts on existing dynamics demand extensive engagement and

adaptation from stakeholders. Conversely, solutions with lower levels of disruption encounter fewer challenges in replacing governance structures and aligning complex incentives behind a defined solution. This observation underscores the importance of considering the degree of disruption and stakeholder engagement when implementing blockchain solutions to maximise their effectiveness and success.

The Success of Blockchain Lies in the Absence of Intermediaries: The inherent risk of spoilers in blockchain applications is considerable, mainly due to the technology's ability to eliminate third-party functions. This capability potentially provokes these intermediaries to resist the technology's adoption to preserve their roles. In the context of Frontier Tech Hub pilots, spoiler actions encompassed bureaucratic agents who passively allowed potential solutions to "die on the vine." This involved not actively supporting the efforts and simply letting them wither away on their own, as was observed in the case of Karnataka.

Among the six blockchain pilots who answered the survey , four reported that implementing blockchain technology either reduced their reliance on or completely eliminated the need for third-party intermediaries. One pilot noted that the adoption of blockchain did not significantly impact their reliance on third-party intermediaries. This could indicate that the pilot's design or objectives did not focus on eliminating intermediaries or that the potential for disintermediation was not fully realised in this particular case. The only pilot that reported no impact on third parties was Fujitsu Track and Trust, a service provider that provides validation services across production, supply, distribution, and sales networks.

Blockchain seems to thrive most in environments devoid of institutions, implying that blockchain applications which pose less threat to the status quo of these third-party intermediaries are simpler to implement and achieve success. This is, unsurprisingly, particularly true when no intermediaries offer services similar to those envisioned through blockchain. This situation often exists in underdeveloped regions where there is a significant absence of third-party service providers like banks.

Creating Partnerships and Engaging the Ecosystem: The pilot survey and KIIs revealed that identifying relevant ecosystem stakeholders and developing engagement strategies was a challenge. This problem hindered the ability to test assumptions for scaling blockchain solutions. Building alliances among governments, private entities, and NGOs can boost blockchain adoption by driving innovation, developing new use cases, and overcoming regulatory and operational challenges. Such collaboration can create a conducive environment for blockchain implementation, address stakeholders' needs, and reduce resistance.

A case in point is the 'Blockchain Certified Digital Payments for Miners' initiative. In Rwanda, the project was swiftly implemented due to the pre-existing knowledge of blockchain technology among key partners, as revealed during the KII. However, in the Democratic Republic of Congo, the project faced significant hurdles due to a deficiency of blockchain knowledge among essential stakeholders (financial institutions and local partners). The KII revealed that a substantial amount of time and effort were expended in explaining the technology and its

potential benefits, underscoring the necessity for a well-articulated and pedagogical communication plan. Despite their best efforts, the project was subsequently relocated to Burkina Faso.

The 'De-duplicating Aid Nigeria Support' project, led by GeniusTags, faced significant hurdles, primarily due to limited blockchain understanding among local stakeholders and logistical challenges of integrating blockchain into established organisations. These hurdles necessitated comprehensive bureaucratic processes involving regional and international offices in Europe and the United States. To ease the transition, it was suggested that incentives be provided for local teams. However, GeniusTags found success with their 'De-duplicating Aid' project in Syria, largely due to the full support of key institutions like MercyCorps and other leading agencies that had not been present during their Nigerian operations. For the pilot, this underlines the critical role of strategic partnerships in successful on-the-ground implementation.

Blockchain's decentralisation, security, and transparency make stakeholder engagement crucial. The understanding and acceptance of these features among key actors significantly impact the speed and ease of implementation. Blockchain operates on a distributed ledger requiring the consensus of all participants, which makes a comprehensive communication plan vital. Knowledge gaps can pose significant barriers, and blockchain's disruptive potential often necessitates supportive environments and incentives. These strategies are particularly crucial for blockchain's successful implementation given its unique demands.

Education and User experience as key factors: The research findings from survey responses and KIIs highlight the critical role of comprehensive educational initiatives in promoting understanding and acceptance of blockchain technology among diverse stakeholders. By investing in educational programs, organisations can bridge knowledge gaps and increase awareness, enabling stakeholders to make an effective use of the solution and thus increase adoption. Additionally, prioritising the development of a straightforward and intuitive user interface is paramount. A user-friendly design enhances usability and minimises the learning curve, ultimately increasing the adoption and success of blockchain-based solutions. By ensuring that the user experience is intuitive and accessible, organisations can overcome barriers to adoption and maximise the benefits offered by blockchain technology.

Lack of Familiarity from the Pilots Using Blockchain: The enabling factors from the Assessment Framework that have to do with traditional humanitarian or development activity design and management (the Social Problem dimensions) generally scored higher than those particular to the other two dimensions, which are more specific to using a blockchain. This finding makes sense given there is little experience, evidence, or tools to help select, design, and implement blockchain solutions for humanitarian and development purposes.

This finding is further reinforced by the higher score on the Blockchain and Token Design dimensions by actors from the Web3 space, GLO and Stellar, as opposed to those from the more traditional development space (Frontier Tech Hub and Mercy Corps). The study observed that the level of technical blockchain knowledge was higher with GLO and Stellar than with the other

pilots included in the study and so it is logical to assume that this knowledge resulted in more attention paid to blockchain and token selection, design, and management.

More specifically, Frontier Tech Hub pilots primarily used developers with experience coding blockchains while the Web3 actors like Glo and Stellar sometimes used more advanced technical skill sets like token engineering). During the Frontier Tech Hub pilots, it was common for the actors involved to lack the necessary access to blockchain-specific knowledge as new needs arose throughout the course of their pilot initiatives. In the web 3.0 ecosystem, actors commonly rely on their professional networks, platforms like GitHub, Discord, and other blockchain-specific sources to seek answers to their queries. Indeed, pilot actors associated with the Frontier Tech Hub often lacked prior knowledge of the existence of these resources or how to effectively navigate them. This knowledge gap created a disparity in accessing and leveraging the available resources, potentially hindering the ability of Frontier Tech Hub pilot actors to obtain timely and relevant information within the blockchain space. Bridging this gap and providing necessary guidance and support in utilising these resources could significantly enhance the effectiveness and efficiency of Frontier Tech Hub pilot initiatives.

Key Lessons from Respondents: Survey respondents identified five key takeaways worth mentioning when designing and implementing a blockchain pilot:

- *Expect Delays and Cost Overruns*: Blockchain initiatives, like any tech-based project, can encounter delays and unexpected costs. Therefore, integrating flexibility into your schedule and budget is crucial to adapt to these unexpected obstacles.
- *Maintain Focus*: Instead of attempting to transform every component of the system simultaneously, it is advisable to concentrate on a specific problem area and aim for excellence in that domain. This approach can result in a more manageable and successful project. For example, over the span of five years working in the web3 domain, Xcapit experienced a paradigm shift in their approach. Initially, they were heavily invested in the field's technological facets, creating complex tools driven by this emergent technology. However, they found that these tools frequently did not align with or address substantial, existing issues that demanded solutions. This realisation spurred a shift in their mindset. The respondent started prioritising pressing problems that people were grappling with, rather than being solely consumed by the technology itself.
- *Engage and Educate Stakeholders:* Identifying and engaging stakeholders who can drive project adoption is crucial. Further, educating key teams such as legal and finance about blockchain early in the project can facilitate smoother integration. Demonstrating the practical application of blockchain can often be more effective than trying to explain the technical intricacies.
- *Thorough Understanding of the Problem:* A deep comprehension of the problems we are trying to address is essential. Validating and testing the solution with those most impacted by these problems is equally important. Starting with niche problems and refining solutions based on feedback can lead to more effective results.

- *Education and User Experience: Widespread education on the topic of blockchain can help promote understanding and acceptance of the technology. Additionally, investing in creating a simple and seamless user experience can significantly increase the adoption and success of the blockchain solution.*

Additional Factors for Success: While it may sound obvious, the pilots underscored the importance of persistence as a key factor for success in blockchain projects. This highlights the significance of overcoming challenges and maintaining commitment to the project's goals. Additionally, the presence of strong advocates within organisations and credible legal and security teams played a pivotal role in reassuring potential users about data privacy and regulatory concerns. This, in turn, facilitated the adoption and utilisation of the blockchain solution. Other successful projects attributed their achievements to factors such as aligning incentives and cultivating knowledge among stakeholders about the value-adds associated with blockchain utilisation.

Finally, blockchain technology should not be used for the sake of using innovative tech. It should provide clear, substantial advantages over existing solutions. If the blockchain solution in question does not enhance efficiency, transparency, or security (or any other key metric relevant to the specific application) to a degree that justifies its implementation and maintenance costs, then it may indeed fail to provide sufficient value. Therefore, before starting a blockchain pilot, a thorough cost-benefit analysis and comparison with other technologies should be carried out.

Evidence from sector applications: Literature review

This section relies on the insights gathered from a comprehensive literature review that explores the application of blockchain technology in three key areas: **Supply Chains, Decentralised Funding, and Land Rights**. While the primary focus of the review is on the implications and potential of blockchain in development and humanitarian contexts, relevant evidence from commercial sectors has also been included to provide a balanced and comprehensive understanding.

The purpose of this literature review was to contrast the findings of the two study questions using external evidence and identifying correlations between this external evidence and this study's findings. Each of the three key areas is organised in the same manner. First it looks at Study Question 1 (the value adds) and Study Question 2 (the enabling factors) and then presents considerations for Future Applications.

Blockchain technology is being increasingly explored for its potential to enhance transparency, traceability, and efficiency in supply chain management. In the context of humanitarian settings, where the effective delivery of essential goods and services is crucial, blockchain can provide a decentralised and secure platform for tracking and verifying the authenticity of goods, as well as facilitating coordination among multiple stakeholders.

By leveraging blockchain technology, humanitarian organisations can overcome challenges such as counterfeiting, lack of visibility, and inadequate accountability in supply chains, leading to more effective and accountable humanitarian interventions.

5.1.1 Study Question 1: Evidence around the value-add of blockchain-based solutions

The extant literature suggests significant potential for blockchain-based solutions to add value in the context of international development and humanitarian use cases. A broad collection of articles and reports attest to the salutary impact of blockchain technology on various facets of supply chains. According to both the World Economic Forum.[28] (WEF) and Harvard Business Review[29]Blockchain applications can augment supply chain transparency, traceability, fraud reduction, corruption prevention, and overall efficiency.

Emerald delineates multiple impetuses for blockchain adoption within humanitarian supply chains, including enhanced accountability, visibility, traceability, trust, collaboration, and time efficiency. While barriers such as stakeholder engagement issues, technical skill gaps, resource constraints, and regulatory challenges remain, case studies substantiate the potential value of blockchain in promoting visibility, traceability, and trust.[30]

Moreover, reports by GSMA[31] and Etemadi & Kumar[32] underscore the potential of blockchain to improve transparency, accountability, cost-effectiveness, and efficiency within supply chains, particularly those involving humanitarian aid and sustainability. Studies by CSIS[33], Kaur and Singh[34], Kshetri[35], and Saeednia and Zarei[36] corroborate these findings, suggesting that blockchain can indeed augment transparency and accountability in humanitarian supply chains and enhance the efficiency and effectiveness of humanitarian operations.

Several practical instances demonstrate the potential value-add of blockchain technology. The United Nations World Food Programme (WFP)[37], for instance, deployed a blockchain-based system called "Building Blocks" in refugee camps in Jordan, managing and tracking the disbursement of cash-for-food aid with the objective of enhancing efficiency, transparency, and security.

The innovative partnership between the Blockchain Charity Foundation and Mercy Corps resulted in the launch of the “Humanity First Token” (BHFT), issued on the BNB Chain.[38] This initiative allowed refugees to receive digital tokens directly, which they could then exchange for essential goods at local vendors, providing a unique solution for refugees who lack the necessary identification to open traditional bank accounts.

Oxfam's Unblocked Cash transfer program in Vanuatu,[39] a blockchain-powered initiative, exemplifies the efficiency of blockchain technology in aid distribution. This program has streamlined the delivery of aid by reducing costs and delivery times while augmenting transparency and accountability.

In Nepal, World Vision International has capitalised on blockchain technology through their Sikka project,[40]distributing digital tokens to beneficiaries via SMS, which can then be exchanged for cash or goods, thus rendering aid distribution more transparent and trackable even in delicate contexts.

The practical examples underscore the potential value-adds of blockchain technology, such as enhanced trust, visibility, traceability, speed, and cost-effectiveness, corroborating findings from the reviewed literature. Blockchain technology facilitates secure tracking, control, and transparent recording of transactions, thereby bolstering trust among stakeholders. The top value-adds identified in the pilots, such as trust, visibility/traceability, speed, and reduced costs, clearly align with the findings from the literature review.[41] Further, the decentralisation inherent to blockchain suggests potential cost-saving advantages. These pilot studies, in conjunction with the literature review, contribute to the broader understanding of the benefits that blockchain-based solutions can confer upon international development and humanitarian supply chains. Future academic inquiries and policy explorations should persist in dissecting specific strategies and implementations to maximise this technology's potential, while simultaneously addressing the identified challenges.

5.1.2 Study Question 2: Pre-conditions and/or approaches that test and scale blockchain solutions, and deliver value

There is extensive literature on preconditions and approaches to testing blockchain solutions in value-chains. In general, the literature agrees that to achieve desirable results, practitioners must consider certain prerequisites and strategies. This includes gaining a comprehensive understanding of the advantages of blockchain technology, integrating resilient organisational procedures, and confirming the user-friendly execution of the technology.[42] Blockchain technology provides secure tracking and management, unchangeability, and the creation of trust amongst participants through an economical IT solution.[43]

Sohail Jabbar et al. emphasise the trials and prospective trajectories of applying blockchain technology in supply chain management.[44] They recognize the substantial difficulty in maintaining the integrity of products and processes in an environment involving multiple stakeholders. Many existing solutions are hampered by fragmented data, unreliable provenance, and diverse protocol regulations spanning numerous distributions and procedures. Blockchain technology is becoming a prominent solution due to its capability of providing secure tracking and control, unchangeability, and the creation of trust amongst participants at a reduced IT cost. To effectively trial and enlarge blockchain solutions in humanitarian supply chain management, practitioners should concentrate on addressing the technical and non-technical trials in blockchain application for supply chain uses. This involves studying the appropriateness of various consensus algorithms for supply chain applications and understanding the tools and technologies in the blockchain ecosystem. By addressing these trials, practitioners can aim to achieve desirable results through the application of blockchain technology in humanitarian supply chain management.

Soumyadeb Chowdhury et al. review the adoption of blockchain technology for managing risks in operations and supply chain management.[45] They state that the impact of blockchain technology implementation on the precision, reliability, visibility, incorruptibility, and promptness of supply chain processes and transactions makes it appealing for enhancing the robustness, transparency, accountability, and decision-making in risk management. In order to

competently trial and enlarge blockchain solutions in humanitarian supply chain management, practitioners need to comprehend the benefits of blockchain technology, integrate resilient organisational procedures, and confirm the user-friendly execution of the technology. The authors' study findings suggest that these factors positively influence the intention to adopt blockchain technology for risk management in operations and supply chain management.

Mehrdokht Pournader et al. present the latest academic and industrial frontiers on the application of blockchain in supply chain, logistics, and transport management.[46] Their systematic literature review identifies four main clusters in the co-citation analysis: Technology, Trust, Trade, and Traceability/Transparency.

Given the consensus among these authors, it is plausible to assert that the Enabling Factor Framework is a valuable instrument for assessing key components needed for successful blockchain implementation in supply chain management, including humanitarian contexts. By assessing and addressing these factors, practitioners can enhance their understanding, navigate challenges, and maximise the potential of blockchain technology in humanitarian supply chain management.

In conclusion, the effective testing and scaling of blockchain solutions in supply chain management, particularly within humanitarian contexts, necessitates a thorough understanding and application of specific pre-conditions and strategies. The KIIs with the pilots that address value chain issues highlight the key value-adds and challenges in implementing blockchain technology.

The top value-adds identified by the pilots were trust, visibility/traceability, speed, and reduced costs. These align with the literature, which emphasises the benefits of blockchain technology in enhancing supply chain transparency, traceability, efficiency, and trust-building among stakeholders. The pilots' focus on leveraging blockchain for secure tracking and control, data immutability, and improved transparency resonates with the literature's findings on addressing data fragmentation, unreliable provenance, and varied protocol regulations in supply chain processes.

The Enabling Factor Framework emphasises the importance of gaining a comprehensive understanding of the advantages of blockchain technology, integrating resilient organisational procedures, and ensuring user-friendly execution. Similarly, the findings highlight the significance of these factors in effectively trialling and scaling blockchain solutions in supply chain management, including in humanitarian contexts.[47] More specifically, the Enabling Factor Framework's dimensions of Social Impact, Blockchain Design Assessment, and Token Diagnosis align with the identified benefits of blockchain technology, such as secure tracking and management, unchangeability, trust-building, and enhanced transparency. The focus on technical and non-technical challenges, consensus algorithms, ecosystem tools, and technology roles also resonates with the articles' emphasis on addressing trials and understanding emerging themes and applications of blockchain in supply chains.

However, challenges exist in the adoption of blockchain technology, both technical and non-technical, as evidenced by the literature. These include the selection of appropriate consensus algorithms, understanding the ecosystem's tools and technologies, and addressing barriers to adoption. The comparison with the pilots suggests that while the value-adds of trust, visibility/traceability, and speed were emphasised, aspects like immutability and decentralisation were less prominent in the pilots.

In conclusion, the literature review reinforces the premise that blockchain-based solutions may improve international development and humanitarian supply chains, enhancing trust, transparency, and efficiency in supply chain management. However, further research is needed to fully understand and unlock the extensive value that blockchain solutions can bring, particularly in terms of their impact on social, economic, and environmental sustainability. It is crucial to strike a balance between realising the potential gains and addressing the associated risks in order to harness the full potential of blockchain technology in international development and humanitarian contexts. These risks should be carefully evaluated and addressed during the deployment of blockchain solutions in international development and humanitarian contexts.[48]

5.1.3 Considerations for future applications

Drawing upon the comprehensive review of the studies presented, which focused on the application of blockchain in supply chains within international development and humanitarian settings, the evidence and conclusions extracted give rise to a number of important recommendations for future applications in these specific contexts:

Deep understanding of blockchain: Practitioners working on supply chains within humanitarian and international development contexts need to develop a comprehensive understanding of blockchain technology. This encompasses recognizing its strengths, limitations, and potential risks, all of which can inform better strategic decisions when considering blockchain-based supply chain solutions.[49]

Issue-specific applications: It is important to use blockchain for supply chain issues that can truly benefit from its inherent features, such as transparency, immutability, and decentralisation. Clear problem statements that can be addressed by blockchain should be identified before moving ahead with these solutions in humanitarian settings.[50]

Inclusive stakeholder engagement: Successful application of blockchain in supply chains necessitates broad stakeholder involvement. The users and other key stakeholders in the humanitarian supply chain should be engaged to provide their insights and feedback, ensuring the solution is tailored to meet the needs of the context.[51]

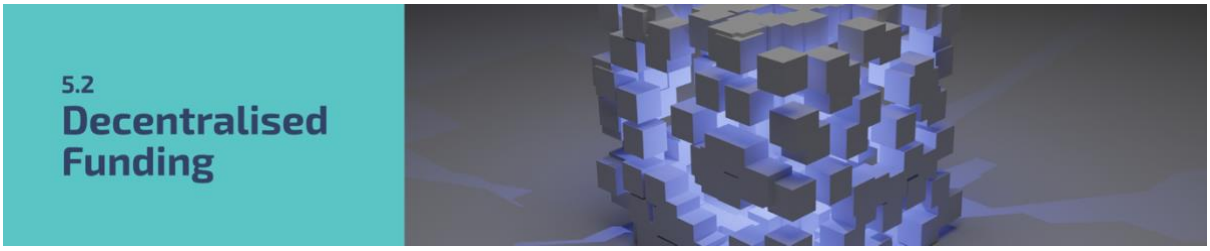
Human rights and equality focus: Humanitarian contexts require special attention to human rights and equality. The design and deployment of blockchain applications in these supply chains should proactively mitigate potential risks that could intensify existing inequalities or create new ones.[52]

Sustainability drive: The design and evaluation of blockchain applications in humanitarian supply chains should contribute positively to social, economic, and environmental sustainability, ensuring their long-term effectiveness and viability.[53] Supporting this notion, when blockchain applications are designed with a holistic sustainability perspective in mind, they can better address complex issues and support the responsible use of resources, all essential for meaningful, long-lasting impact in humanitarian supply chains.

Integration with existing systems: The COVID-19 pandemic has highlighted vulnerabilities in humanitarian supply chains, emphasising the need for resilience. Innovative technologies, including blockchain, can enhance their efficiency. It is crucial for blockchain solutions to seamlessly integrate with existing supply chain systems in these settings.[54] Compatibility and interoperability should be priorities to avoid disruption and facilitate smooth data exchange between different stakeholders.[55]

Investment in research and development: Continued investment in research and development is necessary to uncover the full potential of blockchain technology in humanitarian supply chains. This will result in more efficient, secure, and user-friendly blockchain solutions, while also identifying best practices for implementation in these contexts[56].

In summary, the reviewed literature indicates that the potential of blockchain technology for improving supply chains in international development and humanitarian contexts is significant. However, realising this potential requires a strategic, informed, and inclusive approach, with a focus on addressing real-world issues, fostering inclusivity, ensuring smooth integration with existing systems, and promoting sustainability. Future applications should adhere to these recommendations to effectively deliver value in these specific settings. These findings are in line with this research.



Decentralised funding, powered by blockchain technology, offers a direct and efficient channel for aid funding in humanitarian settings; it is a component of Decentralised Finance (DeFi). It eliminates intermediaries, promotes transparency and accountability, and enhances financial inclusion. By leveraging blockchain, organisations can overcome barriers and ensure funds reach beneficiaries more directly. This transformative approach empowers communities, improves transparency, and enables faster aid distribution.

5.2.1 Study Question 1: Evidence around the value-add of blockchain-based solutions

DeFi, underpinned by blockchain technology, is presenting a new paradigm in international development and humanitarian contexts, including decentralised funding. It offers a unique combination of features - efficiency, transparency, and accountability - that have profound implications for how aid funding is channelled to beneficiaries. Several examples highlight the value-add of blockchain-based solutions in decentralised funding initiatives:

One notable example is the Venezuela pilot conducted by Fundacion S4V. The pilot aimed to stimulate and grow the national and local NGO ecosystem by leveraging blockchain technology to enable Venezuelan diaspora to directly donate cryptocurrencies to local organisations. This direct transfer of funds without intermediaries not only cuts out intermediaries but also enhances transparency and accountability in aid distribution.

Another example is Disberse[57], which developed a financial services platform using blockchain and smart contracts to improve the tracking and distribution of aid funds. By eliminating traditional intermediaries, the platform enables donors to deposit funds and transfer them directly to any other client on the Disberse platform. This approach increases transparency, reduces costs, and ensures that funds reach their intended recipients in a timely manner.

Furthermore, initiatives focusing on cash and voucher assistance have utilised blockchain to empower recipients with greater agency in decision-making. Projects like WFP's Building Blocks[58] and Oxfam's Unblocked Cash Solution[59] have demonstrated the value of blockchain in improving the transparency, efficiency, and traceability of cash transfers, enabling recipients to choose how to redeem their entitlements and reducing delivery time.

Private donations have also been transformed by blockchain-based solutions. For instance, Oxfam's Smart Donations program[60] allows donors to set parameters around the use of their funds, ensuring more control and transparency in the donation process. Similarly, DAOs (Decentralised Autonomous Organizations) such as DAO charity Ukraine and GitCoin enable token holders, including private donors, to vote on funding decisions, fostering a more decentralised and participatory approach to aid funding.

The advantages of decentralised funding through blockchain technology are evident. It offers directness and efficiency by minimising intermediaries, supports transparency and accountability through public ledger records, contributes to financial inclusion by reaching the unbanked, reduces costs by bypassing traditional financial systems, provides a secure foundation for transactions through decentralisation, and empowers local communities by involving them in decision-making processes.[61]

By integrating blockchain technology, the humanitarian sector can harness the transformative potential of decentralised funding, ensuring more effective and impactful aid distribution while reinforcing transparency, efficiency, accessibility, and accountability. These examples illustrate

the tangible benefits of blockchain-based solutions in the context of decentralised funding for international development and humanitarian assistance.[62]

Blockchain technology, as an enabling infrastructure, can play a significant role in promoting financial inclusion. It holds the potential to facilitate decentralised finance (DeFi) projects that aim to reach individuals or communities who are unbanked or underbanked, thereby extending the reach of financial services. It is important to note, however, that the successful implementation of such initiatives also depends on parallel interventions, such as ensuring individuals have the necessary access to and understanding of financial systems. This feature assumes critical significance in the humanitarian sphere, where aid recipients may lack access to conventional financial systems. Hence, while blockchain can significantly contribute to DeFi projects, complementary interventions addressing other societal and infrastructural challenges are required.[63]

The elimination of intermediaries can lead to substantial cost reductions. By bypassing traditional financial systems, blockchain can lower the costs associated with transactions, ensuring that a greater proportion of aid reaches those in need.[64]

Moreover, blockchain technology brings a secure foundation for transactions. Its decentralised structure establishes a system of trust built on cryptographic proof, a boon in unstable regions where conventional banking systems may falter.[65]

Lastly, blockchain fosters the empowerment of local communities. With DAOs, local communities can actively participate in decision-making processes pertaining to fund allocation, fostering a sense of agency and engagement.[66]

In conclusion, blockchain's potential for decentralised funding in humanitarian contexts is transformative. By integrating blockchain technology, the humanitarian sector could more effectively and impactfully distribute aid, reinforcing transparency, efficiency, accessibility, and accountability[67].

5.2.2 Study Question 2: Pre-conditions and/or approaches that test and scale blockchain solutions, and deliver value

The successful deployment of decentralised funding solutions powered by blockchain technology relies on several preconditions and approaches.

One crucial precondition for the success of decentralised funding platforms is regulatory clarity. Establishing clear and progressive regulatory frameworks strikes the right balance between encouraging innovation and protecting investors and users. By providing legal certainty and a favourable environment, these platforms can instil trust and confidence among participants, as exemplified by the regulatory considerations mentioned in the literature review.[68]

Scalability and efficiency are vital factors in ensuring the effectiveness of decentralised funding platforms. Solutions such as Layer-2 protocols and shading enable platforms to handle a significant volume of transactions quickly and cost-effectively. This scalability is essential for

accommodating the growing demand and providing users with seamless experiences. The literature review highlights the multi-layered architecture of DeFi and the importance of different layers working together to create a composable infrastructure.[69]

Security is of utmost importance in safeguarding funds and assets on decentralised funding platforms. Robust security measures, including addressing vulnerabilities in smart contracts, implementing encryption mechanisms, and proactive monitoring, ensure a secure environment for transactions and assets. By prioritising security, platforms can instil trust and protect participants from potential security breaches.[70]

Creating user-friendly interfaces is key to attracting and engaging users. Intuitive and accessible interfaces simplify the process of interacting with the platform. By designing interfaces that are easy to navigate and understand, platforms remove barriers to entry and empower non-technical users to participate with confidence.[71]

Fostering a strong and supportive community is vital for the growth and adoption of decentralised funding platforms. Engaging users, developers, and stakeholders encourages collaboration, innovation, and network effects within the ecosystem. Partnerships with governments, NGOs, tech companies, and local communities create an environment conducive to the platform's long-term success.[72]

Piloting and iterative development are essential steps in refining decentralised funding platforms. Conducting initial pilots with a limited number of participants allows for testing the functionality and user experience. User feedback and testing results inform iterative development, ensuring the platform evolves based on real-world usage and user needs.[73]

Collaboration among various stakeholders is crucial. Governments, NGOs, tech companies, and local communities working together drive the adoption and impact of decentralised funding platforms. Leveraging the expertise, resources, and networks of these stakeholders enhances the platform's effectiveness and helps address complex challenges more efficiently.[74]

Investing in capacity building is vital to empower users and developers. Comprehensive training programs covering blockchain wallet management, smart contract interaction, and digital asset security ensure participants have the necessary skills and knowledge to navigate the platform confidently.[75]

Sustainability is a key consideration in platform design. Prioritising energy efficiency, ensuring reasonable transaction fees, and promoting inclusivity and accessibility contribute to the platform's long-term viability. A sustainable platform can make a lasting impact on decentralised funding initiatives.[76]

By considering these preconditions and adopting the recommended approaches, stakeholders can effectively test, scale, and deliver value through decentralised funding solutions powered by blockchain technology.

5.2.3 Considerations for future applications

Future applications of blockchain technology for decentralised funding in humanitarian settings should consider several factors to maximise their effectiveness and impact:

Context-specific solutions: Every humanitarian crisis has its unique challenges and attributes. The implementation of blockchain in such scenarios requires an in-depth understanding of the context and customization of solutions to fit that context. For instance, if a community is largely illiterate, a text-heavy blockchain interface would not be ideal. Instead, an intuitive, user-friendly, and perhaps symbol-based interface might be more effective.[77] The ultimate beneficiaries of any blockchain solution in humanitarian settings would be those affected by the crisis. Thus, it is important that the applications developed are not only accessible to this group but are also easy to use. High degrees of complexity could deter usage. The application interfaces should be designed for minimalism, clarity, and ease-of-use, with user education as an integral part of the implementation process.[78] To make the best use of blockchain solutions, the end-users, who might be the local community, must possess a basic understanding of the technology. Efforts towards improving digital literacy would go a long way in encouraging blockchain adoption and ensuring that the community can independently operate and benefit from these systems.[79]

Optimising DAO's for humanitarian and development objectives: A Lean Impact type approach is conducive to testing possible DAO solutions. Starting small and iteratively testing governance models before making substantial investments can help mitigate uncertainties and enhance the potential of DxAOs.[80]

Governance on revenue sharing: DAO governance poses significant challenges and risks both currently and in the future.[81] As decentralised entities, DAOs lack a central authority to establish governance rules, making it the responsibility of the collective to propose and decide on governance procedures. However, there have been instances of individual actors exploiting loopholes or causing governance deadlock due to poorly defined initial rules and roles. These challenges emphasise the need for robust governance frameworks and mechanisms to ensure the integrity and effectiveness of DAO governance.[82]

DAOs and regulation: In the realm of blockchain, including DAOs, the regulatory landscape is largely uncharted territory. There are currently no clear regulatory policies in place for many blockchain applications.[83] Assessing the regulatory environment for the specifics of an envisioned DAO application (especially if the DAO's membership and/or operations across national boundaries) is a critical initial step in the risk management of any DAO.

Smart contract vulnerabilities: DAOs heavily rely on smart contracts, self-executing contracts with the terms of the agreement directly written into lines of code. If these smart contracts have vulnerabilities or coding errors, they can be exploited, leading to potential loss or theft of digital assets.[84]

Scalability: With the growing adoption of blockchain solutions, scalability is a significant concern. Scalability issues can result in slower transaction times and higher costs, which could be counterproductive in a humanitarian setting. Future applications should, therefore, consider using or developing scalable solutions, possibly by exploring layer-two solutions or other scalability technologies.[85]

Data protection and privacy: Data protection and privacy are paramount, especially in humanitarian settings where sensitive data is often involved. Blockchain solutions should incorporate robust mechanisms to ensure the anonymity and privacy of the users. Solutions could range from using zero-knowledge proofs, private blockchain networks, or other appropriate cryptographic methods.[86]

Regulatory compliance: Complying with local and international financial laws is important when implementing blockchain-based funding solutions. Regulatory bodies have been catching up with the technology, and blockchain solutions should be prepared to adapt to these regulations while ensuring they do not infringe on any legal requirements. It is crucial to engage with legal and compliance professionals from the project's inception to navigate this complex landscape.[87]

Partnerships and collaboration: Foster collaboration and partnerships among stakeholders, including governments, NGOs, technology providers, and financial institutions. Collaborative efforts can leverage diverse expertise, resources, and networks to address regulatory, operational, and technical challenges. Encourage knowledge sharing, exchange best practices, and establish partnerships to collectively navigate the complex landscape of decentralised funding in humanitarian settings.[88]

In conclusion, the literature review highlights the transformative potential of blockchain technology in decentralised funding for international development and humanitarian contexts. Blockchain-based solutions, such as DeFi and DAOs, offer unique features including efficiency, transparency, accountability, and directness. By leveraging blockchain, decentralised funding enables funds to be channelled directly to beneficiaries, enhances transparency and accountability, extends financial services to the unbanked, reduces costs, and establishes a secure and trusted environment. However, successful implementation requires careful consideration of context-specific solutions, optimization of DAOs, robust governance frameworks, security measures, scalability solutions, data protection, regulatory compliance, and collaboration among stakeholders. Future applications should strive to address these considerations to maximise the effectiveness and impact of decentralised funding in humanitarian settings. Overall, the literature supports the notion that decentralised funding has the potential to revolutionise international development by reshaping financial mechanisms and empowering local actors, ultimately contributing to more efficient and impactful humanitarian assistance.

5.3 Land Rights

The application of blockchain technology in land titling is an emerging field of study, promising improved efficiency, transparency, and security in the management and verification of land and property rights. In the context of humanitarian settings, the potential benefits of this technology are particularly significant, as it can help address the complexities and challenges associated with displacement, resettlement, and land disputes.

5.3.1 Study Question 1: Evidence around the value-add of blockchain-based solutions

Evidence of the value added by blockchain-based solutions in international development and humanitarian contexts is compelling, as illustrated by the groundbreaking pilot project in the Republic of Georgia.[89] This project employed blockchain technology to fortify the security and guarantee the immutability of information in the land registry. The project led to the creation of a dependable, tamper-proof database for land ownership information. As a result, the efficiency and transparency of the land registration process were notably increased, expediting land ownership verification and circumventing the need for labour-intensive, time-consuming manual procedures. The project also facilitated the seamless tracking of changes in land ownership over time, substantially reducing the potential for corruption and fraud, and promoting transparency.

Moreover, research such as that conducted by Deininger, emphasises the potential of blockchain-based solutions to tackle diverse land rights issues, including reducing corruption and fostering greater access to credit.[90] The use of blockchain technology allows for reliable, accessible identification of land rights, a crucial factor in the full exploitation of land resources.

Blockchain technology has the potential to address the documentation of users' land rights in the informal land rental market.[91] Blockchain technology is a peer-to-peer protocol that can be leveraged to keep track of transactions over the internet and provides transparency and traceability that can be used in the management of land rights. When it comes to the formalisation of land rights, blockchain technology promises to authenticate owners and other users of land and provides a fixed ledger of land use rights transactions. However, the uptake of the technology in land administration is limited by human-related factors. These limitations include, but are not limited to, the accuracy of data being entered into the system, the ability of the system to facilitate data preservation, pre-existing institutional and legal pillars, and the digital divide across communities. Part of overcoming these barriers requires the political will of governments to invest in digital technologies and develop institutional capacities to overcome current limitations.

The relationship between Person(s), Right(s) and Object(s) in a Land Administration system is the basis for the definition of required functionality, given the complexity within these three elements: identity of a person, legal diversity ('bundle of rights') and the diversity in objects. The paper analyses if some of the principles of Good Governance in Land Administration (transparency, accountability, security, rule of law) are being met with blockchain technology. In this context it is concluded that the technique does not seem to be mature enough for application in land administration.[92]

Further, advancements in technology now allow for the securing of land rights in ways that are participatory, cost-effective, and comprehensive, something that was unimaginable only a few years ago.[93] Technological solutions range from the use of high-resolution satellite imagery to link tenure to land use and identify gaps in land administration coverage, to the utilisation of cloud computing and open-source software, enabling developing countries to bypass their IT infrastructure limitations.[94]

While blockchain technology offers significant potential in enhancing land rights management and contributing to broader development objectives, it is critical to be cognizant of its limitations. This includes the need for the technology to be integrated alongside robust institutional infrastructure and for improvements to be made in data quality.[95] Blockchain solutions, though transformative, should be implemented as part of a broader strategy to improve land governance, taking into account the need to concurrently improve legal frameworks and institutional strength to ensure effective and ethical use of these solutions. There are valuable insights into both the potential and the challenges of using blockchain technology for creating secure, transparent property registries[96].

In summary, the value-add of blockchain technology in international development and humanitarian scenarios is clear. It provides a transparent, secure platform for recording land properties, preventing registry loss or manipulation, and offering proof of ownership. By addressing issues of insecurity, corruption, and misuse prevalent in land registration, blockchain technology presents a substantial opportunity for impacting land rights and registration positively, demonstrating its significant potential for enhancing global development and humanitarian efforts.

The substantial evidence comprising pilots review, surveys, and in-depth analysis, resonates strongly with the conclusions drawn from the comprehensive literature review. Both the practical insights from our report and the theoretical underpinnings of the literature review converge on the multifaceted value-add of blockchain technology in international development and humanitarian use in land rights.

The pilots of this research, such as Improving Land Records in Karnataka through Blockchain, Protecting land rights forest in Ghana, confirm the literature's bullish approach to the subject at hand. The identified value-adds of trust, visibility and traceability, speed, and decentralisation have been transformative in these contexts.

The literature review also echoes the research's emphasis on broader societal implications, which underscores the role of blockchain in reducing corruption and enhancing access to credit and mirrors our understanding of the technology's broader societal implications.[97] Interestingly, the multiplier effect of smart contracts finds a parallel in the literature review, which highlights the intricate blend of blockchain facets in maximising its benefits. This confluence of insights underscores the complexity and interconnected nature of blockchain technology, a point stressed in both our report and the literature.

Moreover, the importance of a comprehensive, holistic approach to the implementation of blockchain technology is a common thread in our report and the literature review. While evidence underscores the need for strengthening institutional infrastructure, enhancing data quality, and refining legal frameworks, the literature review emphasises the importance of thoughtful implementation to successfully navigate blockchain's inherent challenges.

In conclusion, the synergy between our report's findings and the literature review's conclusions solidifies the understanding of blockchain's potential in international development and humanitarian scenarios.

5.3.2 Study Question 2: Pre-conditions and/or approaches that test and scale blockchain solutions, and deliver value

In order to effectively test and scale blockchain solutions for land rights, the literature suggests that practitioners should bear in mind several pre-conditions and approaches. Significant interest and growth in the topic were found in both technical and land-governance directions.[98]

Primarily, it is vital to recognize the integral role of a robust institutional infrastructure in enhancing land governance.[99] Despite the transformative potential of blockchain, a word of caution is necessary as the literature does not thing that the technology can (nor should) replace the need for strong, reliable institutions. Therefore, a comprehensive approach is needed wherein blockchain technology is part of a larger strategy to strengthen institutional infrastructure.[100]

Practitioners should also prioritise data quality and integrity. The concept of "Garbage In, Garbage Out" as highlighted in our findings underscores the challenge of ensuring accurate data registration on the blockchain. If inaccurate data is recorded, it becomes a permanent part of the record, leading to undesirable cascading effects. It is crucial to establish effective data management protocols to guarantee data accuracy.[101]

Improvement in legal frameworks is another important precondition. These frameworks form the backbone for the efficient and ethical application of blockchain solutions. Legal systems must recognize and enforce blockchain-based land rights and require a conducive legal environment.[102]

In addition to technical and legal aspects, the importance of multi-stakeholder collaboration cannot be overstated. The successful implementation of blockchain technology necessitates

collaboration among governments, private sector, civil society organisations, and local communities.[103] Blockchain technology applications should consider local customs, traditional land use practices, and gender dynamics to ensure equitable and context-sensitive solutions.[104] Blockchain can help in making land administration more inclusive. Its decentralised nature can empower individuals and communities by enabling them to participate directly in land transactions and decision-making processes, potentially promoting more equitable land distribution.[105]

Furthermore, pilots should be aware of the socio-cultural context within which land rights are being secured. This encompasses understanding local customs, traditional land use practices, and gender dynamics. Considering the sensitivity of data involved, privacy and security are of utmost importance. Blockchain solutions should safeguard against unauthorised access and ensure the privacy of individuals and communities.

Blockchain technology has the potential to address the documentation of users' land rights in the informal land rental market, is a peer-to-peer protocol that can be leveraged to keep track of transactions over the internet and provides transparency and traceability that can be used in the management of land rights. When it comes to the formalisation of land rights, blockchain technology promises to authenticate owners and other users of land and provides a fixed ledger of land use rights transactions. However, the uptake of the technology in land administration is limited by human-related factors. These limitations include, but are not limited to, the accuracy of data being entered into the system, the ability of the system to facilitate data preservation, pre-existing institutional and legal pillars, and the digital divide across communities. Part of overcoming these barriers requires the political will of governments to invest in digital technologies and develop institutional capacities to overcome current limitations.

Before scaling up, pilot testing of blockchain solutions in controlled environments is recommended to understand potential issues and mitigate them.[106] Also, the sustainability and scalability of the solution should be considered from the outset. blockchain applications should be designed with user-centric principles. They should be easy to use and accessible to people, regardless of their level of technological literacy. Transparency and accountability should be promoted, providing users with access to their data and information about its usage and storage.

In summary, the effective implementation of blockchain solutions for land rights requires a multi-dimensional approach. It should encompass robust institutional and legal frameworks, ensure data quality, security, and privacy, facilitate multi-stakeholder collaboration, consider socio-cultural contexts, prioritise capacity building, allow for pilot testing, and promote user-centric design and transparency.[107] These pre-conditions and approaches, when properly integrated, can maximise the value delivered by blockchain solutions in land rights management.

5.3.3 Considerations for future applications

Future applications of blockchain in land administration should take into consideration not only the technological facets but also the social, political, and economic contexts in which they are implemented.

Dealing with complexity of land rights: While blockchain can efficiently track formal land rights, it might struggle with the intricate, layered nature of formal and informal claims common in many parts of the world, especially in the Global South.[108] Future applications should consider ways to incorporate this complexity into blockchain systems to reflect the realities of land ownership and prevent marginalisation of informal claims.

Understanding limitations of technical solutions: Acknowledge that blockchain alone is not a standalone solution for land administration. It should be integrated with broader reform efforts targeting institutional corruption, legal frameworks, and social norms to bring about comprehensive improvements in property relations.[109]

Sustainability and scalability: Evaluate the scalability and sustainability of blockchain solutions, considering factors such as digital literacy, infrastructure support, and regulatory frameworks. Explore layer-two solutions and other scalability technologies to accommodate larger transaction volumes and ensure long-term viability.[110]

Understand the context: Gain an in-depth understanding of the local social, political, and economic contexts in which the project will be implemented. Tailor blockchain solutions to fit the specific needs and challenges of the target region, considering the complexities of formal and informal land claims.

Address privacy and security: Implement robust data protection and privacy measures to safeguard sensitive land-related information. Consider the use of cryptographic techniques, private blockchain networks, or zero-knowledge proofs to ensure the anonymity and security of users' data. Blockchain-based land titling systems should be designed and implemented with careful attention to ethical considerations, such as data privacy, consent, and protection of vulnerable groups. Social impacts, including potential displacement or exclusion of marginalised communities, should be assessed, and addressed to ensure equitable outcomes.[111]

Enhancing Accessibility and usability: Design user-friendly interfaces and processes that are accessible to all stakeholders, regardless of their technological literacy levels. Simplify complex procedures and provide user education to maximise usability and ensure the meaningful participation of local communities.[112]

Engage legal and compliance professionals: Involve legal and compliance professionals from the inception of the project to navigate the complex legal and regulatory landscape. Ensure compliance with local and international financial laws while maintaining the project's integrity and alignment with legal requirements.

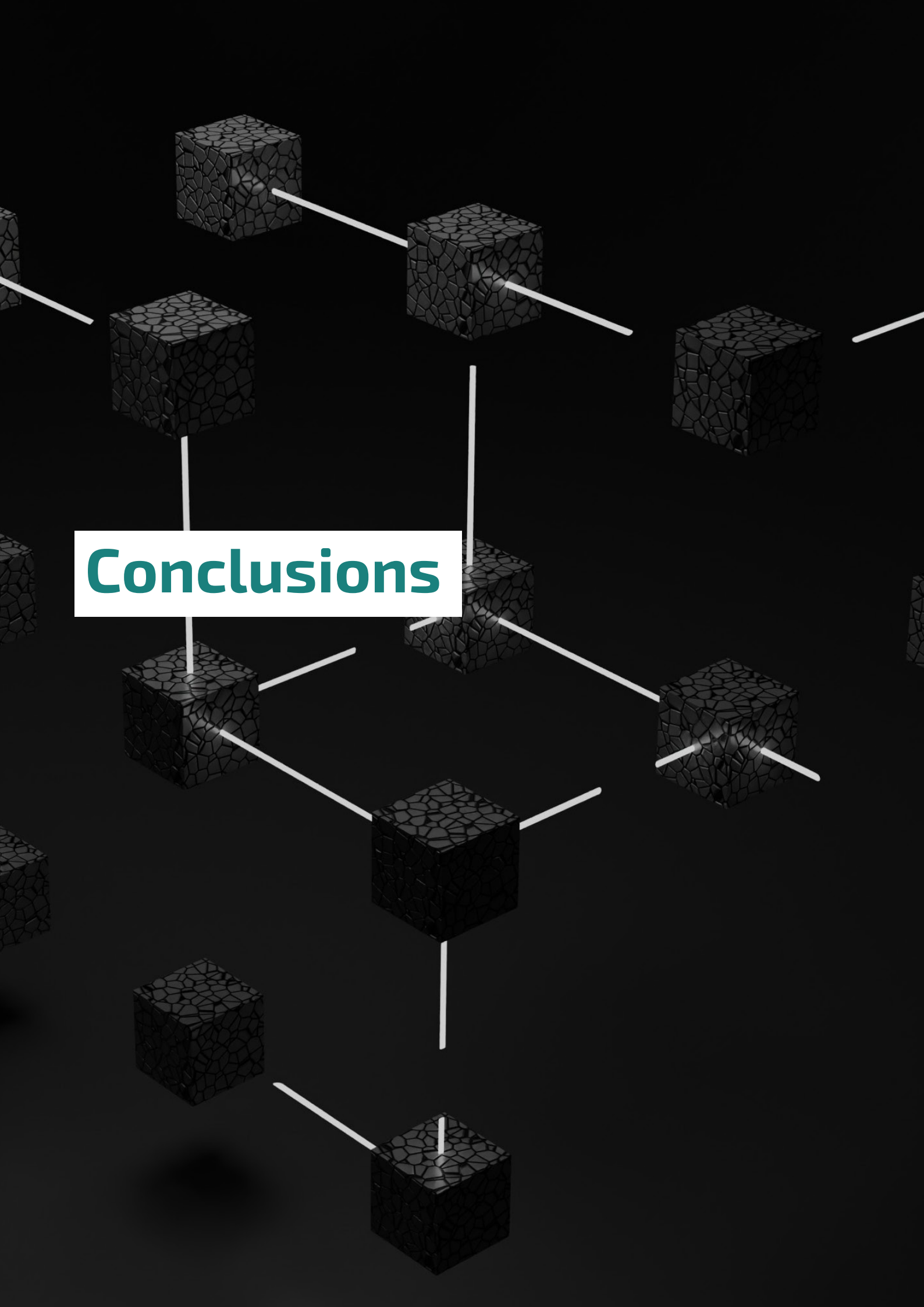
Foster governance and accountability: Establish transparent governance mechanisms and dispute resolution processes to ensure fairness, transparency, and accountability in land administration. Develop clear guidelines and procedures for addressing conflicts and resolving disputes among stakeholders.[113]

Scalability and network congestion: Considering the scalability challenges of blockchain technology, it is important to assess the potential impact of network congestion and transaction volumes on the performance and usability of blockchain-based land administration systems. Scaling solutions and optimizations should be explored to accommodate larger transaction volumes.[114]

Wrapping up, the surveyed literature underlines blockchain's capacity to introduce transformative changes in land rights management in the context of international development and humanitarian efforts. This potential, however, can only be fully realised through an approach that is comprehensive, well-informed, and broad-based. This approach must tackle on-the-ground challenges related to land rights, ensure all-inclusive access to land administration services, harmoniously merge with existing land registration infrastructures, and keep the long-term sustainability of the initiative front and centre. As we move forward, blockchain implementations in land rights need to adhere to these guiding principles to efficiently derive value in these distinctive circumstances. This research echoes these insights, thereby reaffirming their crucial importance.

In conclusion, the literature review highlights the potential of blockchain technology in addressing challenges related to land rights in international development and humanitarian contexts. The evidence suggests that blockchain-based solutions can improve efficiency, transparency, and security in land administration and titling. The literature emphasises the need for a comprehensive approach that combines technical solutions with robust institutional infrastructure, legal frameworks, and multi-stakeholder collaboration.

Furthermore, the review identifies considerations for future applications, such as addressing the complexity of land rights, understanding the limitations of technical solutions, ensuring sustainability and scalability, considering the context, addressing privacy and security concerns, enhancing accessibility and usability, engaging legal and compliance professionals, fostering governance and accountability, and addressing scalability and network congestion. By incorporating these considerations, blockchain technology has the potential to revolutionise land rights management, contributing to more equitable and efficient land administration systems. However, it is crucial to approach blockchain implementations in land rights with a holistic understanding of the social, political, and economic contexts to ensure their effectiveness and long-term sustainability.



Conclusions

The objective of this section is not to repeat the findings already identified in the previous chapters, but instead to present crucial themes that have emerged from our in-depth analysis and key actionable recommendations. Each theme encapsulates significant findings and provides forward-looking implications for the Frontier Tech Hub pilots and other blockchain applications. The objective is to bridge the gap between theory and practice, drawing lessons from past experiences while outlining actionable insights for future endeavours.

It is all about trust

The role of trust in driving development outcomes is well documented.[115] Trust plays a crucial role in the success of blockchain implementation in development and humanitarian contexts. Designing, managing, and measuring trust within the blockchain ecosystem are challenging but necessary endeavours. Blockchain technology, with its features like decentralisation, tamper-proof mechanisms, transparency, and resistance to censorship, enhances confidence in the system. Blockchain technologies aim is thus to fortify trust through transparent and secure mechanisms and robust institutional designs. While measuring trust is difficult due to its subjective nature, designing theories of change in behavioural terms can help measure trust through specific actions performed by actors. This measurement can provide evidence for adaptive and lean impact models.

Building trust is a predecessor to behaviour change

Building trust is an important step before people start adopting a new solution or technology. Participant awareness, which is assessed as part of the Enabling Factor Framework, focuses on building the necessary level of trust for participants to accept the proposed solution. In simple terms, it means that blockchain does not replace trust but rather increases people's confidence in a system that is part of the proposed solution. Participant awareness mainly concentrates on educating participants and enhancing their knowledge about the benefits of the blockchain-enabled solution.

While there is evidence indicating that participant awareness is a significant risk when introducing blockchain, none of the pilots (to our knowledge) used a behavioural approach to understand the objective of participant awareness, which is to build trust in the blockchain-enabled solution. Since trust is a behaviour-based concept, not using a behavioural model to design and measure it poses a risk to the effectiveness of activities aimed at building trust, including participant awareness activities.

Participant awareness

The findings from the KIIs, surveys and literature review highlight the importance of education and awareness within the ecosystems where these pilots are being implemented, which span across diverse geographical and socio-economic contexts. What is unclear at this point is what

knowledge (i.e., awareness, education) is needed by specific actors (funders, implementers, end users, etc.) and how to achieve it.

Pilots wrestled with questions like:

- What blockchain literacy is needed by specific actors to build the trust for their respective "buy in" into the proposed solution? How do we identify this?
- What are the optimal activities (communications, capacity development, etc.) to build this literacy and cultivate this trust?
- How do we know when we have obtained the required level of ecosystem knowledge and awareness?

Tools require informed use

Blockchains are versatile tools with various design elements, including digital architecture and the integration of behavioural sciences to create effective incentive mechanisms.[116] The nature of blockchain being code-based makes it accessible for experimentation and adaptive management. However, to optimise its use in a specific ecosystem, reliable evidence is required to inform decision-making.

The performance of blockchain in achieving desired behaviours within an ecosystem is a key aspect to consider. This process begins with mapping the ecosystem to assess the feasibility and cost-effectiveness of implementing blockchain technology. Different pilot objectives involve different actions from various actors within the ecosystem. These actions rely on trust relationships, such as trust in using an app for cross-border payments, trust in participating in a supply chain, or trust in using a land title to secure a loan.

The pilot objectives aim to create the necessary capabilities, opportunities, and motivation for these actions, with blockchain serving as a tool to facilitate these factors. However, it is important to consider how other tools and activities may be needed to fully achieve the desired capabilities, opportunities, and motivation. Determining "how" blockchain facilitates change involves understanding the value-add it brings and how it improves efficiency through different mechanisms, as outlined in Table 5.

Complexity invites risk

Blockchain ecosystems are complicated, which makes it challenging to recognize, evaluate, and handle risks. This challenge becomes even more difficult in humanitarian and development contexts due to limited time, resources, and high levels of uncertainty associated with complex challenges.[117] Frontier Tech Hub's Lean Impact approach addresses these difficulties by continuously testing and validating key assumptions as part of the risk management process when scaling up pilot projects. However, there is an opportunity to incorporate additional tools and methods based on systems and behaviour to further enhance the effectiveness of the existing Lean Impact approach.

Risk portfolios for blockchain applications

The general blockchain specific risks identified in this report could be expanded on to build application specific risk profiles that can be used to inform assumption testing, risk management and other performance management tools and processes.

The general risks included in the Enabling Factor Assessment could be expanded on for more detailed general risk areas (see table 11 below) as well as Risk Profiles for applications in Supply Chain, Land Titling, Decentralised Funding, or any other priority sector of application. These Risk Profiles could contain disaggregated risks for more specialised applications within each area (Humanitarian Supply Chains, Agricultural Supply Chains, etc.) with risk definitions, drivers, factors of effect, mitigation strategies etc. to inform design, scenario planning, sensitivity analysis and assumption testing.

Table 8: General Blockchain Risks[118]

Risk Categories	Risk Sub-Categories
Technology	Integration, Data Privacy, Security, Performance, Scalability, Interoperability
Strategic	Value Proposition, Incentive Alignment, Reputation, Adoption and Network
Financial	Funding, Accounting, Internal Control, Benefit Accrual, Market Volatility
Legal/Regulatory	KYC, Anti-Trust, Asset Definition, Cross-border Regulations
Operational	Governance, Auditability, Asset Ownership, Smart Contract Vulnerabilities, User Experience
Human Factor	User Education, Resistance to Change, Trust, Misuse, Dependency on Key Individuals

Recommendations

As we transition from the analysis to action, the following section on recommendations will provide a road map for integrating blockchain technology effectively in international development and humanitarian settings. These suggestions are carefully distilled from our comprehensive study, and they aim to address the identified challenges and harness the potential of blockchain.

They incorporate various aspects, from technical considerations to behavioural elements and ethical concerns. They provide guidance not only for project implementation but also for creating an environment conducive to the innovation and sustainability of blockchain initiatives. In this way, our recommendations seek to pave the way for more impactful and successful blockchain applications in the future.

Leverage measurement models

Leveraging measurement models such as the Lean Impact Approach, the Blockchain Adoption Model and/or the Capabilities, Opportunity, and Motivation (COM-B)[119] may help address factors related to behavioural, technological, organisational, and environmental contexts to optimise adoption. As an example, the BAM framework shows how various stakeholders and factors contribute to the successful adoption of blockchain technology. This model includes the following factors:[120]

- *Technological context:* Relative advantage, compatibility, complexity, trialability, and observability. Relative advantage is affected by perceived benefits and costs.
- *Organisational context:* Organisational readiness, organisational size, senior management support, and organisational age. Organisational readiness is influenced by the availability of human and technological resources and by the organisational structure.
- *Environmental context:* Competition intensity, external pressure, regulatory uncertainty, collaboration, and the scope of the business ecosystem. External pressure can be divided into competitors, customers, suppliers, regulators, and shareholders. Collaboration is divided into competitors, customers, suppliers, regulators, IT vendors, and universities. The scope of the ecosystem is defined by the number of participants and the geographic dispersion.

Mitigate data integrity risks

Recognize the risk of negative cascading effects when incorrect or unreliable data is entered into the blockchain. Recommend the development of structured data management protocols and guidelines to ensure data integrity and accuracy. Promote the implementation of effective personally identifiable information (PII) protection protocols to safeguard vulnerable individuals' assets and privacy.

Build Governance, partnership and capacity

Establish effective governance structures and stakeholder engagement mechanisms to facilitate decision-making, policy development, and acceptance of blockchain technology. Invest in capacity-building programs to enhance the understanding and skills of land administration officials, technicians, and relevant personnel in utilising blockchain technology effectively. Encourage practitioners to build alliances and collaborations among governments, private entities, NGOs, and other stakeholders to drive innovation and overcome regulatory and operational challenges. Highlight the importance of knowledge sharing, engagement strategies, and targeted support to bridge the gap between traditional organisations and blockchain-native startups. Foster dialogue and collaboration with regulators and policymakers to navigate legal and regulatory challenges associated with blockchain implementation. Stay informed about evolving regulations and work towards creating an enabling environment for blockchain technology in the international and development sectors.

Continuously measure, evaluate and learn

Stress the importance of ongoing evaluation, learning, and adaptation in blockchain initiatives. Encourage practitioners to monitor the progress, assess the impact, and iterate their strategies based on the lessons learned from the pilot projects and the evolving blockchain landscape. This includes identifying appropriate metrics, data collection methodologies, and evaluation criteria to determine the success and value-add of blockchain applications[121].

Design for specific ecosystems

Understand the unique characteristics and dynamics of the target ecosystem when designing blockchain applications. Map the ecosystem to determine the feasibility and cost-effectiveness of using blockchain technology, considering factors such as technological context, organisational context, and environmental context.

Incorporate behavioural insights

Integrate behavioural science approaches into the design and implementation of blockchain pilots. Consider the motivations, incentives, and behavioural factors that influence participants' actions and decision-making processes. To strengthen the effectiveness of participant awareness activities and foster trust in blockchain-enabled solutions, it is crucial to incorporate a behavioural lens, such as the Capabilities, Opportunity, and Motivation (COM-B) model. By considering the behavioural aspects of trust, organisations can design and measure participant awareness initiatives more effectively. This entails addressing not only the capability component but also the opportunity and motivation aspects of behaviour change. By utilising a comprehensive behaviour model, organisations can better understand and address the factors that influence participants' trust-building behaviours, thereby increasing the likelihood of successful adoption and positive outcomes in blockchain initiatives.

Test assumptions iteratively

Implement a lean and iterative approach to testing assumptions throughout the pilot project. Continuously gather feedback, adapt strategies, and refine the pilot based on the evidence generated.

Foster an understanding of blockchain as a trust tool

Recognize that blockchain technology does not replace trust but can enhance it by providing transparent and secure mechanisms. Design and manage blockchain applications with a focus on building and maintaining trust among participants incorporating trust-building mechanisms into the design of blockchain solutions. Develop frameworks and metrics to measure the impact of blockchain technology on trust within the ecosystem. Use a behavioural approach to assess the effectiveness of trust-building activities.

Implement risk management strategies

Identify and manage risks associated with blockchain implementation, such as technological complexity, data quality, legal and regulatory compliance, and user resistance to change. Develop risk profiles specific to blockchain applications to inform risk management practices.

Prioritise user experience

Focus on designing user-friendly interfaces and applications to enhance the adoption and acceptance of the technology. Provide training, support, and user-friendly tools to increase user confidence and participation.

Explore the potential of smart contracts

Highlight the benefits of smart contracts, such as cost savings and speed, while acknowledging their limitations in handling complex transactions. Recommend leveraging smart contracts for simpler transactions with high levels of certainty until further evidence and tools are available to manage more complex transactions.

Address ethical considerations and accountability

Ethical considerations should be the bedrock of all blockchain initiatives in international development and humanitarian contexts. Prioritise data privacy, consent, and protection of vulnerable groups. Conduct thorough impact assessments to mitigate negative social impacts and ensure equitable outcomes. Align with humanitarian standards and principles to foster trust and accountability. Actively engage with local communities and stakeholders to incorporate their perspectives and address their concerns. By addressing these considerations, blockchain initiatives can contribute to a more accountable, transparent, and inclusive humanitarian ecosystem.

Plan for scalability and sustainability

When designing blockchain solutions, it is crucial to anticipate scalability and long-term sustainability. Building a solution with future growth in mind ensures that as the project evolves, it will not outgrow its foundational design or resource allocation. To achieve this, there should be an estimation of the necessary resources and infrastructure required to sustain growth, such as increased computational capacity or more sophisticated data management systems. Additionally, robust governance structures should be established early on to guide the project as it expands and navigates new challenges.

These structures would handle decision-making processes, conflict resolution, and ensure the integrity and transparency of the project. Thus, scalability and sustainability are not mere afterthoughts but fundamental components to be embedded in the design and implementation of blockchain solutions. This forward-thinking approach ensures the continued success and expansion of initiatives, enabling them to maximise their impact in the long run.

Appendices

8.1 Methodology

This study utilises a comprehensive approach to gather, collate, and analyse data pertinent to the application of blockchain technology in a variety of settings. The methodology is primarily determined by the Scope of Work (SOW) and is supplemented by additional pilots identified by the Impact Plus team, utilising a set of inclusion criteria that considers the availability of evidence, funding sources, objectives, and scaling objectives. The study collects data from diverse sources including literature reviews, document reviews, KIIs, weekly discussions with Frontier Tech Hub staff, and a survey.

Throughout the course of the study, two analytical frameworks are deployed: the value-add Framework and the Enabling Factors Framework. These frameworks were developed to provide structured approaches for assessing and evaluating the value-added by blockchain technology and the key factors that enable its successful use. They are used as qualitative code books for analysing the literature and document review, KII transcripts, and survey results.

As part of our commitment to data security, all materials are securely stored and managed with access granted only to Frontier Tech Hub and the Impact Plus team.

Additionally, a Consultative Committee comprising experts in blockchain, social and environmental startups, international development, and humanitarian work meets periodically during the course of the research. The committee provides technical feedback on the research methodology, validates research findings, and reviews and provides feedback on the research reports.

The study also involves comprehensive value assessment and enabling factor frameworks, with a scoring system for each dimension. The blockchain design assessment is followed by a token diagnosis to evaluate the type of token used, its issuance, and distribution.

This extensive methodology ensures a holistic evaluation of blockchain technology's potential and actual contributions to humanitarian and development contexts. It supports the study's commitment to generate meaningful and actionable results that inform strategic decisions and implementation of blockchain technology.

8.1.1. Sampling strategy

In this study, the sampling was primarily determined by the Scope of Work (SOW), which outlined a list of specific Frontier Tech Hub pilot programs to be included. The initial selection criteria for these pilot programs were based on their prioritisation and learning potential, as established by Frontier Tech Hub. To expand the range of pilots covered by the study, the Impact Plus team identified additional pilots using the following inclusion criteria:

- *Availability of evidence*- Given the infancy of blockchain technology, by far the biggest inclusion criteria is the accessibility of data and quality of data on the various pilots to provide an optimal learning opportunity.

- *Different types of funding sources*- The initial Frontier Tech Hub pilots were all funded by UKaid through a selection process where UKaid employees nominated the candidates for government funding. The additional Impact + identified pilots are funded by private donations, foundations, and other sources. Given the importance of funding mechanisms in navigating scale up phases, it was hoped that results would speak to the influence of different types of funding mechanisms.
- *Alternative development and humanitarian objectives*- While the initial Frontier Tech Hub list of pilots covers land titling, supply chain and humanitarian assistance objectives; the additional pilots include decentralised funding, cross border payment systems and microinsurance.
- *Different scaling objectives*- "Scaling" has a spectrum of objectives with different replication and duplication characteristics. A preliminary assessment of available materials at the time of study design indicates varying levels of clarity in the scaling objectives but that few, if any, pilots have advanced beyond the "Transition to Scale" phase.

8.2 Data collection and analysis methods

Data Collection: The pilot list above, in addition to an external literature review, served as the data sources for this mixed methods study. Data sources included:

- Literature Review of external evidence on relevant themes and similar objectives from other applications
- Document Review of pilot application materials to include proposal applications, white papers, sprint reports, pilot reports, etc.
- KIIs of pilot implementation staff, Impact Leads, fund managers and key experts.
- Discussions with Frontier Tech Hub staff during weekly check ins that allowed for initial results to inform subsequent data collection and analysis.
- Survey: The survey focused on goals, implementation processes, challenges, enabling factors, success metrics, smart contract use, and integration with legacy information technology systems among other aspects. A total of eight responses were collected, representing seven distinct blockchain projects. However, it is important to note that two of the responses pertained to a single initiative in Venezuela that did not ultimately use blockchain technology. Therefore, references in this report will be made to six projects to accurately reflect the blockchain applications being discussed. The participating projects encompassed a diverse range of initiatives, including:
    - Blockchain technology for addressing humanitarian aid duplication. GeniusTags
    - Stellar Aid Assist. Stellar Development Foundation
    - A blockchain-enhanced platform to support the humanitarian crisis in Venezuela. Brink.
    - Glo Dollar.
    - OS City. Municipality of Monterrey and UNICEF Venture Fund.

- Xcapit. UNICEF Venture Fund. FundTrack & Trust. Datarella GmbH

- Consultative Committee: The Consultative Committee, composed of experts in areas like blockchain, social and environmental startups, international development, and humanitarian work, meets twice during the course of the research were responsible for providing technical feedback on the research methodology, authenticating, and verifying research findings and reviewing and offering feedback on the research reports. This diverse assembly of professionals were selected for their unique perspectives, technical knowledge, and valuable insights. The first meeting, a virtual conference lasting 90 minutes, was held on 31st March 2023. This important meeting allowed members to influence the direction of the research and ensure the generation of meaningful and actionable results. The second meeting is scheduled for 24th May 2023. During this meeting, preliminary results will be presented to the members. Their feedback will be collected and used to refine and finalise the report.

Data Analysis: Throughout the course of the study, two analytical frameworks were created and refined, namely the value-add Framework and the Enabling Factors Framework. This framework set up criteria and guiding questions for each value-add, enabling the Assessment Framework to be used as a qualitative code book for analysing materials in the literature and document review, KII transcripts, and survey results.

These frameworks were developed to supply structured approaches for assessing and evaluating the value-added by blockchain technology and the key factors that enable its successful use.

1. *value-add Analysis Framework*: This framework was created to address study question #1. The framework outlines dimensions of value-add (informed by external evidence[122]) for using a blockchain in comparison to the next best alternative. Each dimension includes guiding questions meant to assess the value-add. The full framework can be found in Annex 8.4.

2. *Enabling Factors Framework* : This framework was developed to help answer study question #2 by using evidence from an external literature review, internal document review and initial KII's to identify 1.) factors that are most likely to contribute to successful development and humanitarian pilots and 2.) general risk factors in the use of a blockchain in a humanitarian or development context. The full framework can be found in Annex 9.5.

The testing of these two frameworks during the course of the study validated the core concepts of each but also led to modifications that improved their usefulness. The two frameworks also served as qualitative code books for the qualitative analysis of pilot materials during the desk review.

Data and security management: All materials were stored in a Google folder to which only Frontier Tech Hub and the Impact Plus team have access. There will be no attribution in this final

report and no PII was ever recorded as part of this study. There was no primary data collection from any type of marginalised population.

8.3. List of pilots

Pilot Name:	Blockchain Technology for the Humanitarian Supply Chain
Location:	Bangladesh & Pakistan
Sector:	Humanitarian Aid / Supply Chain
Timeline:	June 2017 - November 2019
Partners:	Datarella, PA Consulting
Description:	The pilot proposed using blockchain technology to address the lack of data consensus and collaboration among humanitarian aid actors. This innovative technology promised real-time tracking of goods, ending the need for extensive paperwork and the associated costs of tracking humanitarian supplies. The expected outcome of this blockchain-enabled platform was a substantial increase in transparency, efficiency, and collaboration across the supply chain.

Pilot Name:	Safeguarding land-based climate investments in Ghana with blockchain
Location:	Ghana
Sector:	Climate and Environment
Timeline:	September 2022 - Ongoing
Partners:	BenBen & Oko Forests
Description:	In response to the challenges posed by Ghana's existing land and tree tenure system, this pilot initiative was proposed using a blockchain Decentralised Autonomous Organization (DAO). The goal was to simplify the tree tenure certification process, enabling communities to access carbon credits. Theoretically, the DAO could hasten and reduce the cost of transactions between Customary Land Secretariats, farmers, and investors. This would after help connect Ghanaian communities to the international carbon market.

Pilot Name:	Tracking UKAid Payments on the Blockchain
Location:	Iraq & Palestine
Sector:	Humanitarian Aid/ Funding
Timeline:	August 2019 - October 2020

Partners:	Disberse
Description:	This pilot explored the potential benefits of using distributed ledger technology (DLT) to track UK Aid payments throughout the delivery chain. The proposed platform was designed to record and track international aid transactions across various delivery stages, serving as a financial service to donors and implementing partners involved in the aid sector.

Pilot Name:	**Blockchain certified digital payments for miners**
Location:	Democratic Republic of Congo, Rwanda, and Burkina Faso
Sector:	Extractive Industries
Timeline:	June 2020 - Present
Partners:	Minexx
Description:	The challenge of conflict minerals entering supply chains has persisted due to poor law enforcement and the fact that the issue originates at the beginning of the supply chain. To address this problem, this pilot proposed implementing a blockchain-certified digital payments platform to ensure fair payment for miners in the informal sector and reduce the likelihood of conflict minerals entering international supply chains.

Pilot Name:	**High Tech Solutions for supply chain and distribution**
Location:	India
Sector:	Supply Chain
Timeline:	May 2020 - Closed
Partners:	AsterQuanta
Description:	The Public Distribution System (PDS) in India, a welfare programme targeting the most vulnerable populations, was the focus of this pilot. With between 750-800 million individuals receiving subsidised goods like wheat, rice, and kerosene as a safety net against food insecurity, improving the efficiency and transparency of this vast system was crucial. This pilot introduced Artificial Intelligence (AI) and Blockchain technology (BCT) into the PDS supply chain in the Chikkaballapur district in Karnataka, India. AI was used to enable contactless recognition of beneficiaries, streamlining the identification and distribution process. Concurrently, Blockchain technology was employed to increase transparency and accountability along the supply chain, allowing for real-time tracking and verification of transactions and deliveries.

	The goal of the pilot was to reduce the waiting time for beneficiaries to collect goods, minimise leakage or loss of goods during transit, improve the quality of the goods distributed, and increase overall transparency in the system.

Pilot Name:	**De-duplicating aid to enhance the impact of humanitarian assistance**
Location:	Nigeria
Sector:	Humanitarian Aid
Timeline:	December 2021 - Present
Partners:	Genius Tags
Description:	The blockchain application developed in this pilot assigns each household receiving aid a unique ID that records the assistance they receive. This enables a clear and secure tracking of aid allocation, ensuring that resources are not duplicated or wasted. An important feature of this application is its commitment to data privacy and adherence to humanitarian principles.

Pilot Name:	**A blockchain-enhanced platform to support the humanitarian crisis in Venezuela**
Location:	Venezuela
Sector:	Humanitarian Aid
Timeline:	December 2021 - March 2023
Partners:	Fundación S4V
Description:	This pilot aimed to create a secure and transparent platform powered by blockchain technology. This platform was designed to enable donors to trace the impact of their contributions from the Venezuelan diaspora, thereby improving the transparency and accountability of aid distribution.

Pilot Name:	**Improving Land Records in Karnataka through Blockchain**
Location:	India
Sector:	Government
Timeline:	December 2021 - December 2022
Partners:	PwC India
Description:	The pilot was launched to address land ownership issues in Karnataka, India, where establishing accurate property ownership is a significant challenge due to

	the state's reliance on presumptive titling for property registration.

Additional pilots:

Project's Name:	**Glo**
Location:	Global
Sector:	Non-profit
Timeline:	Created in 2021
Description:	Glo is a non-profit stablecoin that aims to end extreme poverty by generating basic income for people in need. It is pegged to the US dollar and fully backed by a fiat reserve invested in US treasuries. The interest earned from the reserve is donated to GiveDirectly, which distributes it as basic income. Glo can be bought or redeemed for $1 and can be used for various purposes. By converting money to Glo and using it, individuals and businesses can help Glo grow and reach more needy people.

Project's Name:	**Stellar Development Foundation**
Location:	Global
Sector:	Non-Profit
Timeline:	Created in 2014
Description:	Stellar is an open-source network optimised for payments and asset issuance. It allows users to create, send, and trade digital representations of all forms of value, including fiat currencies, cryptocurrencies, real estate, and more. Stellar is designed to enable all the world's financial systems to freely interoperate with each other on a single network. As a public network, Stellar has no owner and is owned by the public. The software runs across a decentralised, open network and oversees millions daily transactions. Stellar relies on blockchain technology to keep the network coordinated but offers a faster, cheaper, and more energy-efficient end-user experience than typical blockchain-based systems.

Project's Name:	**Agrifin from MercyCorps**
Location:	Ethiopia, India, Indonesia, Kenya, Nigeria, Tanzania, Uganda, Zambia, and Zimbabwe
Sector:	Climate resilience, food security, and financial inclusion
Timeline:	Created in 2012

Description:	Mercy Corps' AgriFin program envisions a future where every smallholder farmer thrives in a digitally interconnected world, reaching 16 million smallholder farmers. Through partnerships with over 150 organisations, they provide bundled digital products and services to empower farmers. Mercy Corps' AgriFin program collaborates with various public, private, and government partners to achieve their mission. They have reached over 8 million smallholders with digital services and continuously generate insights through their work. By combining digital agriculture, financial services, and data, they contribute to the knowledge base in this field. One notable partnership is with NASA, where Mercy Corps is expanding the AgriFin program to incorporate satellite data. This collaboration enables smallholder farmers to access state-of-the-art imagery, modelling, and analysis to manage their crops and adapt to the impacts of climate change.

Project's Name:	**Rahat**
Location:	Nepal
Sector:	Financial Inclusion
Timeline:	Created in 2018
Description:	Rahat is an open-source, blockchain-based digital aid distribution management system developed by Rumsan in Nepal. The project aims to simplify and make the humanitarian aid distribution process more efficient and transparent. It uses mobile-based blockchain tokens to manage and monitor transactions, ensuring security and real-time visibility. The intervention sector is focused on providing quick relief and financial resilience to vulnerable communities in disaster-prone areas. By leveraging blockchain technology, Rahat reduces administrative costs and transaction risks and enables decentralised distribution. The project is actively working to scale and refine its prototype, with successful pilot projects impacting the lives of over 150 families affected by COVID-19. The team, led by women, comprises diverse professionals from various sectors striving to implement technology for social impact.

Project's Name:	**Xcapit**
Location:	Argentina
Sector:	Financial Inclusion
Timeline:	Created in 2018
Description:	Xcapit, based in Argentina, is a blockchain and AI-driven platform that aims to revolutionise financial services by providing easy and safe access to

	personal finance. The project addresses the challenges of high inflation and low financial education prevalent in Latin America, where a sizeable portion of the population lacks access to financial services. Xcapit's application offers features such as financial planning, automated tailored investments, financial education, and a transparent donation network. By leveraging blockchain and cryptocurrencies, Xcapit promotes a culture of savings, financial education, and inclusive wealth management. The project was founded in 2018 and focuses on the intersection of technology and finance to empower individuals in improving their economic situations.

Project's Name:	**Os City**
Location:	Chile
Sector:	Digital Identities
Timeline:	Created in 2016
Description:	OS City, based in Chile, is a blockchain platform that allows users to write into desired blockchains, enabling tamper-proof and portable records. Their platform enables users to create certificate templates and issue their own digital certificates using different blockchains, including bitcoin, Ethereum, ethereum classic, RSK, and BFA (Federal Argentinian Blockchain). The focus of their impact is on Latin America, particularly in countries like Mexico, Argentina, Chile, Brazil, and Colombia, with an emphasis on the public sector and the artisan industries. OS City has piloted various use cases, such as university diplomas, artisan origin assurance, government licences, and sustainability commitments. Their goal is to create a fair, sustainable, and trustworthy ecosystem for the artisan industries in developing countries. OS City aims to gain trust in blockchain technology as a standard approach for reliable records and intends to explore opportunities in digital identities. The project was founded in 2016 and has collaborated closely with the UNICEF Venture Fund, receiving support and recognition for their efforts in bringing trust and efficiency to government processes in Latin America.

Project's Name:	**Statwig**
Location:	India
Sector:	Health and supply management
Timeline:	Created in 2016
Description:	StaTwig, based in India, has graduated from the UNICEF Venture Fund. The team at StaTwig has developed two products, VaccineLedger and BabyBoo,

	which enable the tracking of vaccines from the manufacturer to the child. Using blockchain technology, critical information such as temperature, humidity, and location is recorded on a blockchain ledger, ensuring trust and transparency in vaccine supply chains. Stakeholders can access this immutable data, and each vaccine or shipment is tagged with a unique QR code for easy tracking. They have open-sourced their supply chain management platform, VaccineLedger, under the MIT License, enabling wider participation and scalability. StaTwig aims to deploy its solutions on a larger scale, partner with industry players, and engage with programs like Gavi Infuse to further enhance their impact.

8.4. Value assessment framework

Table 9: Guiding Questions value-add Dimensions.

Value Add Dimensions	Guiding Questions
Trust	What are the specific types of information sharing and/or transactions that require trust? Does this question become: what type of trust do you want to create and by whom? For the envisioned beneficiaries, what do you want them to trust and what actions should they take as a result of that trust?
Decentralised Structure	How is information shared and data managed between the various parties? Who are the parties? Which parties are less important and which parties gain or become more important?
Improved Security and Privacy	What type or level of data security is needed for these transactions? What type of access and anonymization is needed?
Reduced Costs	What are the costs associated with aggregating, amending, cleaning, reporting, and auditing the data for these transactions? Are there any cost savings that stem from mitigating the need for specific actors? Could these actors be barriers to scale?
Speed	How long does it take to conduct these information sharing or transactions? How has this improved overall performance in meeting your

	objectives?
Visibility and Traceability	What does the business model require for transparency and traceability of these transactions? What type of data sharing is needed and what are the benefits of this data sharing?
Immutability	How critical is a tamper resistant ledger to the business model? What type of information tampering is being mitigated and by whom?
Individual Control of Data	Does the business model require increased individual control over their own data? What individuals gain more control over what types of information? What types of digital, financial, or other types of capacity do these individuals need to use this new control over this data? What ethical issues were encountered in the approach to data management?
Tokenization	How are tokens used? What types of access and usage rights to the goods, services, and data does the model require?
Ethical Sustainability & Accountability	How has the initiative empowered or engaged the affected population? How are they providing feedback on the initiative's performance? How does the initiative ensure that it is inclusive and accessible to all members of the community, including vulnerable or marginalised groups? What opportunities exist for scaling up or replicating the initiative to other development contexts or humanitarian crises?

8.5. Enabling factor framework

The scoring for each dimension was:

0 - Not met: The initiative does not meet the standard or requirement for the subdimension.

1 - Partially met: The initiative partially meets the standard or requirement for the subdimension, but there is still significant room for improvement.

2 - Mostly met: The initiative mostly meets the standard or requirement for the subdimension, but there are some areas that could be improved.

3 - Fully met: The initiative fully meets the standard or requirement for the subdimension, and there is little room for improvement.

N/A Non-Applicable

Table 10: Enabling Factor Framework Matrix

SOCIAL IMPACT	
Theory of Change and Outcome Assessment:	a. Clear problem statement: Define the specific social problem the initiative aims to address.
	b. Proposed solution: Describe how the blockchain initiative will address the social problem and the expected outcomes.
	c. Assumptions and risks: Identify any underlying assumptions and potential risks associated with the initiative's theory of change.
	d. Indicators of success: Establish measurable indicators to track the progress and outcomes of the initiative.
Needs assessment	a. Scope of the problem: Evaluate the magnitude and severity of the social problem being addressed.
	b. Gap analysis: Identify gaps in existing solutions and how the blockchain initiative can fill those gaps.
	c. Stakeholder involvement: Assess the level of involvement of relevant stakeholders in identifying and addressing the social problem.
Target population analysis	a. Demographic profile: Assess the characteristics of the target population, including age, gender, socioeconomic status, and location.
	b. Vulnerability assessment: Evaluate the specific vulnerabilities and needs of the target population.
	c. Accessibility: Assess the ability of the target population to access and benefit from the blockchain initiative, including potential barriers and enablers.
Community Impact	a. Direct and indirect benefits: Assess both the direct benefits to the target population and the indirect benefits to the broader community.
	b. Economic impact: Evaluate the potential economic effects of the blockchain initiative, such as job creation, income generation, or financial inclusion.
	c. Social cohesion: Assess how the initiative could contribute to social cohesion, trust, and collaboration within the community.
	d. Environmental impact: Evaluate the potential environmental consequences of the initiative, such as energy consumption or waste reduction.

	e. Capacity building: Assess whether the initiative will help build local capacities, skills, and knowledge within the community.
	f. Scalability and replicability: Evaluate the potential for the initiative to be scaled up or replicated in other communities facing similar social problems.
Accountability	a. Feedback loops: Establish feedback loops with users, target population, and other stakeholders to gather their input and insights, and incorporate them into decision-making processes.
	b.Reporting: Implement transparent and accessible reporting mechanisms to share progress, results, and learnings with stakeholders, including donors, partners, and the wider public.
	c. Evaluation: Conduct regular evaluations, including independent assessments, to assess the initiative's effectiveness, efficiency, and impact, and identify areas for improvement.
	d. Transparency: Ensure transparency in the use of blockchain technology, including the purpose of its use, the data being collected and stored, and the mechanisms in place to ensure data privacy and security.
	e. Traceability: Ensure that the use of blockchain technology allows for traceability of transactions and data, making it easier to identify potential errors or fraudulent activities.
	f. Inclusivity: Ensure that the blockchain solution is inclusive and does not exacerbate existing power dynamics or marginalise certain groups of people. It is important to engage with the target population and other stakeholders to ensure that their needs and perspectives are considered.
BLOCKCHAIN DESIGN ASSESSMENT	
Outlining the type of blockchain	a. Blockchain type: Determine whether the initiative uses a public, private, or consortium blockchain, and justify the choice based on the specific use case and requirements.
	b. Consensus mechanism: Identify the consensus mechanism (e.g., Proof of Work, Proof of Stake, or Delegated Proof of Stake) and assess its appropriateness for the initiative's goals and scalability.
	c. Interoperability: Evaluate the potential for the blockchain initiative to interact with other blockchains, legacy systems, or external data sources.
	d. Scalability: Assess the initiative's ability to oversee increased transaction volumes and user adoption over time.
Assumptions/ Risks	a. Spoilers: Has any analysis (such as political economy, stakeholder, system analysis, or similar) been conducted to identify third-party actors whose functions, mandates, resources, identity, or interests may be threatened, mitigated, or diminished in a way that could incentivize them to hinder the use of the tool? How might these actors use their resources to obstruct the tool's usage?

	b.Data Privacy: Are effective data privacy protocols in place to prevent mishandling of relevant PII to include ensuring that only accurate data makes it on chain (especially data pertaining to individual or organisational identities)?
	c.Regulatory: To what extent was an analysis conducted to ensure that the regulatory environment supports the envisioned use of blockchain technology?
	d.Data Control: How was the level and type of permissions determined? Has there been an analysis to ensure that individuals have maximum control over their data, considering the objectives of the pilot? Was a data user map or a similar exercise conducted?
	e.Interoperability: How well does the envisioned blockchain fit into pre-existing IT infrastructure from a purely technical perspective? What are the costs (money, time, skill sets) required for doing so?
	f. Participant Awareness: To what extent does the pilot require different actors (implementers, users, etc.) to have technical knowledge of blockchain in order to achieve the objectives?
TOKEN DIAGNOSIS	
Type of token	a. Token classification: Determine the classification of the token, such as utility token, security token, or payment token, and its implications for regulatory compliance and use cases.
	b. Token standard: To what extent does the initiative identify and use a token standard, such as ERC-20 or ERC-721, and assess its compatibility with existing blockchain infrastructure and tools?
	c. Token issuance and distribution: Evaluate the process of token issuance and distribution, including initial coin offerings (ICOs), token sales, or airdrops, and its impact on token accessibility and adoption.

8.6. Enabling factor framework calculations

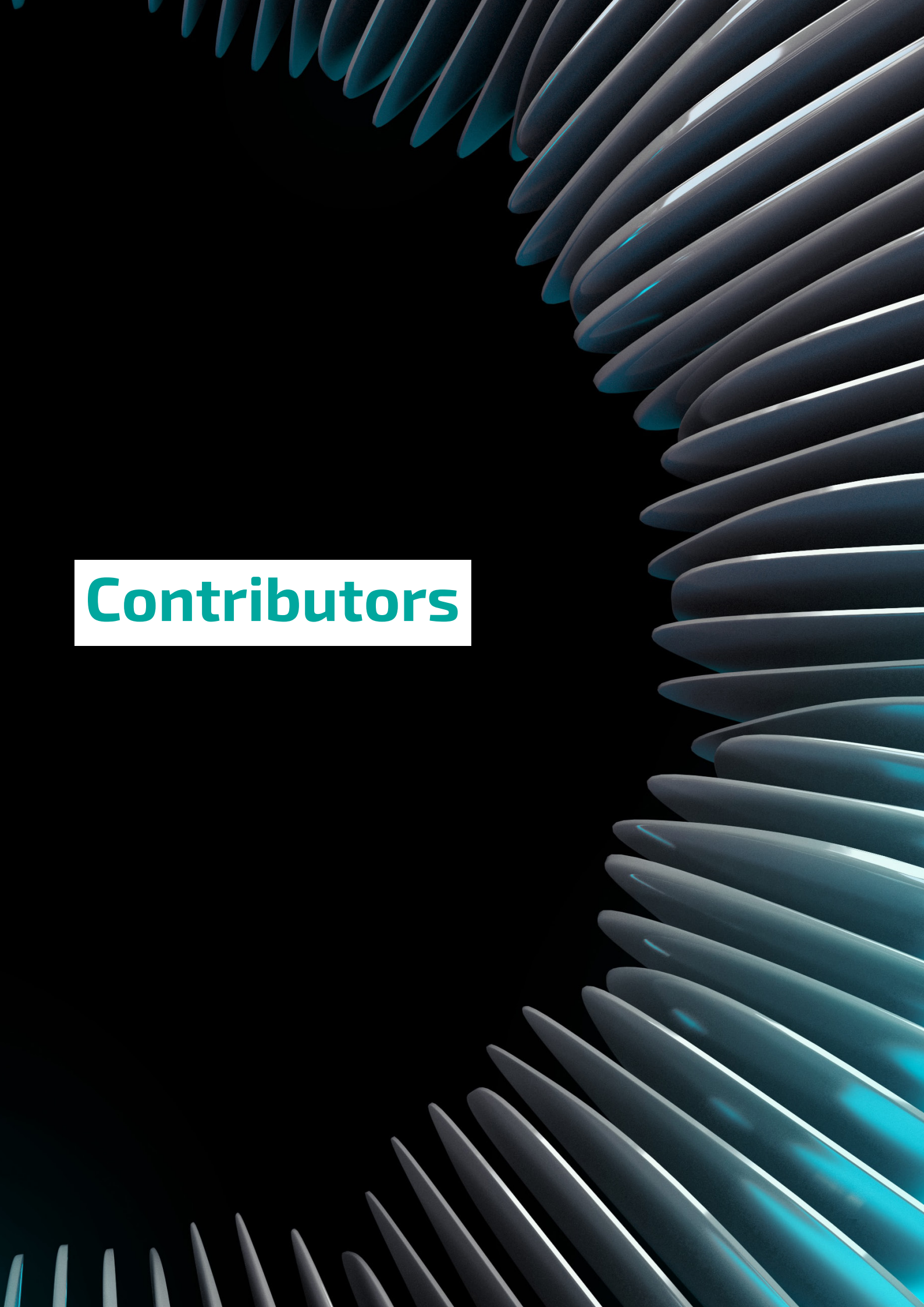
The below table gives the mean, standard deviation, and range for each dimension of the Enabling Factor Framework. The scoring for each dimension was:

- 0- Not Met
- 1- Partially Met
- 2- Mostly Met
- 3- Fully Met
- NA- Not Applicable

Table 11: Descriptive Statistics of Frontier Tech Hub Pilot Enabling Factors

SOCIAL PROBLEM						
Theory of Change and Outcome Assessment	Clear problem statement	Proposed solution	Assumptions and risks	Indicators of success		
MEAN	2,00	2,22	1,44	1,56		
STANDARD DEVIATION (SD)	0,71	0,67	0,73	0,88		
RANGE	2	2	2	3		
Need assessment	Scope of the problem	Gap analysis	Stakeholder involvement			
MEAN	1,89	1,56	1,38			
STANDARD DEVIATION (SD)	0,78	0,88	0,52			
RANGE	2	3	1			
Target population analysis	Demographic profile	Vulnerability assessment	Accessibility			
MEAN	1,00	0,88	1,00			
STANDARD DEVIATION (SD)	0,53	0,99	0,50			
RANGE	2	3	2			
Community Impact	Direct and indirect benefits	Economic impact	Social cohesion	Environmental impact	Capacity building	Scalability and replicability
MEAN	1,44	1,44	1,13	1,00	1,29	1,63
STANDARD DEVIATION (SD)	0,88	0,88	0,99	1,29	0,76	0,74
RANGE	3	3	2	3	2	2

Accountability	Feedback loops	Reporting	Evaluation	Transparency	Traceability	Inclusivity
MEAN	1,38	1,88	1,25	1,75	2,00	1,50
STANDARD DEVIATION (SD)	1,19	0,83	1,04	0,71	1,07	0,76
RANGE	3	2	3	2	2	2
BLOCKCHAIN DESIGN ASSESSMENT						
Outlining the type of blockchain	Blockchain type	Consensus mechanism	Interoperability	Scalability		
MEAN	1,44	1,00	1,67	1,56		
STANDARD DEVIATION (SD)	1,01	1,12	0,71	0,88		
RANGE	3	3	2	3		
Assumptions/Risks	Spoilers	Data Privacy	Regulatory	Data Control	Interoperability	Participant Awareness
MEAN	1,33	1,00	1,56	1,11	1,50	1,33
STANDARD DEVIATION (SD)	0,71	0,71	0,88	0,78	0,93	0,71
RANGE	2	2	3	2	3	2
TOKEN DIAGNOSIS						
Type of token	Token classification	Token standard	Token issuance and distribution			
MEAN	0,56	0,67	0,67			
STANDARD DEVIATION (SD)	1,13	1,32	1,32			
RANGE	3	3	3			



Contributors

9.1 Study Team Composition

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- Eduard Peris Deprez - Project Coordinator & Editor

9.2 The Frontier Tech Hub

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9.3 Consultative Committee

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- Caroline Hill, Senior Director of Global Policy, and Regulatory Strategy at Circle.
- Paul Perrin, Director of Evidence and Learning at the University of Notre Dame
- Jofre Rocabert, Access Manager from the Norwegian Refugee Council
- Stefan Renton, Head of Sustainability from Polygon Labs
- Tori Samples, Senior Product Manager from the Stellar Development Foundation.
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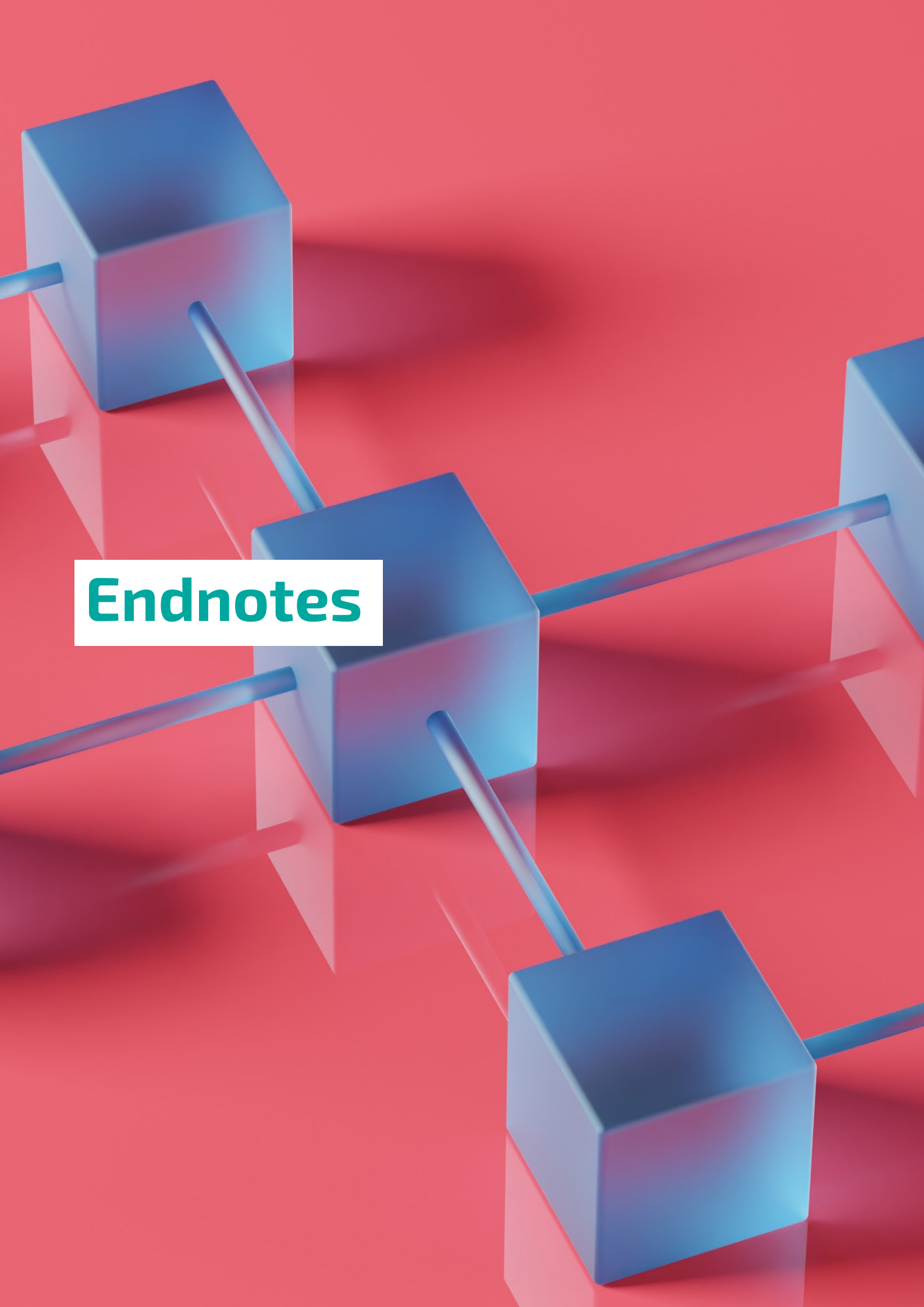

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[18] *0 indicated the dimension was not applicable; 1 represented some value but not the most valuable; 2 denoted the dimension as the most valuable in solving the problem.*

[19] The value-add of 'Trust' is verified through metrics such as 'Increased Transparency' and 'Reduced Corruption', where the incorruptible nature of blockchain promotes transparency and reduces possibilities of fraudulent activities. 'Decentralised Structure' relates to 'Better Stakeholder Collaboration' as a metric, given that it enables multiple parties to interact in a fair, non-hierarchical manner, fostering greater collaboration. 'Cost savings', as a metric, confirms the value-add of 'Reduced Costs', while 'Time savings' proves the 'Speed' value-add, where transaction and processing times are notably minimised due to the technology's inherent efficiency. The value-add of 'Improved Security and Privacy' is linked to the 'Enhanced

Security and Privacy' metric, emphasising the robustness of blockchain in maintaining secure, private transactions. 'Immutability' aligns with 'Improved Data Accuracy', as the irreversible nature of blockchain entries ensures accurate, tamper-proof records. 'Individual Control of Data' is a value-add that contributes to 'Increased Transparency' and 'Enhanced Security and Privacy', as it provides individuals the autonomy to manage their data, thus ensuring both privacy and openness. 'Visibility and Traceability' is mirrored in 'Improved Efficiency in Supply and Distribution', where blockchain's end-to-end visibility enhances supply chain efficiencies. 'Tokenization' relates to 'Cost Savings' and 'Time Savings', as it facilitates efficient, cost-effective transactions. Lastly, 'Ethical Sustainability & Accountability' corresponds to 'Reduced Corruption' and 'Increased Transparency', underscoring the role of blockchain in promoting ethical, accountable practices within the humanitarian sector. Therefore, each value-add, in essence, is related to a success metric, thus validating their significance and role in enhancing blockchain's application in humanitarian aid.

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