BLOCKCHAIN TECHNOLOGY IN DISASTER RISK MANAGEMENT: TRANSFORMING THE DELIVERY OF EMERGENCY RELIEF

CAROLINA KÄLLNER| DIVISION OF RISK MANAGEMENT AND SOCIETAL SAFETY | LTH | LUND UNIVERSITY, SWEDEN

Blockchain Technology in Disaster Risk Management: Transforming the Delivery of Emergency Relief

Carolina Källner

Supervisor: Magnus Hagelsteen

Lund 2019

Blockchain Technology in Disaster Risk Management: Transforming the Delivery of Emergency Relief

Carolina Källner

Number of pages: 52
Illustrations: 8

Keywords
blockchain technology, cash-based transfers, emergency relief, humanitarian aid

Abstract
Persisting challenges such as corruption and a lack of coordination among humanitarian organisations continuously lead to almost a third of all development assistance not reaching those in need. As various attempts of solving this dilemma have not been successful, an innovative approach is required. Organisations such as the World Food Programme have started to trial the use of blockchain technology as a payment system and alternative tool for distributing cash-based transfers. This study seeks to establish whether blockchain technology is an effective tool for the delivery of emergency relief through a scoping study and interviews with twelve informants from within and outside of the humanitarian field. Consistently, both study formats find that the benefits of blockchain technology can contribute to creating a more effective and efficient humanitarian system. Among these are the decentralisation, traceability and openness of the technology. By simplifying cooperation, increasing transparency and drastically reducing costs, the technology can tackle persisting challenges in the field. Still, drawbacks of blockchain technology necessitate a number of requirements, including internet connectivity, political will and an initial investment, to be in place for a successful implementation. Disasters with small-scale destruction, a connected environment and a long-term presence of aid agencies fulfil these requirements and can therefore potentially benefit from blockchain technology in the future. Blockchain technology will not prove to be a useful tool in every disaster scenario. In humanitarian contexts that meet the criteria the technology promises to help those in need in an efficient and dignified manner.

Riskhantering och samhällssäkerhet
Lunds tekniska högskola
Lunds universitet
Box 118
221 00 Lund

http://www.risk.lth.se

Telefon: 046 - 222 73 60

Division of Risk Management and Societal Safety
Faculty of Engineering
Lund University
P.O. Box 118
SE-221 00 Lund
Sweden

http://www.risk.lth.se

Telephone: +46 46 222 73 60

Acknowledgements

Researching for and writing this thesis would not have been possible without the input of the twelve informants. Their invaluable insight and commitment to the topic forms the heart of the thesis. Throughout the process they have shared their honest opinions, reflected on their own experiences and have unhesitantly answered some tough questions thrown at them. The knowledge you shared with me and the different perspectives you offered made the findings in this thesis in step with actual practice. Thank you!

Never having conducted any primary research before, the guidance and support of my supervisor, Magnus Hagelsteen, was especially precious. Despite the added challenge of researching and writing this thesis from abroad, he has always been by my side, giving me feedback, answering questions and providing guidance whenever necessary. Your encouragement gave me the sureness to follow through with my ideas. Thank you!

Throughout this process, I was able to always rely on my family and friends having my back and supporting me as much as they could. From helping me move during the final weeks of the thesis to reading my unpolished drafts, you have all lend a hand without me ever having to ask. I am truly grateful for having you in my life. Thank you!

Content

List of Abbreviations

CBT – Cash-based Transfers

DFID – United Kingdom Department for International Development

EU – European Union

GDPR – General Data Protection Regulation (EU)

GIZ – Gesellschaft für internationale Zusammenarbeit (German Development Agency)

ODI – Overseas Development Institute

PoS – Proof of Stake validation mechanism

PoW – Proof of Work validation mechanism

UK – United Kingdom

UN – United Nations

UNHCR – United Nations High Commissioner for Refugees

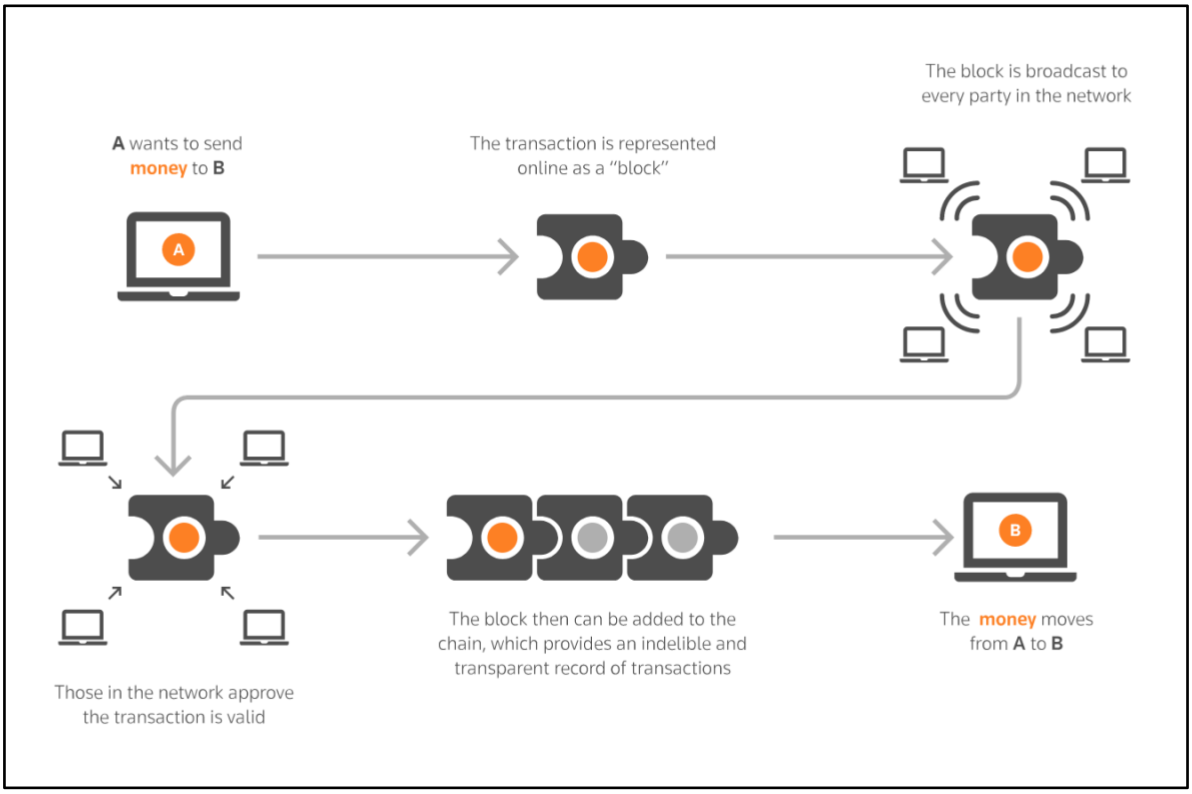
US – United States of America

WFP – World Food Programme

1. Introduction

30% of development assistance did not reach its intended target in 2011 (Ki-Moon, 2012), translating into infrastructure not developed, education not improved, health programs not implemented and most importantly, people living without the aid that was meant to be provided to them. The causes for failing beneficiaries as well as donors on such a large scale are multifaceted. Two of them are the insufficient coordination within the humanitarian sector and corruption. A lack of coordination among emergency relief actors heightens the probability of misallocated resources through for example exclusion and inclusion errors (Balcik et al., 2010; Stephenson, 2005). Corruption and fraud intentionally channel funds to those least in need, highlighting deficiencies with regard to accountability and transparency and diminishing the trust of donors (Ki-Moon, 2012). Both of these risks are deeply rooted in the environment in which those providing assistance have to act. Per definition the characteristics of a disaster, shaped by the disrupted functioning of a society, urgency and the grave suffering of people (United Nations General Assembly, 2016), complicate accountability, transparency and order. An opaque environment is created by the hundreds of aid organisations with varying missions and scales, no single agency coordinating actions authoritatively, competition for media attention and in the end funds, high turnover of field staff, blurry facts and dynamic information flows (Stephenson, 2005). How to turn this opaque chaos into a clear system has become a permanent struggle. A wide variety of methods of resolution have so far had limited success. Since Amartya Sen's famous argument for cash-based transfers (CBT) in 1980 (Sen, 1980), more than 200 resources and studies evaluating the effectiveness of CBT in different types of humanitarian settings have been published (ODI, 2015). They compellingly find that CBT are an efficient, cost-effective and most importantly accountable way of providing aid to people in need (Peppiatt et al., 2001). Compared to in-kind assistance, CBT reduce the cost of delivering humanitarian aid, increase the speed and flexibility of humanitarian responses, provide the affected populations with a dignified choice and increase accountability and transparency of the humanitarian sector (Peppiatt et al., 2001). Nevertheless, only around 6% of humanitarian aid is delivered through the means of CBT as risks, such as corruption, misallocation and diversion, remain being perceived as high (ODI, 2015). Others have argued for a central authority, preferably a United Nations (UN) agency, in disasters to achieve coordination and an effective distribution of scarce resources (Minear, 2002). A move actively resisted by donor nations and the organisations and agencies themselves, including the UN (Stephenson, 2005). Donor nations want to preserve their ability to inject political agendas and impose conditions on the resources they provide (Minear, 2002). Aid agencies are concerned about the reduced power, independence and flexibility a central authority would cause (Minear, 2002). An innovative approach and new perspective are thus required.

With the invention of blockchain technology in 2008 such a new tool for delivering emergency relief could be created. When a white paper on a digital currency system published under the pseudonym Satoshi Nakamoto appeared (Nakamoto, 2008), no one associated it with humanitarian aid. The technology first rose to prominence with the introduction of Bitcoin as an independent, digital currency (Yli-Huumo et al., 2016). Blockchain itself, however, is a foundational technology based on distributed ledger technology (Yli-Huumo et al., 2016), that could also transform other areas of society, such as the current system of delivering aid in humanitarian emergencies. How this works is illustrated in simple terms in Graph 1.



Graph 1. Illustration of Blockchain Technology (Source: Thomson Reuters, 2017)[1]

Distributed ledger technology provides a consensus validation mechanism through a network of computers that facilitates decentralised peer-to-peer transactions (Nakamoto, 2008). The two most common consensus validation mechanisms are Proof of Work (PoW) and Proof of

[1] The graph gives the impression that each block consists of only one transaction. This is incorrect, as many transactions are bundled together to form one block.

Stake (PoS) validation (Panesir, 2018). In the case PoW, network participants, often referred to as miners, compete to add the next transaction block to the blockchain by solving a complex cryptographic puzzle (Nakamoto, 2008). In the case of PoS, network participants invest digital coins in the blockchain network to represent their stake in the block (Panesir, 2018). Each transaction is validated and, along with a group of validated transactions, added as a new block to an already existing chain of blocks, the "blockchain"[2](Yli-Huumo et al., 2016). Each block can be identified by a hash (unique code), created through an algorithm to generate a string of letters and numbers, and the hash of the previous block to ensure the chronological order of the blocks (Nakamoto, 2008).

This process of transferring a range of assets securely without intermediaries (Nakamoto, 2008) combines several characteristics, including accountability, transparency and decentralisation (Dr Herweijer et al., 2018), which at first glance make the technology uniquely suitable for emergency relief. In addition to the beforementioned advantages of CBT, some of the risks commonly associated with CBT could be alleviated through the use of blockchain technology. Transaction costs and times could be omitted, monitoring and evaluating each transaction in real-time would become possible and transaction confidentiality would be ensured (DutchChain, 2017; GSM Association & DFID, 2017; Ko & Verity, 2016), leading to a more efficient, secure and transparent system of emergency relief. In the end, if effectively deployed, blockchain technology could not only be a tool for the delivery of cash-based aid but also for supply chain traceability of in-kind assistance and monitoring and evaluation of all humanitarian aid deliveries. As a result, learning from past disasters for future emergencies could become routine instead of being the exception.

These benefits for disaster risk management have convinced several actors in the humanitarian sector to explore the opportunities they present to them in practice. Most prominently, the World Food Programme (WFP) launched a project in 2017 called "Building Blocks" designed to replace its CBT in refugee camps (WFP, 2018). The private blockchain is based on the Ethereum protocol, a blockchain-based decentralised transaction ledger with smart contract functionality (Wood, 2014). A smart contract is an encoded rule reflecting any kind of multi-party interaction (Kalra et al., 2018). By May 2018, the WFP had transferred

[2] This process consists of five steps, which are described below using the example of the most common validation mechanism, PoW. Firstly, a number of transactions are bundled together in a block. Secondly, miners verify that the transactions to be processed are legitimate. Thirdly, miners attempt to solve a complex mathematical puzzle to define the order in which blocks are added to the blockchain. This mathematical problem requires finding a pseudo-random number through trial and error through computational processing power and time. Confirming the solution to the mathematical puzzle is, however, done quickly, thereby creating trust in the process. How this makes blockchain immutable is explained in Appendix 1. Fourthly, the first miner to solve the problem receives a reward. Fifthly, the block containing the verified transactions is added to the blockchain.

over $ 9 million through blockchain to refugees in Pakistan and Jordan (Opp, 2018). The organisation plans to expand its project in 2019 to all 500,000 refugees served by the WFP in Jordan and new refugee camps in East Africa (DutchChain, 2017). While this is only one example of the potential use of blockchain technology, it shows its futuristic viability in the humanitarian field. Yet, the characteristics of each disaster are unique, introducing new requirements and demands to any tool aiming to effectively deliver emergency relief. Hence, the question remains as to whether blockchain technology could present similar opportunities and promising successes in other disaster contexts.

1.1 Research Aim and Question

This thesis aims to critically assess under which circumstances blockchain technology could be used to distribute emergency relief, potentially alleviating the risks associated with common CBT systems. Creating a blockchain-based emergency relief system promises unchartered potential with regard to efficiency, accountability and transparency, but to benefit from its full potential requires overcoming obstacles and changing the status quo. It is therefore necessary to scrutinise the feasibility, effectiveness, risks and opportunities of adopting blockchain technology for CBT. This effort will be guided by the following research questions:

1. **Research Question:**

What knowledge exists around the inherent opportunities of blockchain technology and the challenges it poses?

2. **Research Question:**

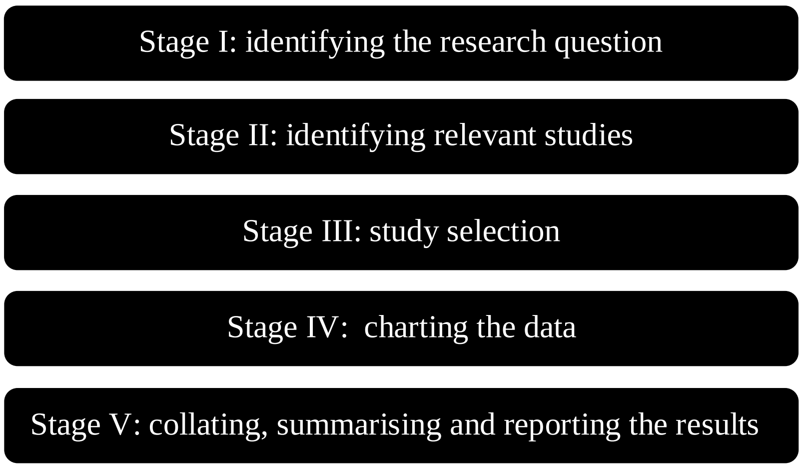
Can blockchain technology be an effective tool to deliver humanitarian aid in emergencies? If yes, in what contexts?

2. Methodology

Methodologically, this research rests on two pillars. On the one hand, a scoping study will give a comprehensive overview of the current state of research analysing the characteristics and possible applications of blockchain technology. In addition, semi-structured interviews were conducted to add an in-depth practical understanding of relevant concepts. Combining these two different types of studies and perspectives will in the end prove valuable to achieve a well-balanced discussion.

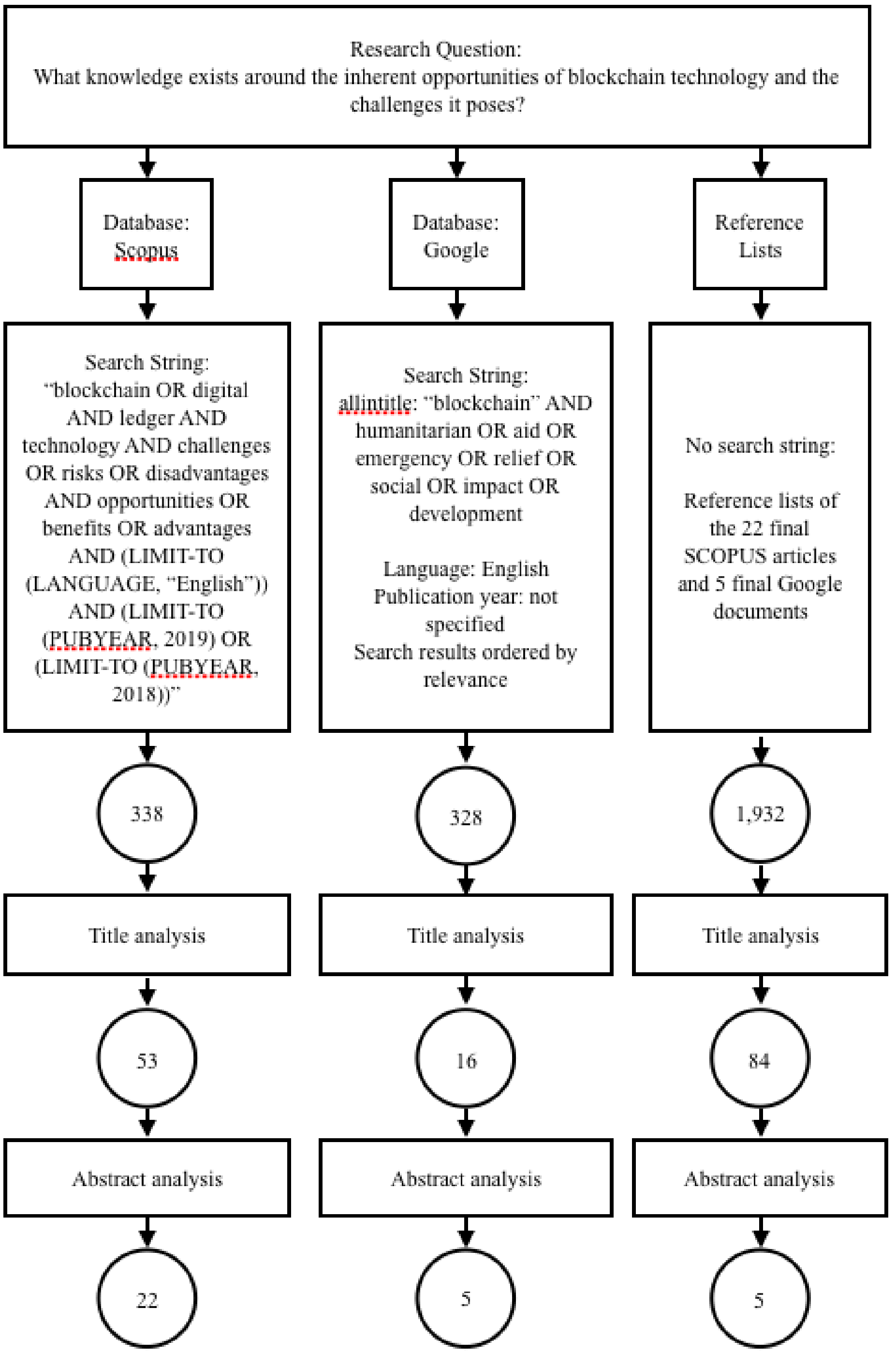
2.1 Scoping Study Methodology

The first pillar is a scoping study consolidating the status, opportunities and risks of blockchain technology in scientific as well as grey literature. While there is no single agreed-upon definition of scoping study, for the purpose of this paper scoping study can be defined as a method for mapping the state of research in a scientific field, thereby identifying gaps in the existing literature (Arksey & O'Malley, 2005). To carry this out in a transparent manner, the five-stage framework developed by Arksey and O'Malley (2005) was applied.



Graph 2. Illustration of Scoping Study Framework
(based on Arksey & O'Malley, 2005)

In the following section the application of the analytical framework to the scoping study will be explained. Beforehand, the flowchart shown in Graph 2 gives an overview of the scoping study selection process.



Graph 3. Flowchart of Scoping Study Selection Process

<u>Stage I:</u>

As basis for this scoping study, the first research question was composed:

> **What knowledge exists around the inherent opportunities of blockchain technology and the challenges it poses?**

Only a limited number of scientific articles have been published addressing this research question, since blockchain technology only received widespread attention in 2016. As a result, it was decided to keep the research question broad and also include grey literature in the inquiry.

<u>Stage II:</u>

Firstly, Scopus was used to search for scientific literature with the following search query string:

> "blockchain OR digital AND ledger AND technology AND challenges OR risks OR disadvantages AND opportunities OR benefits OR advantages AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (PUBYEAR, 2019) OR (LIMIT-TO (PUBYEAR, 2018))".

This query limited the search to documents published in English in either 2018 or 2019 to ensure that the results reflect the current status of research, as the results of prior articles could have already been overridden by the dynamic research progress in the field. Through the use of multiple synonyms it was attempted to narrow the search to all articles discussing the benefits and challenges of blockchain technology. The search in Scopus with the above stated search query string resulted in 338 documents.

Secondly, Google was used to substitute the scientific literature with grey literature. It was the aim of the Google search to fill the research gap left by Scopus, as none of the documents found in the aforementioned database were tailored to the humanitarian sector. Thus, the following search query string was used:

> allintitle: "blockchain" AND humanitarian OR aid OR emergency OR relief OR social OR impact OR development

The query limited the search results to documents that dealt with blockchain technology in the wider humanitarian sector through the use of multiple synonyms. In addition, the search was limited to English as the language of publication and the search results were ordered by Google according to relevance, not publication date. The key words "challenges" and "benefits" used in the Scopus search were intentionally left out, as this would not have yielded a sufficient number of results. However, in the next stage of the process it was made sure that the Google results as well address the research question. The Google search led to 328 results.

Thirdly, at a later stage, the reference lists of the selected documents of the Scopus and Google search, including 1,932 document titles, were explored to see if important articles or reports were missed in the previous two searches.

Stage III:

This stage was divided into two parts, a title analysis and an abstract analysis. To start with, the suitability of all documents was determined on the basis of the title of document and its fulfilment of one criterion:

1) Relevance to research question

Next, an abstract analysis was conducted to gain an in-depth understanding of the document with regard to three criteria:

1) Relevance to research question
2) Quality
3) Level of detail

Firstly, this process was carried out for the 338 Scopus documents under consideration. Once all titles were read, 53 documents from this search remained relevant. After the abstract analysis 22 articles were chosen to be read in their entirety.

Secondly, the different criteria were applied to the Google search results. In this case, it was decided to only read the first five pages (50 results). Skimming through the later pages deemed them insufficient with regard to quality and content already at first sight. After the title analysis 16 documents remained for consideration. As Google results do not have abstracts, the results were skimmed through quickly as part of the abstract analysis. The final selection resulted in 5 documents.

Thirdly, the 1,932 references of the final 27 documents were evaluated. Quickly reading all the titles left 84 documents that fulfilled the criterion and were not duplicated of already selected documents. In the end, the abstract analysis narrowed this number down to 5 additional documents.

Stage IV:

As a next step, once all 32 documents were read thoroughly, the data obtained needed to be charted. Charting data is a technique that aims to achieve a synthesis and interpretation of qualitative data according to key themes (Arksey & O’Malley, 2005). This process was divided into two steps. Firstly, the numerical data of the documents was charted according to the following categories: document title, authors, publication year, journal title or institution, country of publication and type of publication. Secondly, an in-depth analysis of the content of the documents was conducted. Here, the data was structured into six categories relevant to the research question defined in Stage I. These categories were:

1) definition of blockchain,
2) focal industry or use case,
3) benefits,
4) challenges and risks,
5) prediction of future development.

<u>Stage V:</u>

Lastly, the results have to be summarised and reported on, as found in Chapter 3.1.

2.2 Interview Study Methodology

The objective of the interview study was to supplement the theoretical understanding of the topic with practical insight. The interviews were supposed to contribute to answering the research questions through gathering experiences of those who have worked with blockchain technology and can reflect on the opportunities the technology provides and the challenges it poses.

2.2.1 *Informants*

Three different groups of people were considered as potential informants, with the goal of interviewing between 10 and 12 people in total. Firstly, disaster risk management or other professionals from the humanitarian sector that have worked with blockchain technology before were contacted. As blockchain technology is in its infancy in the humanitarian field, only a handful of potential informants could be identified. All of the five humanitarian professionals contacted agreed to take part in the study. Secondly, to supplement these and in the spirit of learning, professionals working with blockchain technology in other industries and fields of work were considered as potential informants. Of the 14 professionals reached out to, six agreed to be interviewed. It was expected that the majority of practitioners to be interviewed would be pioneering the technology in their respective organisations based on the conviction that it entails fundamental advantages. Thirdly, to counterbalance this perspective and in an effort to compile a variety of experiences, blockchain experts, such as researchers, were also be considered as informants. Three experts were contacted, and one was willing to share his knowledge. In total, 22 informants were contacted and 12 agreed to be interviewed. Eight informants never responded to the request and two explained that they did not feel they had sufficient knowledge of the topic. All potential informants were contacted either through an existing network, of the author, her supervisor or her colleagues, or through snowball sampling. The detailed distribution of informants across sectors and occupations can be found in Table 1.

	Informant	Position / Organisation
Professionals from the humanitarian sector	Informant 1	Consultant for the World Bank, UNHCR, DFID, and GIZ
	Informant 2	Senior policy program officer at WFP
	Informant 3	Systems engineering officer at WFP
	Informant 4	Finance officer at WFP
	Informant 5	Program coordinator at GMFA
Professionals from other industries	Informant 6	Co-founder of a blockchain consultancy
	Informant 7	Entrepreneur
	Informant 8	Country manager and consultant at an innovation consultancy
	Informant 9	Co-founder of a blockchain consultancy
	Informant 10	Managing director of a digital consultancy
	Informant 11	Portfolio manager at an energy innovation centre
Blockchain Experts	Informant 12	Founder of blockchain competence centre

Table 1. Distribution of Informants by Industry and Occupation

This categorisation gives an overview of the prior experience the informants have had with blockchain technology and in which context these experiences were made. It shows that most of the informants are not technical experts and software engineers but are rather responsible for projects and programs within different. All of the informants have worked with or advised clients on blockchain technology for the last couple of years, forming their assessment of the technology.

2.2.2 *Procedure of interviews*

It was decided to carry out the interviews in a semi-structured manner. Quantitative study formats such as surveys or questionnaires were deemed inadequate, considering the in-depth character of questions to be posed in pursuit of answering the research questions (Brinkmann & Kvale, 2015). As the expertise of informants varied from group to group, semi-structured interviews were preferred over a structured format. This gave the interviewer the chance to adapt the questions according to the knowledge and experience of each informant and allowed the informants to expand on topics they excelled in (Brinkmann & Kvale, 2015). Prior to the first interview an interview guide was constructed to ensure the consistency and comparability between the different interviews (Brinkmann & Kvale, 2015). The questions in the guide were based on the research questions of the thesis. To allow space for open discussion and the development of ideas, the questions in the interview guide are broad. This was experienced as beneficial during the interviews as it gave the interviewer the opportunity for the development of a conversation around the topics most prevalent to the individual informant. After conducting the first interview, the interview guide was reviewed to see if any changes needed to be made. As a result of the observations, the order of questions was adapted and the last question was added to the interview guide, found in Table 2.

Table 2. Interview Guide of Semi-structured Interviews

Interview Guide:

1. Could you please state your name and your current position?
2. What is the first thing that comes to your mind when you hear the word “blockchain”?
3. Can you tell me about your background with regard to blockchain technology?
    a. How long have you worked with blockchain technology?
    b. How were you first introduced to the technology?
    c. To what extent has your work revolved around blockchain technology?
4. What opportunities and advantages does blockchain technology present?
    a. For your organisation?
    b. For your partner?
    c. In a project?
5. What kind of challenges have you or has your organisation / company observed respecting blockchain technology?
6. What advice would you give to an organisation wanting to explore blockchain technology?
7. What is your prediction how blockchain technology will develop in the future?

Once a time for the interview was agreed upon with the informant, they were able to choose the communication medium of their preference. Except for two interviews that were conducted over the phone, all were conducted via Skype or similar platforms. All interviews were audio only, without the use of a video to ensure a consistent format. In the conversations prior to the interview, the informants were asked for an interview lasting between 20 and 25 minutes. Overall, the interviews lasted between 26 and 53 minutes. Thus, all interviews lasted longer than the predicted time, as most informants were willing to go into detail discussing their blockchain projects. After a quick introduction, including a description of the research aim and a clarification of the formal parameters, the interview was started and with it the recording. Each informant was given the option to remain anonymous and was asked for permission to record the interview. Using the interview guide as a rough direction of the interview, the questions were asked as they arose in the conversation. Every interview consistently started with a quick introduction of the informant and their experience and connection to blockchain technology. Depending on the information given in this section, the questions were either steered to gain insight into the general challenges and opportunities connected to blockchain technology or the specific application in the humanitarian sector, particularly as a tool for delivering CBT.

2.2.3 *Analysis of interviews*

Once all interviews were recorded, they were transcribed into a formal, written style, resulting in 111 pages of transcriptions. The focus of the interviews was on the experience and knowledge of the informants with regard to blockchain technology, not their subconscious emotions. The analysis of transcripts was performed similarly to that of the literature. The data was structured or coded (Brinkmann & Kvale, 2015) into six different categories, reflecting the questions of the interview guide. These categories were similar to those of the scoping study i.e.:

1) blockchain related experience,
2) first association,
3) benefits,
4) challenges,
5) advice,
6) prediction of future development.

The results can be found in Chapter 3.2.

2.3 Limitations of Methodology

The methodology applied in this thesis has several constraints limiting the universal accuracy of the data collected, and conclusions drawn. Both the set-up of the scoping study and the interview study bring about inherent limitations. The scoping study's foundation is the choice of databases and the framing of the search query string. In this research, only two different databases were used and only 1% of the found documents were selected for in-depth consideration. This was a consequence of the resources available and the selection criteria. Choosing different and more databases or defining broader selection criteria could have resulted in more diverse results. Additionally, it should be mentioned that limitations placed on the search, such as English as the publishing language, resulted in documents concentrated in the western hemisphere geographically and in engineering and computer science faculties functionally. Thus, it is possible that relevant literature was not read as part of the scoping study.

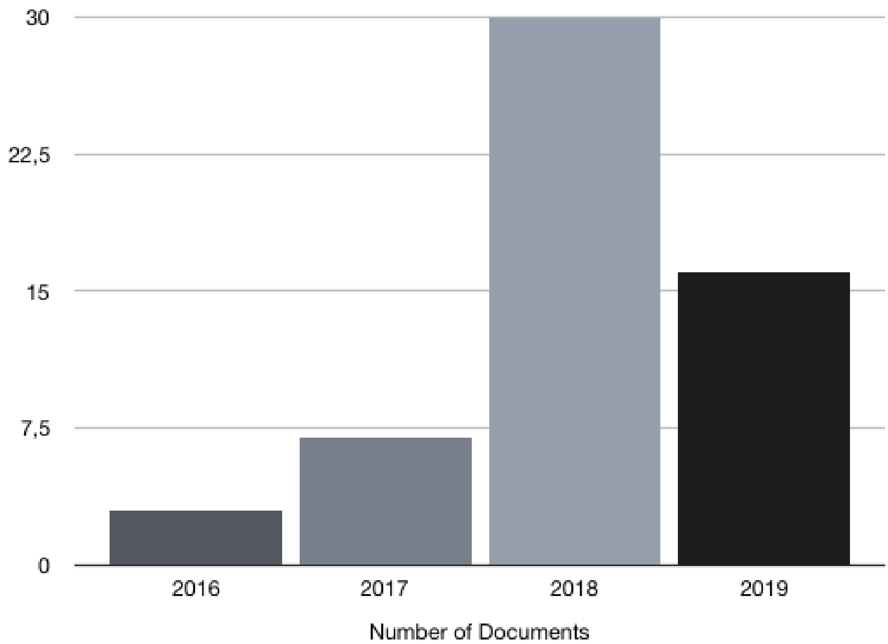
The results of the interview study are entirely dependent on the choice of informants. Using snowballing as one the techniques for contacting potential informants bares the risk of introducing another psychological bias to the study, as it can be presumed that people are more likely to recommend people with similar opinions. Besides the methods, interviewing a non-representative number of people also means that the results can only depict a part of reality. Furthermore, the data collected in the scoping study and in the interview study was interpreted by the author, whose own psychological biases such as the confirmation bias could have influenced the interpretation of the data.

3. Results

This chapter presents the results of the scoping study and the interview study. Both the primary and the secondary research accumulated seek to lay the foundation for answering the research questions.

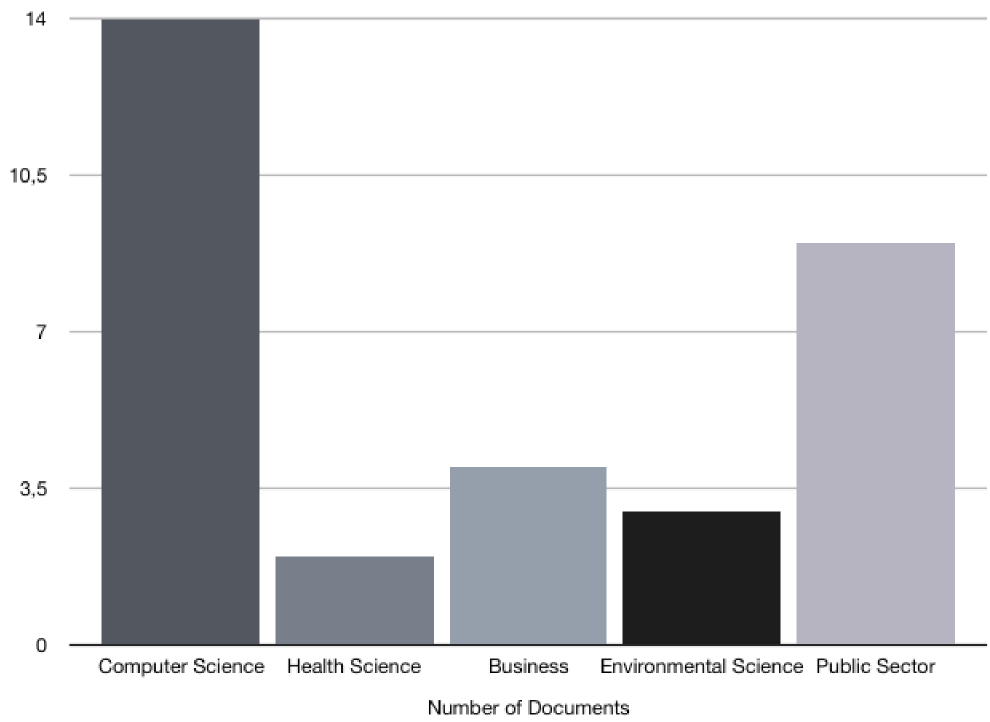
3.1 Results of the Scoping Study

Before delving into the current state of knowledge of blockchain technology, a better understanding of the documents considered should be established. All of the 32 documents studied are reviewed simultaneously, without making a differentiation between the scientific and grey literature, as the findings of both largely concur. They were published between 2016 and 2019, with a clear majority of 20 published in 2018, thereby reflecting the most recent findings available to date. A search in Scopus, illustrated in Graph 4, found that no paper with the keyword “blockchain” in the title or abstract was published before 2016.



Graph 4. Publication Dates of Papers with Keyword “Blockchain” in SCOPUS

Most of the documents are either journal articles or conference papers, but some are also book chapters or reports published by various international organisations. Sorting them by discipline, one finds that most could be categorised as computer science or engineering papers, as illustrated in Graph 5.



Graph 5. Distribution of Considered 32 Documents by Discipline

However, there are also some from disciplines in which blockchain technology could find an application. Only nine documents relate directly to applications in the humanitarian or public sector, highlighting the need for research in this field. While this scoping study reflects research from around the globe, ranging from Taiwan to Pakistan to Morocco, it should be noted that most documents had at least one contributor from a developed country. The detailed numerical analysis can be found in Appendix 2-4.

In the next sections, a synthesis of the knowledge that exists around the inherent opportunities and challenges of blockchain technology is presented.

3.1.1 *Definitions of blockchain technology*

As all of the 32 documents studied define blockchain technology differently, it can be presumed that no single agreed upon definition of blockchain technology exists. Not only do the definitions differ in terms of phrasing, but also with regard to the approach of defining the technology. While 24 definitions describe the functioning of the technology and the origin of the name, eight also define it through its inherent characteristics or its possible applications, differentiating it from traditional databases. A couple also take into account the impact the technology could potentially have in the future. In Radanović and Likić (2018) an example for a technical definition of blockchain technology can be found:

> "Blockchain is a decentralised database (ledger) that stores a registry of assets and transactions across a peer-to-peer computer network acting as a public registry of ownership and transactions, which is secured through cryptography, and over time, its history gets locked in blocks of data that are then cryptographically linked together and secured" (Radanović & Likić, 2018, p.584)

This definition classifies blockchain technology as a type of database and then continues to describe its setup and mode of operation, indirectly pointing towards some of the inherent characteristics of the technology, such as decentralisation, transparency and security. Other definitions addressing the functionality use key words such as infrastructure, technology or network to classify blockchain technology. These types of classifying blockchain technology are different in scope, with database being the narrowest definition and infrastructure being the broadest.

3.1.2 *Benefits of blockchain technology*

A multiplicity of benefits of blockchain technology can be found in both the scientific and the grey literature. For clarity purposes, these have been grouped into three categories, namely decentralisation, traceability and automation. While decentralisation and traceability are addressed by all 32 authors, automation is considered by 12.

Decentralisation is the cornerstone of blockchain technology (Boucher, 2017). Due to the distributed ledger and consensus mechanism, blockchain technology operates without a central database and instead uses network nodes (Nakamoto, 2008). As a result, there is no single point of failure, no intermediary, no central authority in the case of transactions (Abujamra & Randall, 2019; Killmeyer et al., 2017; Kouhizadeh & Sarkis, 2018). This characteristic manifests itself as a benefit in varies ways. Firstly, in the case of financial transactions, local banks are left out as intermediaries, reducing transaction costs drastically and decreasing the latency of international transactions (Boucher, 2017; GSMA & DFID, 2017). Secondly, without a central database the digital identity, a reflection of the physical person, is the owner of its data and can determine how his data is being used (Flynn et al., 2019; UK Government Chief Scientific Adviser, 2016). In the case of humanitarian aid, beneficiaries would receive control of their own data (Thompson, 2018). Thirdly, storing data on network nodes prevents data loss that can occur in centralised databases in the case of unexpected events (Gatteschi et al., 2018). Fourthly, as all network nodes hold a record of all transactions, blockchain technology is almost tamper-proof (Flynn et al., 2019; Zwitter & Boisse-Despiaux, 2018). This creates trust in an otherwise trustless environment (Makhdoom et al., 2019). Last but not least, the decentralised system of blockchain technology allows for easier cooperation, as no owner or administrator has to be identified and there is no hierarchy between users (Lo et al.,2017). All participants on a blockchain network have equal status, can submit, review and verify records and see the most up-to-date information (GSMA & DFID, 2017). This is the primary characteristic that unmistakably differentiates blockchain technology from other databases (Lo et al., 2017).

Traceability is one of the greatest promises of blockchain technology and the result of transparency and immutability (Johng et al., 2018). Transparency arises through the public announcement of each transaction, which takes place for each node of the network to maintain the same copy of the chain of transactions (Alketbi et al., 2018; Killmeyer et al., 2017). Immutability of all data once recorded on a blockchain is ensured through the decentralised nature of the technology in addition to the timestamp attached to every transaction (Lin & Liao, 2017; Makhdoom et al., 2019). Together they ensure accountability, as each transaction made on the blockchain can be traced back at any time (Zwitter & Boisse-Despiaux, 2018). For this reason, UN Women has for instance explored whether blockchain technology could result in information and resources being used in a more transparent and accountable manner, as CBT could be traced from the donor to the beneficiary in real-time (Skogvang, 2018; Thompson, 2018). This would avoid financial aid getting lost to corruption and fraud (de Vrij, 2018; UK Government Chief Scientific Adviser, 2016).

Automation, through the use of smart contracts in conjunction with blockchain technology, sets significant efficiency gains in motion (Rodrigues, Bocek, & Stiller, 2018). Smart contracts here refer to code stipulating the obligations to be performed by each party to the contract and the execution conditions (Gatteschi et al., 2018; Wu & Tran, 2018). The blockchain protocol then automatically assesses the execution conditions and, when all determination conditions are fulfilled, puts the contract terms into effect (Wu & Tran, 2018). Processes or intermediaries that themselves do not add value can be omitted, such as local banks in CBT processes of humanitarian aid organisations or accounting companies in some auditing processes (de Vrij, 2018; Karajovic, Kim, & Laskowski, 2019). Moreover, the implementation of a contract can be effectively ensured without the supervision of a third party (Wu & Tran, 2018). The combined increase in efficiency can save costs and accelerate the speed of processes (Killmeyer et al., 2017; Zwitter & Boisse-Despiaux, 2018).

3.1.3 *Challenges with blockchain technology*

A large quantity of challenges, some specific to the industries deliberated, can be found in the literature. These have been grouped in the categories scalability, data security, immaturity and ideology. Scalability is seen as a serious issue by 21 of the 32 documents inquired, while data security and immaturity are a concern of 20 authors each. The aspect of ideology is less prevalent in the literature, only addressed in six articles.

The **scalability** of blockchain technology is the most commonly mentioned flaw of the technology, addressed by 19 articles. Due to the decentralised nature of the ledger, each network node has a copy of all transactions (Killmeyer et al., 2017). This system reduces the speed of transactions and requires high processing power and data storage (Wu & Tran, 2018). To date, mainstream public blockchains can only process up to 20 transactions per second, whereas traditional payment systems such as VISA can process an average of 1,700 transactions per second (Lo et al., 2017). Additionally, the computational power needed for blockchain protocols based on Proof of Work validation consumes extremely large amounts of energy (Kouhizadeh & Sarkis, 2018; Niranjanamurthy et al., 2018). It is estimated that Bitcoin's electricity consumption is comparable to that of Uzbekistan or 4.7 million US households (Digiconomist, 2019). This calls into question not only the financial viability of public blockchains but also its impact on the environment and sustainability (de Vrij, 2018). It has to be noted, however, that these numbers vary greatly depending on the type of blockchain, it being public, permissioned or private (Casino et al., 2019). In the case of private blockchains, where the number of network nodes is limited, this does not present a notable challenge (Karajovic et al., 2019). However, public blockchains could quickly increase in scale, profoundly testing the scalability of the technology (Casino et al., 2019).

Data security has become a wide-spread household discussion in the European Union (EU) since the implementation of the General Data Protection Regulation (GDPR) in 2018. For the public, the security of data has become an important issue (Boucher, 2017). In the case of blockchain technology, its ability to deliver data security is disputed. Firstly, the often promised anonymity of data (Lu, 2018; Niranjanamurthy et al., 2018) is not factually accurate. Blockchain technology only warrants pseudo-anonymity. This is provided through the combination of a user ID with unlinkability, meaning the impossibility to link an address of the blockchain system with a real identity or IP address (Conoscenti et al., 2016; Makhdoom et al., 2019). Whether this is actually sufficient to guarantee the anonymity of those using the technology is disputed (Harris, 2018; Zwitter & Boisse-Despiaux, 2018). Secondly, traceability can also be regarded as an issue in connection with data privacy and confidentiality (Carminati et al., 2018; Lo et al., 2017). Some therefore argue that blockchain technology should not be deployed to store sensitive information (Rodrigues et al., 2018). Thirdly, the robustness of blockchain is generally considered to be high. Yet, blockchain attacks could be accomplished through, for example user identity theft, node theft, the injection of malicious code, denial of service or 51% attacks[3] (Alketbi et al., 2018; Lin & Liao, 2017; Niranjanamurthy et al., 2018). 51% attacks target the consensus mechanisms of blockchain technology through acquiring the majority of a blockchain's nodes, thereby being able to control it (Radanović & Likić, 2018).

Immaturity means that the technology has only been researched, tested and implemented for a limited amount of time and experts are still far and few between (Min, 2019; Radanović & Likić, 2018). Some of the risks associated with the technology and long-term consequences are therefore still unknown (Lindman et al., 2017; Wu & Tran, 2018). One example is the impact of advances in quantum computing on blockchain technology, as these could render public key encryption currently used in blockchains insecure (Casino et al., 2019). The novelty of the technology also implies that standards, regulations and laws surrounding the design, implementation and use of blockchain technology are still largely lacking (Lu, 2018; Wu & Tran, 2018). For companies or organisations already developing blockchain solutions this means that they cannot ensure the future compliance of their blockchain protocols with the legislation in their respective countries (Harris, 2018; Min, 2019). Another side effect of the lack of norms is the increased difficulty to ensure interoperability of different blockchain protocols (Casino et al., 2019; Flynn et al., 2019).

Ideology, connoting the ideals which form the basis of blockchain technology, is only mentioned by few authors. Nonetheless, these draw attention to the fact that the benefits discussed in the previous section are based on the assumption that the ideology of blockchain technology is seen as largely positive (Niranjanamurthy et al., 2018; Ølnes & Jansen, 2018). It signifies a distribution of power and a change in governance structures, challenging existing regimes of authority and control (Ølnes & Jansen, 2018). Implementing blockchain technology hence requires convincing decision-makers of the advantages of such as shift and effective change management (Niranjanamurthy et al., 2018). To benefit from the full potential of blockchain, i.e. its ability to allow for cooperation in a trustless environment, organisational changes are required which run contrary to the intuition of those who have worked in government structures or highly competitive business environments for a large part of their life (Ølnes & Jansen, 2018).

3.1.4 *Predicted future development*

Without exception all articles, book chapters, papers and reports attest blockchain technology the potential to become a disruptive technological force in the future. How far in the future is,

[3] 51% attack refers to a type of attack "where a group of transaction validators controls more than 50% of the network's computing power" (Radanović & Likić, 2018, p.584)

however, highly disputed. Observed developments, such as 33% of 3,000 global C-suite executives surveyed already considering or actively engaging with blockchain (Casino et al., 2019; IBM, 2017) and state governments (Estonia, United Arab Emirates) pioneering blockchain, lead some to believe that the broad adoption of blockchain technology in different types of industries is not far away. Conversely, others consider the potential of the technology not fully proven yet and point towards existing challenges before the technology can be mainstreamed (Flynn et al., 2019; Makhdoom et al., 2019; Radanović & Likić, 2018). Firstly, a majority of authors agree that further research is necessary to find solutions to unsolved issues, such as the scalability of the technology and its high energy consumption (Abujamra & Randall, 2019; Alketbi et al., 2018; Tribis et al., 2018). Secondly, with only few blockchain projects implemented before 2017, a comprehensive analysis of the long-term costs and risks associated with blockchain technology does not yet exist (Wu & Tran, 2018). Questions regarding ongoing maintenance of the systems, their long-term viability, risks associated with changes to the organisational and business structure as well as threats to social interaction remain unanswered (de Vrij, 2018; Min, 2019; UK Government Chief Scientific Adviser, 2016).

3.2 Results of the Interviews

To contextualise the data of the interviews, it is imperative to understand who made the following statements. Five of the informants work within the humanitarian field, six are professionals of different industry sectors and one informant is a research expert. Table 1 in the Methodology Chapter gives a more detailed overview of the occupations and sectors the informants work in and the experiences they have gathered. How their viewpoints conform or dissent will be illustrated in the next sections.

3.2.1 *Definition of blockchain technology*

As spontaneously defining a complex technology over the phone could have put pressure on the informants, they were instead asked for the word they associate with blockchain technology. The responses received can be grouped into four categories: public image, functionality, personal experience and impact, highlighting the ambiguity of the concept.

Public image incorporates those associations that illustrate how the wider public has reacted to the technology. This is the category seven informants in total fall in. Reactions here range from “hype” to “misunderstood” and “cryptocurrencies”. Informants 1 and 6 both referred to the hype and continued to explain that the hype behind the technology is actually detrimental to the dissemination of research and factual knowledge in the field. Informant 9, who used the word “misunderstood”, took a similar approach, clarifying that too much inaccurate information is circulating, with many people suddenly asserting that they are experts in the technology. Informant 5 articulated “cryptocurrencies”, rationalising that this seems to be what the public associate blockchain technology with. The informant, however, made clear that this is unfortunate, as the challenges bitcoin for example has experienced are not representative of the foundational technology.

Functionality, personal experience and impact are less prominent, with only one to three informants falling in each category. Functionality encompasses those associations that describe the technical dimension and functioning of the technology. Informants 3 and 8 fall into this category, describing blockchain as a “distributed ledger and database technology” and a “complex network” respectively. Personal experience includes those associations that refer to a specific blockchain project the informant was part of. Only Informant 4 had a personal association, replying with “Building Blocks”, the WFP’s blockchain project in Jordan. Impact covers those associations that enclose a prediction of the effect blockchain technology will have on a particular industry or society. Informants 11 and 12 both fall into this category as they used the words “disruption” and “change” to characterise the impact of blockchain technology. While both of these words seem to have a positive undertone, Informant 10 pictured the technology as a “hammer in search of a nail”, referring to the lack of successful use cases and thereby indirectly voicing scepticism.

3.2.2 *Benefits of blockchain technology*

A wide variety of advantages of blockchain technology were pointed to by the informants. Under the categories decentralisation, transparency and immutability, trust as well as openness these have been consolidated. Whereas decentralisation and trust were mentioned by all informants as a benefit, transparency and immutability were touched upon by 11 and openness by 4 informants.

Decentralisation is seen as the main benefit of blockchain technology by all the informants. Distributing information across users, instead of holding them in one central place, generates a variety of positive effects according to the informants. Firstly, distributing information means distributing power and governance. In the humanitarian sector, where ownership of all involved parties, including the beneficiaries, is valued and sought after, blockchain technology could include those in processes that are usually overlooked (Informant 2). At the moment, creating a wallet for someone on a blockchain does not give the person the same access a banking card would, but it does include the person in a network (Informant 1). In the future, this could change and coins on a blockchain could become an accepted currency in many countries, thereby giving people with a wallet on a blockchain access to an array of services they are usually deprived of (Informant 7). In any case, decentralisation means greater control by the end user and that the ownership of data lies with the individual person (Informant 4). This aspect is highlighted by Informant 9:

> "We don't know what happens with our data when we use other technologies or other solutions. We use social media and social networks and even IOP systems, there we don't really have control over our data, what's happening and how they're using it. With blockchain that changes drastically."

Secondly, the informants are in agreement that decentralisation allows for easier ways of cooperation. In the humanitarian sector, donors, governments and other organisations could collaborate and share information on a blockchain (Informant 3). As Informant 4 emphasises:

> "You can achieve coordination with traditional IT solutions, but there's always an issue of who's going to be the administrator or the owner of the system."

This problem seizes to exist with blockchain technology, as decentralisation means shared ownership of the system itself and the data on it (Informant 2). All actors on the blockchain cooperating still have to agree on many other terms and conditions of using such a new system (Informant 10). As a result, the informant notes:

> "The advantage is not blockchain, the advantage will be the collaboration part of it."

Thirdly, decentralisation disintermediates actors that do not add value by exposing activities that lack additional value to a project, system or operation (Informant 9). In the case of CBT, the disintermediated actors would be the local banks that are usually the middle man between an international aid organisation and the beneficiaries (Informant 4). Leaving out the local banks eliminates almost all of the transaction costs, eradicates some of the previously existing risks, such as the financial risk of transferring large sums of money to a bank in a shaky environment and abolishes the need for advanced transfers (Informant 4). Moreover, it increases the speed of registering new beneficiaries from up to two weeks to a couple of minutes and improves data privacy of beneficiaries as their data no longer needs to be shared outside the UN system (Informant 4).

Traceability is another characteristic of blockchain technology that 11 out of 12 informants perceived as advantages. It is the result of the interplay of transparency and immutability (Informant 8). In the case of the delivery of emergency relief, this means that it becomes easier to trace where the donor money goes (Informant 2). Corruption and fraud become much more difficult and easier detectable (Informants 2,5 and 7). Inclusion and exclusion errors could be reduced significantly (Informant 2), meaning that the chances of those most vulnerable receiving aid could be increased. In addition, aid organisations could use blockchain technology to improve their monitoring and evaluation processes, as they are no longer reliant on the information they are given by the banks but can trace the cashflows themselves (Informant 4). In an appropriate environment this could mean that supermarkets in refugee camps could take into account and stock food and other items more according to the needs of the refugees (Informant 4). Other use case such as the supply chain management and traceability of in-kind assistance, once the processes are automated, would also become possible (Informant 4). All of these potential processes would increase the accountability of organisations, on the one hand towards their donors, and on the other hand, towards the beneficiaries they are assisting (Informant 2).

Trust is the product of the described characteristics of blockchain technology and a valuable asset in a trustless environment (Informant 12). Human interaction has always been based on trust to a certain degree (Informant 12). Through globalisation, trust has become less common and harder to achieve. Why this is the case is explained by Informant 12:

> “Back in the old days, in one village, where you didn't have much contact with the outside, then every villager knew what everybody else was doing and so everybody could trust themselves on that basis. But now the whole world, we are not able to know everybody, so 7 billion people. So, what else can we do to regain this trust that you need to do business, what you need to feel save and feel comfortable. Then along comes blockchain technology that could restore this trust.”

Openness is another benefit of blockchain technology, only mentioned by four informants. It refers to the technology being openly available, its functioning and processes being transparent and the lack of attachment of the technology to a specific company or organisation (Informants 2,3,4 and 9). In the case of aid organisations, this means that they can develop or acquire a blockchain protocol in a cost-effective manner (Informant 4). Moreover, this would potentially allow aid organisations to hand over a specific blockchain to another, local aid organisation or the government, once they have completed their mission in the country (Informant 2). As a result, the continuity of assistance to beneficiaries could be ensured and more long-term successes could be monitored and evaluated (Informant2).

Other benefits, such as security (Informant 5,12), robustness (Informant 7) and anonymity (Informant 10), are only mentioned by few and are to be regarded as disputed, as will become evident in the next section.

3.2.3 *Challenges with blockchain technology*

Each informant recounted the challenges they had experienced in conjunction with blockchain technology. Some of these were specific to project or use case at hand, but broadly they can all be grouped into four categories, namely immaturity, ecosystem, scepticism and technical challenges. Immaturity and the ecosystem were addressed in different ways by all informants. Scepticism and technical challenges were discussed by 10 and 6 informants respectively.

Immaturity is the most obvious flaw of blockchain technology according to the informants. With only a decade under its belt, and only a few years of practical use cases, many organisations and companies are still waiting to see how the technology will develop in the future (Informant 12). All of the informants regard the technology as immature and draw attention to the relatively limited amount of research that has been conducted about the challenges the technology presents and the consequences it might have on processes and people. As a result of the lack of time that has passed, some informants assert that a successful use case of the technology has yet to be found (Informant 1, 4, 10). Informants 1 and 4 here refer to the fact, that the existing use cases, such as the WFP's "Building Blocks" project, could have been carried out with other, more traditional databases. As long as the trump card of blockchain technology, the possibility for cooperation, has not been played, the full potential of the technology has not been explored and its advantages compared to other technologies are limited (Informant 1, 10).

The **ecosystem,** in which blockchain technology seeks to be applied, often presents the first problem according to the informants. In order for blockchain technology to work in a humanitarian setting, several requirements need to be in place (Informants 1,3,4). Firstly, internet connectivity is required to process transactions based on the blockchain (Informant 3). Long-term crises, such as the Syrian civil war and resulting refugee camps, can establish such an internet connection (Informant 4). In other settings, where the camps are more remote or where a natural disaster has wiped out the networks, aid organisations cannot operate a blockchain (Informant 4). Secondly, the beneficiaries that are to be reached need to be digital (Informant 1). While mobile phones might be owned by most beneficiaries of one emergency, in another context this might not be the case (Informant 1). In such an instance, a digital identity of the beneficiary needs to be created first, before he or she can receive any assistance through the blockchain (Informant 1). Thirdly, if the coins or tokens that represent a currency on the blockchain, are not commonly accepted, many of the advantages discussed before do not materialise (Informant 1). In the case of WFP's "Building Blocks" project in the Zaatari refugee camp, the camp's size allows for the comparison to a city (Informant 1). Supermarkets within the camp have been equipped with iris scanners as a tool for identifying beneficiaries and they can pay in these supermarkets using their blockchain wallet (Informant 4). However, the benefits of the blockchain are limited to the camp (Informant 1). It does not give refugees access to a bank, or other opportunities outside the camp, therefore not creating any systematic change (Informant 1). Furthermore, the benefits of traceability, monitoring and evaluation by the organisations are also limited in such a case, as summarised by Informant 1:

> "Ultimately, at the very end, somebody gets paid with cash or with a bank transfer and then you still have a parallel process that you cannot track."

Scepticism from all sides is a hurdle to be overcome with efficient awareness raising and change management (Informants 3,4,6,8). How important change management is for the success of the technology is underlined by Informant 3:

> "Blockchain is just a choice of technology. It's not about choosing or not choosing blockchain, it's about managing the whole collaboration and also the change management"

Independent of blockchain technology, for any new technology to be successful, decision-makers have to be open to change and recognise that holding on to the status quo will not lead to gains in efficiency or growth (Informant 6). Building such a consensus in traditional, hierarchical structures and bureaucratic systems can, however, be tough, as highlighted by Informant 4:

> "Maybe 10% of my time has been spent on the technical parts. 90% has been in consensus building and gaining agreement, overcoming resistance and change management."

The first issue experienced by those trying to discuss blockchain opportunities is often its association with Bitcoin and other cryptocurrencies and the volatility they have experienced in recent years (Informant 3). As a result, blockchain for many that have a superficial understanding of the technology has a negative connotation. Overcoming this scepticism means battling the lack of knowledge and experts that exists around blockchain technology and putting trust in a not yet fully matured technology (Informant 5). At the moment, the result of the persisting scepticism is a lack of market adoption among companies and a lack of regulations and laws passed by governments (Informant 11). Both of these factors present challenges for those that are currently developing blockchain solutions, as they are steering in an unknown future, not knowing if their protocol will fulfil possible future legislation and market demand (Informant 11).

Technical challenges, while only making up a fraction of the challenges mentioned, are experienced by those exploring blockchain technology as well. The most critical of these is data security in connection with immutability. Some of those from within the humanitarian field are concerned about blockchain technologies' compliancy with EU GDPR (Informant 2), while others do not perceive this to be a problem (Informant 3). All informants stress that no sensitive data should be stored on a blockchain to avoid the risk that sensitive data could be abused. As the data is immutable, and no organisation can be certain that it will remain in control of its systems forever (Informant 2), such issues have to be discussed and their implications addressed. Currently, in the WFP's "Building Blocks" project, on the UNHCR identification code, location, family size, phone number and iris scan are saved onto the blockchain (Informant 4). Information pertaining to date of birth, gender, ethnicity etc. are intentionally left out (Informant 4). Aside from this risk with regard to data security, a lack of robustness of the system, argued for by Informant 10, as a result of a so called 51% attack, could also breach data security. While decentralisation here makes a cyberattack more complicated and time intensive, it does not make it impossible (Informant 12). Informant 10 even goes so far as to asserting that decentralisation makes fraud easier, as there is no central trusted authority protecting the data. Other potential technical problems, such as interoperability, scalability and electricity consumption are regarded as less pressing. Scalability is a concern for those wishing to over time expand their blockchain protocol, but has not be encountered so far, as most of the private blockchains have a limited number of nodes (Informant 12). In line with this, electricity consumption would only become problematic once large scale blockchains are implemented and does not seem to be of concern for companies (Informant 12).

3.2.4 *Advice regarding blockchain technology*

All informants were able to pass on some lessons learned. Merging these pieces of advice results in the following step-by-by approach to exploring blockchain technology:

1) Acquire an independent and comprehensive understanding of the technology
2) Evaluate the added value and risks of implementing a blockchain solution
3) Implement on a small scale
4) Find partners to cooperate with

Firstly, almost all informants stressed that it is vital for organisations and companies alike to achieve a thorough level of understanding of the technology itself before deciding whether it can be an effective tool in the respective context. In addition, informant 5 asserts that the expert knowledge should come from within the organisation, therefore calling on organisations to either train in house experts or hire them. A similar tone but different approach is also expressed by Informant 1, who believes that organisations need to seek neutral partners, such as think tanks or academic institutions, to acquire a deeper understanding of the technology.

Secondly, as with any changes to the status quo, the benefits and risks have to be assessed carefully. The first question should therefore always be if there even is a problem that needs fixing. As Informant 6 noted:

> "You should not try to replace existing working business models with blockchain."

As simple as this advice sounds, many companies might be inclined to explore blockchain just because it is the latest buzzword in the technological world (Informant 10). Key criteria can be whether an organisational boundary is crossed (Informant 4), the business model is new and disruptive (Informant 6), shift in organisational structure or culture is possible (Informant 9). As the needs and preferences of customers and society in general are changing, business models need to change as well (Informant 6). Using an old business model and combining it with blockchain technology will according to the informant not make the business more profitable. Organisations have to be aware of the ideology on which blockchain is based and evaluate whether this ideology matches their business model (Informant 6). In addition to the business model, a certain environment needs to exist around blockchain technology for it to be successful (Informant 10).

Thirdly, all informants concurred that companies and organisations should start by implementing a blockchain solution on a small scale, preferably in a way that is non-intrusive. Business crucial processes should in a first stage be left out of the blockchain transformation (Informant 12). This way the risks in case of failure are minimised (Informant 10). If a first trial is successful, over time more processes can be integrated into the blockchain solution (Informant 12). The informant predicts that:

> "Blockchain as a technology, it's like the smartphone. You don't know how much you need it until you start to use it."

Fourthly, as the main advantage of blockchain opposed to other databases is its decentralised nature and resulting ability to support cooperation, finding partners is a vital step (Informant

2). In a humanitarian context this could be actors addressing the same emergency and aiding the same beneficiaries over a longer period of time (Informant 4). Informant 12 asserts that:

> "If you really want to get something out of this technology as a company or as an institution, you have to open up yourselves to other player out there.",

The statements underline both the value of cooperation as well as the difficulties it can present to some. Cooperation means losing independence, which in turn means losing power. Losing power never sounds appealing to organisations striving for market share, media attention or donor funding (Informant 4), but it can present new opportunities and especially in the humanitarian context, it could bring structure to an opaque environment.

3.2.5 *Predicted future development*

With the exception of Informant 10, all informants come to the conclusion that blockchain technology will have a significant impact on business and society in the future. Some assert so with exuding confidence, calling on decision-makers to accept the fact that the world is changing and embracing this change, as Informant 11 puts it blatantly:

> "You can either adapt or die."

While this might sound crass, for some business this could turn out to be true (Informant 6). Other informants point to examples such as Estonia's reinvention as a digital country to support their hypothesis that blockchain technology will have large scale societal impact, maybe even reshaping our understanding of democracy and governance (Informants 1 and 9). Some of the other informants are rather cautiously optimistic, referring to the lack of research and the many unknowns that still exist around blockchain technology (Informant 5 and 12). These unknowns could turn out to be grave negative consequences of the technology that one is not yet aware of, they could also be use cases that have not even been thought about. No matter how optimistic the informants are, they agree that it will take time for organisations, especially traditional, large institutions, to adapt to the changing environment. Before blockchain technology becomes mainstream, a long time will pass by.

Informant 10 is the only informant with a dissenting opinion, believing that traditional databases will take over some of blockchain technology's features and will therefore make it obsolete. Part of the reason why he believes this to be true is that the advantage of decentralisation many bet on, will not turn out to be a benefit for companies operating in capitalism. The inherent competition will not allow for cooperation on a scale that requires a technology such as blockchain. While the informant recognises that the tides could turn, he believes that it would require one of the biggest technological companies to make a considerable investment in blockchain technology for it to be usable on a larger scale.

4. Discussion

To begin with, the results of the two different studies are compared and contrasted to gain an understanding of the overall assessment of blockchain technology and the benefits as well as challenges it poses uniquely to the humanitarian context. In a second step, the requirements for implementing blockchain technology successfully in a humanitarian context are compiled based on the knowledge acquired through the research. Subsequently, diverse humanitarian contexts are juxtaposed to confine the settings to which blockchain technology can potentially be applied to, in doing so formulating an answer to the last research question.

4.1 Comparison of Scoping Study and Interview Study

Both the literature reviewed and the informants interviewed concurred that blockchain technology is a valuable tool that possesses the potential to contribute to solving a variety of issues if applied in an appropriate context. Especially those documents directly addressing the public sector or humanitarian aid foresee the technology redistributing power, thereby influencing the way governance and the delivery of emergency relief have functioned so far (Boucher, 2017; GSMA & DFID, 2017; Killmeyer et al., 2017). Even though the informants are not in agreement over the time it will take to realise such changes, they as well subscribe to the potential of the technology to transform existing systems. Among these systems is the humanitarian system, which should address the lack of cooperation among humanitarian aid organisations and the lack of transparency with regards to the final destination of financial assets. If blockchain technology were able to confront these persisting dilemmas, it could contribute substantially to challenging the status quo and creating a more efficient and transparent humanitarian system.

Blockchain technology is characterised by a variety of encouraging features, such as decentralisation, transparency, immutability and traceability. As highlighted by authors and informants alike, these features are the source for a multiplicity of proven benefits, especially in the realm of emergency relief. Decentralisation allows for simpler cooperation between organisations and institutions and a more efficient use of resources through the reduction of costs (GSMA & DFID, 2017; Lo et al., 2017; Informants 2-3). In addition, decentralisation promises a distribution of power. While seen as a stumbling block by informants and authors looking at the potential use of blockchain technology in capitalist companies (Ølnes & Jansen, 2018), for the delivery of emergency relief it means increased ownership of beneficiaries (Informants 1,2,4,7). Transparency, immutability and the resulting traceability of assets on a blockchain are seen as the second significant benefit of the technology, emphasised in both the literature and the interviews. The combination of these characteristics allows for real-time accountability and less complicated monitoring and evaluation procedures (Zwitter & Boisse-Despiaux, 2018; Informants 2,4). In the humanitarian context, it provides the opportunity to have more control over the effect financial assets have in the field, by frustrating corruption and fraud attempts and avoiding exclusion and inclusion errors (de Vrij, 2018; UK Government Chief Scientific Adviser, 2016; Informants 2,5,7). Other benefits of the technology such as automation, openness and trust are only prevalent in either the literature or the interviews. This could be the result of differing priorities. Automation is only explicitly referred to in the literature, mostly in connection with the ability of blockchain technology to be used in conjunction with other innovative technologies such as the Internet of Things or robotics (Rodrigues et al., 2018). This aspect is not directly relevant to the delivery of emergency relief at this stage. The execution of smart contracts is relevant to the humanitarian field but seems to be overwhelmed by other benefits of the technology. Openness and trust were mainly cited by professionals working in the humanitarian field (Informants 1-5). Both attributes are of special significance to the humanitarian sector. Openness allows for a cost-effective and transparent way of acquiring a technology as well as the opportunity to share it with other actors. This aspect could become relevant to aid agencies in the future, if they aim to provide stability and continuity to beneficiaries after humanitarian missions (Informant 2). In such instances, a blockchain could be shared with governments wishing to continue the efforts of aid agencies. Trust is another aspect of greater relevance to NGOs than to companies. Building trust can be especially difficult in the context of disasters or emergencies, when people have experienced unimaginable suffering and, in some instances, violent human behaviour. For humanitarian organisations, gaining the trust of a population can therefore present a not to be underestimated challenge. Blockchain could generally help bridge the gap. This would, however, require beneficiaries to understand how the technology works. As, at least at this point in time, the public cannot be assumed to have acquired knowledge of the technology, beneficiaries would again have to trust the explanation of the aid organisations. Where a trusting relationship can, however, be formed on the basis of blockchain is between different organisations, either between donors and aid organisations or among aid organisations themselves (Informants 3,4). This could contribute to cooperation, as already touched upon under decentralisation.

While implementing blockchain technology does not come without its challenges, many of the drawbacks emphasised in the research are, however, a testament to the context in which the technology is to be operated. Especially in the literature scalability and data security are highlighted as substantial technical issues. Scalability is, however, only a challenge in the case of public blockchains, which are not to be used in a humanitarian context (Karajovic et al., 2019; Informant 4). Connected shortcomings such as high energy consumption are therefore not applicable here, explaining why this risk was not mentioned by any of the humanitarian professionals interviewed. Data security is another issue that can be circumvented by using the technology in a responsible manner. In cases where full anonymity and a 100% certainty of the security of data is required, the technology should not be used. But in cases where no sensitive data has to be stored, the technology offers a comparably secure transaction mechanism with pseudo-anonymity (Makhdoom et al., 2019; Informant 4). Aside from these technical weaknesses of blockchain technology, three other aspects of the technology can be considered weaknesses. Firstly, the ideology it is based on can be seen as an obstacle in business contexts (Ølnes & Jansen, 2018; Informant 10-12). For humanitarian organisations that are used to cooperating in disasters this is less of an issue than for companies used to competing with each other. Secondly, the immaturity of the technology is stressed in both the literature and by the informants. Overcoming this challenge will require time. Only over time will extensive research and trial projects show whether there are significant, but still unknown risks that could thwart the success of the technology (Lindman et al., 2017; Wu & Tran, 2018; Informants 5,12). Thirdly, as of now, the lack of research and case studies is one of the reasons leading to scepticism among governmental institutions, organisations and companies hesitating to invest in blockchain technology, as underscored by both the scoping and the interview study. In the case of humanitarian organisations this is particularly problematic as not only the aid organisations themselves have to be convinced of the technology to implement it, but also their donors and the governments of the countries affected (Informants 2-6). Convincing this triangle of actors consisting of humanitarian organisations, donors and governments, requires patient change management and awareness raising.

With the discussed benefits and challenges in mind, it is evident why the concurring evaluation of the potential of blockchain technology found in the literature and shared by the informants is positive, ascribing the technology the ability to drive ambitious change. Authors and informants alike, however, caution that all has not been said and done yet, more projects will need to be implemented and more research will need to be conducted to prove that the potential of blockchain technology can materialize in practice.

4.2 Requirements for the Implementation of Blockchain Technology

For blockchain technology to fulfil its promises, it has to be implemented successfully. Based on the research conducted a number of requirements for a successful implementation can be identified. Without these present, implementing blockchain technology bears a high risk of not fulfilling its potential and thereby not significantly furthering the humanitarian cause. These requirements are:

1) **Internet connectivity** is the basic technical prerequisite of blockchain technology (Informants 3,4,5). While interim solutions for temporary disruptions in the network can theoretically be found, such as updating the ledger to a verified status upon reconnecting with the network (Zwitter & Boisse-Despiaux, 2018), pro tem a reliable internet or mobile network connection remains the essential technical foundation for blockchain technology (de Vrij, 2018; Ølnes & Jansen, 2018; Radanović & Likić, 2018). In the case of the WFP's "Building Blocks" project, internet connectivity is required at the vendors in the refugee camps (Informant 4). Other use cases would require internet connectivity at other locations.
2) A **digital identity of actors** is required for them to participate in the blockchain. In simple terms, actors need to have an account, referred to as wallet, in order to be part of the blockchain (Nakamoto, 2008; Ølnes & Jansen, 2018; Zwitter & Boisse-Despiaux, 2018). Depending on the use case, who the actors are can differ. In the case of WFP's "Building Blocks" project, the beneficiaries are the actors that must have a digital identity (Informants 1,3,4). This means that they have to be registered, a wallet has to be created for them and they have to be given a way to identify themselves as the owner of the particular wallet. The WFP's project uses biometrical data, more specifically the scanning of the iris, as the identification method (de Vrij, 2018), but other methods could be utilised as well.
3) **Political will** from the triangle of actors involved in a humanitarian response is a necessity for blockchain technology to be approved as a tool for the delivery of emergency relief (Informants 4,5,6). Persisting scepticism as a result of the immaturity of the technology and the challenges it poses means that support for its implementation is far from guaranteed (Min, 2019; Niranjanamurthy et al., 2018; Ølnes & Jansen, 2018; Informants 3-5). In the context of humanitarian aid, ethical questions around the use of an immature technology for aiding the most vulnerable arise as well (de Vrij, 2018).

4) An **initial investment** is the financial requirement for establishing a blockchain-based system (Min, 2019; Niranjanamurthy et al., 2018). In spite of the long-term financial advantage of blockchain technology, through for example reduced transaction costs (Informants 3,4,8), in the short-term the implementation of any new system or technology requires an investment in time and resources that would not be necessary if one continued to use legacy systems. Especially in the realm of humanitarian aid where funding is a scarce resource, any investment needs to be a conscientious choice.

Whether these demands to the implementation context can be met needs to be determined on a case-by-case basis. Humanitarian contexts are too unique for a generalised assessment of the feasibility of blockchain technology as a tool for the delivery of emergency relief.

4.3 Viability of Blockchain Technology in Humanitarian Contexts

Hitherto, the delivery of emergency relief through the technological tool of a blockchain has, on a large-scale, only been attempted by one organisation in one context, namely the WFP's "Building Blocks" project in Jordan's refugee camps (de Vrij, 2018; Skogvang, 2018). While this project has been described as a success (Informant 4), its context is distinctive. As every disaster is unique, a successful implementation in this context does not guarantee similar accomplishments in different contexts. By combining the practical insight of informants working for the WFP's project and the theoretical knowledge of the characteristics of blockchain technology, this section seeks to establish in what contexts blockchain technology is an effective tool for the delivery of humanitarian aid in emergencies.

Question Word	Responding context categorisation
What?	Small vs large-scale destruction
Why?	Natural vs anthropogenic hazard
Where?	Connected vs disconnected environment
How?	Rapid vs slow-onset event
When?	Short-term vs long-term presence
Who?	Small vs large number of people in need

Table 3. Context Categorisation with Question Words

While an array of typologies classifying hazards and disasters in different categories exists (Becker, 2014), none of them describes the context in sufficient detail for the purpose of this paper. Therefore, a simple method of describing any situation or context will be drawn on, namely defining *What happened?* more precisely through the use of various question words. This approach qualifies the most pertinent information, as collected by those gathering information immediately after an emergency. The resulting categorisation can be found in Table 3.

4.3.1 *Small vs large-scale destruction*

The scale of destruction inflicted by a hazard on a population decisively impacts a number of factors that have implications for the feasibility of blockchain-based assistance. Firstly, the extent of destruction is the main driver determining the type of assistance that is required by the population in need. Two principal options exist here: in-kind assistance and CBT. In-kind assistance refers to the delivery of goods and commodities, such as food, water and medicine, while CBT give beneficiaries the ability to purchase these products by means of cash or vouchers. A blockchain-based system, such as the one piloted by the WFP in Jordan, can only facilitate the delivery of CBT (Informants 1-4). In the case of in-kind assistance, blockchain technology could be used for supply change management, but this would be a different use case. It is therefore relevant to consider what type of assistance is required in a particular humanitarian context. Cash interventions are only appropriate if sufficient food supplies and other goods are available locally to meet the needs and the markets are functioning and accessible (Creti & Jaspars, 2006). Large-scale destruction can significantly limit the availability or accessibility of the goods and commodities needed. In such cases, in-kind assistance is required to aid the population adequately (Creti & Jaspars, 2006). Secondly, the scale of destruction affects the condition the infrastructure, including the telecommunications network. In 2017, the widespread destruction caused by Hurricane Maria in the Caribbean, in particular in Puerto Rico, completely cut off all communication, including internet, to some parts of the affected region (Pasch et al., 2019). Eight months after the hurricane hit the islands reports of an unreliable internet connection across Puerto Rica were still surfacing (Glaser, 2018; Madory, 2017). As a consequence of both factors discussed, blockchain technology is only an effective tool for the delivery of emergency relief when the scale of destruction has not completely overwhelmed the infrastructure of the affected region. In the context of large-scale destruction, blockchain technology should therefore not be the first tool to be considered, but could be introduced at a later stage, though this would require the re-sensitisation of beneficiaries.

4.3.2 *Natural vs anthropogenic hazard*

Differentiating between naturally caused and anthropogenic hazards is the most common categorisation of different types of hazards (Becker, 2014). With climate change and its effect on different types of hazards this categorisation has become less clear cut (Becker, 2014). Whether a drought is a natural phenomenon or caused by human-induced climate change does not impact the viability of using blockchain technology as part of the assistance efforts. Within the category of anthropogenic hazards there are, however, also antagonistic events, such as conflict, terrorism and crime (Becker, 2014). The political will to respond to disasters caused by such events with a blockchain-based system could, at this stage, be inhibited for one imperative reason. Antagonistic events are the result of the purposeful infliction of harm on a group of people. This dynamic brings some of the risks associated with blockchain technology, such as cyberattacks, data security and privacy (Niranjanamurthy et al., 2018; Wust & Gervais, 2018), to the forefront . In the context of terrorism, terrorists could target the affected population a second time through attacking the blockchain-based aid system. In the context of conflict, those in control of internet services in a region could intentionally shut down the internet to limit the access to information and the freedom of expression of a population, thereby obstructing the ability to implement blockchain technology. Moreover, concerns for the security of the data on the blockchain in such an instance can also eliminate the possibility to hand over the blockchain to the government after the completion of the humanitarian mission (Informant 2), which in other instances is a noteworthy advantage of the technology in contrast to traditional databases (Informant 5). In spite of this, the WFP chose the context of the Syrian Civil War for its first large-scale implementation of a blockchain-based system for aid (Informant 4). This was possible as the refugee camps of choice are located in Jordan, often referred to as an “oasis of stability” in a volatile region. It can therefore be deduced that the cause of a disaster, being natural or anthropogenic, does not have a direct effect on the potential to use blockchain technology for the delivery of emergency relief. In the context of antagonistic events, the risks of blockchain technology should be weighed with particular caution against the benefits it brings.

4.3.3 *Connected vs disconnected environment*

In 2011, the United Nations declared internet access a human right, after it had witnessed the increasing restriction of content on the internet through various means and the lack of efforts to provide universal access to the internet (United Nations, 2011). As internet access is a requirement for the implementation of blockchain technology, the level of internet connection present in the region before the disaster is a relevant factor. Internet connectivity, prior to a disastrous event, can be limited by two factors. Firstly, the infrastructure necessary to be connected to the internet can be lacking. This can be either due to the remote location of the region or the development level of the country it is located in. In 2017, the internet penetration rate was below 20% in the 35 least developed countries (ITU Development, 2018; Smith, 2017). Among these are sites of frequent disasters, such as Indonesia, Nepal, Pakistan, Sudan and Yemen (Smith, 2017). Receiving a reliable internet connection to implement a blockchain solution in such locations is therefore not a given. Yet, these countries are making significant progress towards achieving Sustainable Development Goal 9c, achieving universal and affordable internet by 2020 (ITU Development, 2018; UN-OHRLLS, 2018). Secondly, access to the internet can be purposefully blocked. While freedom of expression and access to information are two fundamental principles of democracies, dictatorships sometimes tighten their grip on a population by limiting these rights. One of the ways to accomplish this is through limiting internet access. The political will to implement a blockchain-based assistance program that requires giving foreign organisations and institutions reliable and free internet access is in these contexts questionable. To sum up, the viability of using blockchain technology for the delivery of emergency relief in an environment which was disconnected prior to the occurrence of the disaster is uncertain. In the context of lacking infrastructure in the affected region, the issue will doubtlessly not be resolved in the immediate aftermath of a disaster. It could, however, become an issue of the past in a few years of time. Conversely, if access to the internet is intentionally limited, the pressure created by a disaster could make compelling arguments both for and against the lifting of internet restrictions.

4.3.4 *Rapid vs slow-onset event*

The speed of onset of an event is another criterion by which different types of hazards can be categorised (Becker, 2014). Rapid-onset events are far more common, as most types of hazards fall in this category (Twigg, 2004). While the warning time ranges from a few seconds in the case of an earthquake to several days in the case of most storms and floods, these events all develop fairly quickly (Twigg, 2004). The most common slow-onset event is a drought, which can persist for months or even years before turning into a disaster (Twigg, 2004), as for example experienced by Cape Town in 2018 (Maxmen, 2018). The speed of onset of an event dictates the time the population and aid agencies have to prepare. Preparation is key in the current development stage of blockchain technology, in which only few organisations have thus far experimented with the technology in practice (Abujamra & Randall, 2019). Slow-onset events would therefore provide a less stressful and better thought through context for a new technology to be tested out in. One could also switch to a blockchain-based assistance system after the initial chaos of the immediate impact of a disaster has subsided, but this strategy has drawbacks as well. Once beneficiaries are sensitised, meaning they have been educated regarding the way in which they can receive assistance, the efforts of changing the system include re-sensitising the population in need (Informant 4). This means that organisations preferably stick to one system in one disaster context. For the moment, this means that slow-onset events or humanitarian crises persisting over a long period of time are more appropriate contexts for taking the first steps with a new technology (Informant 4). Over time organisations and institutions will gain more experience with blockchain technology and its immaturity will no longer define the speed of onset of events it is to be used in.

4.3.5 *Short-term vs long-term presence*

Aid organisations either provide short-term assistance in the immediate aftermath of the disaster or are prepared to extend their efforts to the recovery phase, depending on a variety of factors, such as the scale of destruction, the number of people affected and the ability of local authorities to handle the disaster themselves. As implementing a blockchain-based system requires an initial investment of time and resources, the duration for which such a system would then be used is a highly relevant variable in the cost-benefit analysis. The longer a blockchain-based system runs in a certain location, the more cost-effective it is. In the case of the WFP's "Building Blocks" project in Jordan, the refugee camps have been existing for more than seven years and have therefore become permanent settlements of those fleeing violence in their home country (de Vrij, 2018). With no end in sight to the Syrian Civil War, it can be assumed that they will be in place for the next years to come. Investing in a blockchain solution in this context has hence been cost-effective for the WFP (Informant 4). Thus, a short-term presence of an aid organisation does not preclude it from using blockchain technology, but when first trialling the effectiveness of the technology humanitarian missions with a long-term presence are to be preferred.

4.3.6 *Small vs large number of people in need*

The scale of any humanitarian aid mission is defined by the number of people in need. Setting up a humanitarian aid missions always requires time. When a large number of people is in need, time can be an especially scarce resource. With blockchain technology a new beneficiary can be registered within minutes, while the process of registration can take up to two weeks in the case of traditional CBT dependent on local banks (Informant 4). During these two weeks in-kind assistance has to be provided to those in need, requiring additional resources and time that could in the case of a blockchain-based system be used for other purposes. On the other hand, scalability has, as shown in the scoping study, been a frequently discussed challenge of the technology (Killmeyer et al., 2017; Lo et al., 2017). The expansion of the WFP's blockchain project to 500,000 refugees within this year confirms, though, that scalability is not a concern for private blockchains (Dutchchain, 2017). For that reason, blockchain technology can be used both in contexts of small and large numbers of people in need, but its benefits shine brighter when emergency relief has to be provided to large numbers of people.

4.4 Discussion of Limitations

The limitations that arose as a result of the choices made while planning and conducting this research were presented in the Methodology chapter. However, even given these choices and their resulting limitations, one could still have come to different conclusions depending on the presentation of the results. Firstly, the author had to select the information to be presented in this thesis and the choice could have been influenced by various psychological biases, such as the confirmation bias. Secondly, the way in which the information was presented could have influenced the results. While the reason and relevance of analysing the viability of blockchain technology as a tool for the delivery of emergency relief was clearly stated in the introduction, the results and the discussion largely considered the technology in a vacuum. Comparing it to alternatives, such as only assisting beneficiaries with in-kind assistance or finding other solutions to the risks of traditional CBT, could have led to a more positive or more negative evaluation of blockchain technology. Moreover, the thesis only considers a limited amount of perspectives. While beneficiaries, humanitarian aid organisations and donors are considered, the governments and the larger populations in the affected countries are mostly left out. Some challenges as well as advantages could as a result not have been considered.

5. Conclusion

For the past decades, the opaque character of disasters has presented challenges, such as corruption and a lack of coordination among humanitarian aid agencies, to organisations providing emergency relief to those affected. Various attempts of impeding these to create a more transparent and efficient system for the organisations themselves and the beneficiaries have not been successful. To lift the fog, less conventional tools, including technological tools such as blockchain technology, should be vigilantly considered to ensure that the resources available are employed in line with the principles of humanitarian aid.

By conducting a scoping study and an interview study with 12 informants, this thesis aimed to critically assess under which circumstances blockchain technology could be used to distribute emergency relief, thereby alleviating the persisting challenges. Firstly, an overview of the existing knowledge around the benefits of blockchain technology and the challenges it poses was established to better understand the potential impact of the technology. Concurringly, both study formats found that decentralisation, transparency and traceability are unique advantages of the technology setting it apart from other tools available. In the realm of emergency relief, these benefits can contribute to creating a more efficient payment service for cash-based transfers by allowing for more cooperation among aid agencies, increasing transparency of the monetary trail, expanding ownership of beneficiaries and substantially reducing transaction costs. According to informants from within the humanitarian sector, aid organisations and donors can also derive benefit from the openness of the technology and the trust it can create in an otherwise trustless environment. Despite these promising values, blockchain technology is not without its challenges and poses substantial risks if not implemented responsibly. While some of these are not applicable to the humanitarian context, such as concerns around the scalability and ideology of the technology, others bear consequences for emergency relief and therefore need to be addressed. These include the scepticism that exists around the technology, especially with regard to data security, as well as its relative immaturity. Scepticism and immaturity can both be overcome with investments in research as well as trial projects implementing blockchain technology in practice and observing its impact. Effective change management can further contribute to dispel misunderstandings. Admittedly, existing risks around data security and other potential risks that might be discovered in the future will need to be considered responsibly.

Secondly, based on the gained insight of blockchain technology, it was determined that the technology can be an effective tool for the delivery of emergency relief. As a result of its unique characteristics, blockchain technology has the potential to tackle issues such as a lack of cooperation and persistent corruption, creating a system that serves beneficiaries, aid agencies and donors in a more efficient and effective manner. However, this verdict is not without constraints. Four requirements were identified that need to be present for blockchain technology to be implemented successfully. Internet connectivity is the basic technical requirement for transactions to be recorded on the blockchain. Once this is established, actors on the blockchain need to obtain a digital identity to be part of the system. Both political will and an initial investment are then necessary to build a blockchain project.

Thirdly, the scope of applicability of blockchain technology for emergency relief was narrowed by matching the requirements for a successful implementation with disaster scenarios. Above all, the context has to be suitable to providing cash-based transfers instead of in-kind assistance. Furthermore, the scale of destruction of the disaster has to have left the telecommunications network largely intact and the connectedness of the environment prior to the disaster has to allow for a stable internet connection. Trialling the effectiveness of the technology for the first time can be especially valuable in a context where organisations have established a long-term presence and are catering to the needs of large numbers of people. In the future, blockchain technology can particularly be an asset in the case of rapid-onset hazards, as its implementation can be carried out in a shorter timeframe than traditional solutions. As a measure of caution anthropogenic hazards, such as terrorist attacks or violent conflicts, should be carefully evaluated before using blockchain technology in these contexts to ensure that some of the risks of the technology are not be exploited.

Looking into the future, blockchain technology could not only prove to be effective in delivering emergency relief in a transparent and efficient manner to populations in need, it could also be used for other use cases. The technology could enable storing the digital identity of refugees, including their certificates and other documents, and supply change management, for example for tracking in-kind assistance. Blockchain technology allows the humanitarian sector to transform and reinvent itself, block by block putting more emphasis on values such as transparency and cooperation and thereby lifting the fog of the opaque environment in the aftermath of a disaster.

Reference List

Abujamra, R., & Randall, D. (2019). Blockchain applications in healthcare and the opportunities and the advancements due to the new information technology framework. In *Advances in Computers* (Chapter in Press). Elsevier Ltd.

Alketbi, A., Nasir, Q., & Talib, M. A. (2018). Blockchain for Government Services - Use Cases, Security Benefits and Challenges, presented at *2018 15th Learning and Technology Conference* (112–119), Feburary 24-25, 2018, Jeddah, Saudia Arabia: IEEE.

Arksey, H., & O'Malley, L. (2005). Scoping Studies: Towards a Methodological Framework. *International Journal of Social Research Methodology*, *8*(1), 19–32.

Balcik, B., Beamon, B. M., Krejci, C. C., Muramatsu, K. M., & Ramirez, M. (2010). Coordination in humanitarian relief chains: Practices, challenges and opportunities. *International Journal of Production Economics*, *126*, 22–34.

Becker, P. (2014). *Sustainability Science: Managing Risk and Resilience for Sustainable Development*. Amsterdam, Netherlands and Oxford, UK: Elsevier.

Boucher, P. (2017). *How Blockchain Technology Could Change Our Lives*. *European Parliamentary Research Service*. Retrieved from http://www.europarl.europa.eu/RegData/etudes/IDAN/2017/581948/EPRS_IDA(2017)581948_EN.pdf

Brinkmann, S., & Kvale, S. (2015). *Interviews: Learning the Craft of Qualitative Research Interviewing*. Sage Publication.

Carminati, B., Ferrari, E., & Rondanini, C. (2018). Blockchain as a platform for secure inter-organizational business processes, presented at *2018 IEEE 4th International Conference on Collaboration and Internet Computing* (122–129), October 18-20, 2018, Philadelphia, US: IEEE.

Casino, F., Dasaklis, T. K., & Patsakis, C. (2019). A systematic literature review of blockchain-based applications: Current status, classification and open issues. *Telematics and Informatics*, *36*, 55–81.

Conoscenti, M., Vetro, A., & De Martin, J. C. (2016). Blockchain for the Internet of Things: A systematic literature review, presented at *13th IEEE/ACS International Conference on Computer Systems and Applications*, November 29 - December 2, 2016, Agadir, Marocco: IEEE.

Creti, P., & Jaspars, S. (eds.) (2006). *Cash-Transfer Programming in Emergencies*. Oxford, UK: Oxfam.

de Vrij, A. (2018). *Blockchain in Humanitarian Aid: A Way out of Poverty and Famine?.* Leiden University. Retrieved from https://openaccess.leidenuniv.nl/handle/1887/67036

Digiconomist. (2019). Bitcoin Energy Consumption Index. Retrieved from https://digiconomist.net/bitcoin-energy-consumption.

Dr Herweijer, C., Waughray, D., & Warren, S. (2018). Building block(chain)s for a better planet. *Fourth Industrial Revolution for the Earth*. Switzerland: World Economic Forum.

Dutchchain (2017). *Keynote "Can Blockchain end hunger?" by Robert Opp - United Nations World Food Programme*. Retrieved from https://www.youtube.com/watch?v=5iK5h6BOpNo

Flynn, D., Jenkins, D., Andoni, M., Robu, V., Peacock, A., Abram, S., McCallum, P. (2019). Blockchain technology in the energy sector: A systematic review of challenges and opportunities. *Renewable and Sustainable Energy Reviews*, *100*, 143–174.

Gatteschi, V., Lamberti, F., Demartini, C., Pranteda, C., & Santamaria, V. (2018). To Blockchain or Not to Blockchain: That Is the Question. *IT Professional*, *20*(2), 62–74.

Glaser, A. (2018). Connection Racket. *Slate*. Retrieved from https://slate.com/technology/2018/06/the-fcc-plan-to-restore-puerto-rico-internet-and-phone-service-has-a-trade-off.html

GSM Association, & UK Department for International Development. (2017). *Blockchain for Development: Emerging Opportunities for Mobile, Identity and Aid*. London, UK: GSMA and DFID. Retrieved from https://www.accenture.com/t20170601T083538Z__w__/us-en/_acnmedia/PDF-40/Accenture-Digital-Disruption-Development-Unleashed.pdf#zoom=50

Harris, C. G. (2018). The Risks and Dangers of Relying on Blockchain Technology in Underdeveloped Countries, presented at *IEEE/IFIP Network Operations and Management Symposium: Cognitive Management in a Cyber World*, April 23-27, Taipei, Taiwan: IEEE.

IBM Institute for Business Value. (2017). *Forward Together: Three ways blockchain Explorers chart a new direction*. IBM.

ITU Development. (2018). *Achieving universal and affordable Internet in the least developed countries*. ITU. Retrieved from https://unohrlls.org/custom-content/uploads/2018/02/ICT-LDCs-and-SDGs.pdf

Johng, H., Kim, D., Hill, T., & Chung, L. (2018). Using Blockchain to Enhance the Trustworthiness of Business Processes: A Goal-Oriented Approach, presented at *2018 IEEE International Conference on Services Computing,* 249–252, July 2-7, 2018, San Francisco, US: IEEE.

Kalra, S., Goel, S., Dhawan, M., & Sharma, S. (2018). ZEUS: Analyzing Safety of Smart Contracts, presented at *25th Annual Network and Distributed Systems Security Symposium*, February 18-21, 2018, San Diego, US.

Karajovic, M., Kim, H. M., & Laskowski, M. (2019). Thinking Outside the Block: Projected Phases of Blockchain Integration in the Accounting Industry. *Australian Accounting Review,* 1–12.

Ki-Moon, B. (2012). *Secretary-General's closing remarks at High-Level Panel on Accountability, Transparency and Sustainable Development*. Retrieved from https://www.un.org/sg/en/content/sg/statement/2012-07-09/secretary-generals- closing-remarks-high-level-panel-accountability

Killmeyer, J., White, M., & Chew, B. (2017). *Will blockchain transform the public sector? Blockchain basics for government*. *Deloitte Center for Government Insights*. Retrieved from https://www2.deloitte.com/content/dam/insights/us/articles/4185_blockchain-public-sector/DUP_will-blockchain-transform-public-sector.pdf%0Ahttps://dupress.deloitte.com/dup-us-en/industry/public-sector/understanding-basics-of-blockchain-in-government.html

Ko, V., & Verity, A. (2016). *Blockchain for the Humanitarian Sector: Future Opportunities*. *Digital Humanitarian Network*. Retrieved from https://www.academia.edu/30287787/Blockchain_For_The_Humanitarian_Sector_Future_Opportunities

Konstantoloulos, G. (2017). Understanding Blockchain Fundamentals, Part 2: Proof of Work & Proof of Stake. *Medium.* Retrieved from https://medium.com/loom-network/understanding-blockchain-fundamentals-part-2-proof-of-work-proof-of-stake-b6ae907c7edb

Kouhizadeh, M., & Sarkis, J. (2018). Blockchain Practices, Potentials, and Perspectives in

Greening Supply Chains. *Sustainability*, *10*.

Lin, I. C., & Liao, T. C. (2017). A Survey of Blockchain Security Issues and Challenges. *International Journal of Network Security*, *19*(5), 653–659.

Lindman, J., Tuunainen, V. K., & Rossi, M. (2017). Opportunities and risks of Blockchain Technologies in payments - a research agenda, presented at *50th Hawaii International Conference on System Sciences* (1533–1542), January 4-7, 2017, Hawaii, US.

Lo, S. K., Xu, X., Chiam, Y. K., & Lu, Q. (2017). Evaluating Suitability of Applying Blockchain, presented at *International Conference on Engineering of Complex Computer Systems* (158–161), November 6-8, 2017, Fukuoka, Japan.

Lu, Y. (2018). Blockchain and the related issues: a review of current research topics. *Journal of Management Analytics*, *5*(4), 231–255.

Madory, D. (2017). Puerto Rico's Slow Internet Recovery. *Oracle*. Retrieved from https://dyn.com/blog/puerto-ricos-slow-internet-recovery/

Makhdoom, I., Abolhasan, M., Abbas, H., & Ni, W. (2019). Blockchain's adoption in IoT: The challenges, and a way forward. *Journal of Network and Computer Applications*, *125*, 251–279.

Maxmen, A. (2018). Cape Town scientists prepare for "Day Zero". *Nature*, 13–14.

Min, H. (2019). Blockchain technology for enhancing supply chain resilience. *Business Horizons*, *62*, 35–45.

Minear, L. (2002). *The Humanitarian Enterprise: Dilemmas and Discoveries*. Bloomfield, US: Kumarian Press.

Nakamoto, S. (2008). *Bitcoin: A Peer-to-Peer Electronic Cash System*. Retrieved from https://bitcoin.org/bitcoin.pdf?

Niranjanamurthy, M., Nithya, B. N., & Jagannatha, S. (2018). Analysis of Blockchain technology: pros, cons and SWOT. *Cluster Computing*, *5*(2), 1–15.

Ølnes, S., & Jansen, A. (2018). Blockchain technology as infrastructure in public sector. *Proceedings of 19th Annual International Conference on Digital Government Research*, 1–10, Delft, Netherlands.

Opp, R. (2018). *Blockchain at the World Food Programme*. World Food Progamme. Retrieved from https://unite.un.org/sites/unite.un.org/files/technovation/2_wfp_buildingblocks_robert_opp.pdf

Overseas Development Institute. (2015). *Doing cash differently - How cash transfers can transform humanitarian aid*. London, UK: ODI. Retrieved from www.odi.org%5Cnwww.odi.org/facebook%5Cnwww.odi.org/twitter

Panesir, M. S. (2018). *Blockchain Applications for Disaster Management and National Security*. Retrieved from https://search.proquest.com/docview/2057242991?accountid=188395

Pasch, R. J., Penny, A. B., & Berg, R. (2019). *National Hurricane Centre Tropical Cyclone Report: Hurricane Maria*. National Oceanic and Atmospheric Administration. Retrieved from https://www.nhc.noaa.gov/data/tcr/AL152017_Maria.pdf

Peppiatt, D., Mitchell, J., & Holzmann, P. (2001). *Cash transfers in emergencies: evaluating benefits and assessing risks*. London, UK: Humanitarian Network Practice. Retrieved from https://www.nytimes.com/2017/03/09/world/americas/guatemala-city-fire.html?rref=collection%2Ftimestopic%2FGuatemala&action=click&contentCollection=world&region=stream&module=stream_unit&version=latest&contentPlacement=1&pgtype=collection

Radanović, I., & Likić, R. (2018). Opportunities for Use of Blockchain Technology in Medicine. *Applied Health Economics and Health Policy*, *16*, 583–590.

Rodrigues, B., Bocek, T., & Stiller, B. (2018). The Use of Blockchains: Application-Driven Analysis of Applicability. In Raj, P. & G.C. Deka (Eds.), *Advances in Computers, 111*, 163–198. Elsevier Inc.

Sen, A. (1980). Famines. *World Development*, *8*, 613–621.

Skogvang, E. M. (2018). *Blockchain: Uniting Aid and Trade? A case study of the UN Women Blockchain Project to Empower Women and Girls in Humanitarian Settings*. University of Oslo.

Smith, O. (2017). The last places on Earth with no internet. *The Telegraph*. Retrieved from https://www.telegraph.co.uk/travel/lists/the-last-places-on-earth-with-no-internet/

Stephenson, M. (2005). Making humanitarian relief networks more effective: Operational coordination, trust and sense making. *Disasters*, *29*(4), 337–350.

Thompson, J. (2018). Using Blockchain to Improve Aid Transparency and Efficiency |

Development Asia. *Development Asia*. Retrieved from https://development.asia/case-study/using-blockchain-improve-aid-transparency-and-efficiency

Thomson Reuters (2017). *Are you ready for blockchain?*. Retrieved from https://www.thomsonreuters.com/en/reports/blockchain.html

Tribis, Y., El Bouchti, A., & Bouayad, H. (2018). Supply Chain Management based on Blockchain: A Systematic Mapping Study. *MATEC Web of Conferences*, *200*.

Twigg, J. (2004). D*isaster risk reduction: Mitigation and preparedness in development and emergency programming*. London, UK: Overseas Development Institute.

UK Government Chief Scientific Adviser. (2016). *Distributed Ledger Technology: Beyond Block Chain*. London, UK: UK Government Office for Science.

UN-OHRLLS. (2018). *World's least developed countries on target to achieve universal and affordable internet by 2020*. New York City, US: United Nations.

United Nations. (2011). *Report of the Special Rapporteur on the Promotion and Protection of the Right to Freedom of Opinion and Expression, Frank La Rue*. *Human Rights Council*.

United Nations General Assembly (1982). *Resolution on the Strengthening of the coordination of humanitarian emergency assistance of the United Nations*. New York City, US: United Nations.

United Nations General Assembly. (2003). *Resolution on the Strengthening of the coordination of emergency humanitarian assistance of the United Nations*. New York City, US: United Nations.

United Nations General Assembly. (2016). *Report of the open-ended intergovernmental expert working group on indicators and terminology relating to disaster risk reduction*. New York City, US: United Nations.

Wood, G. (2014). *Ethereum: a Secure Decentralised Generalised Transaction Ledger*. Ethereum Project Yellow Paper.

World Food Programme. (2018). *Annual Report 2017: United Nations World Food Programme Innovation Accelerator*. Munich, Germany.

Wu, J., & Tran, N. K. (2018). Application of blockchain technology in sustainable energy systems: An overview. *Sustainability*, *10*, 1–22.

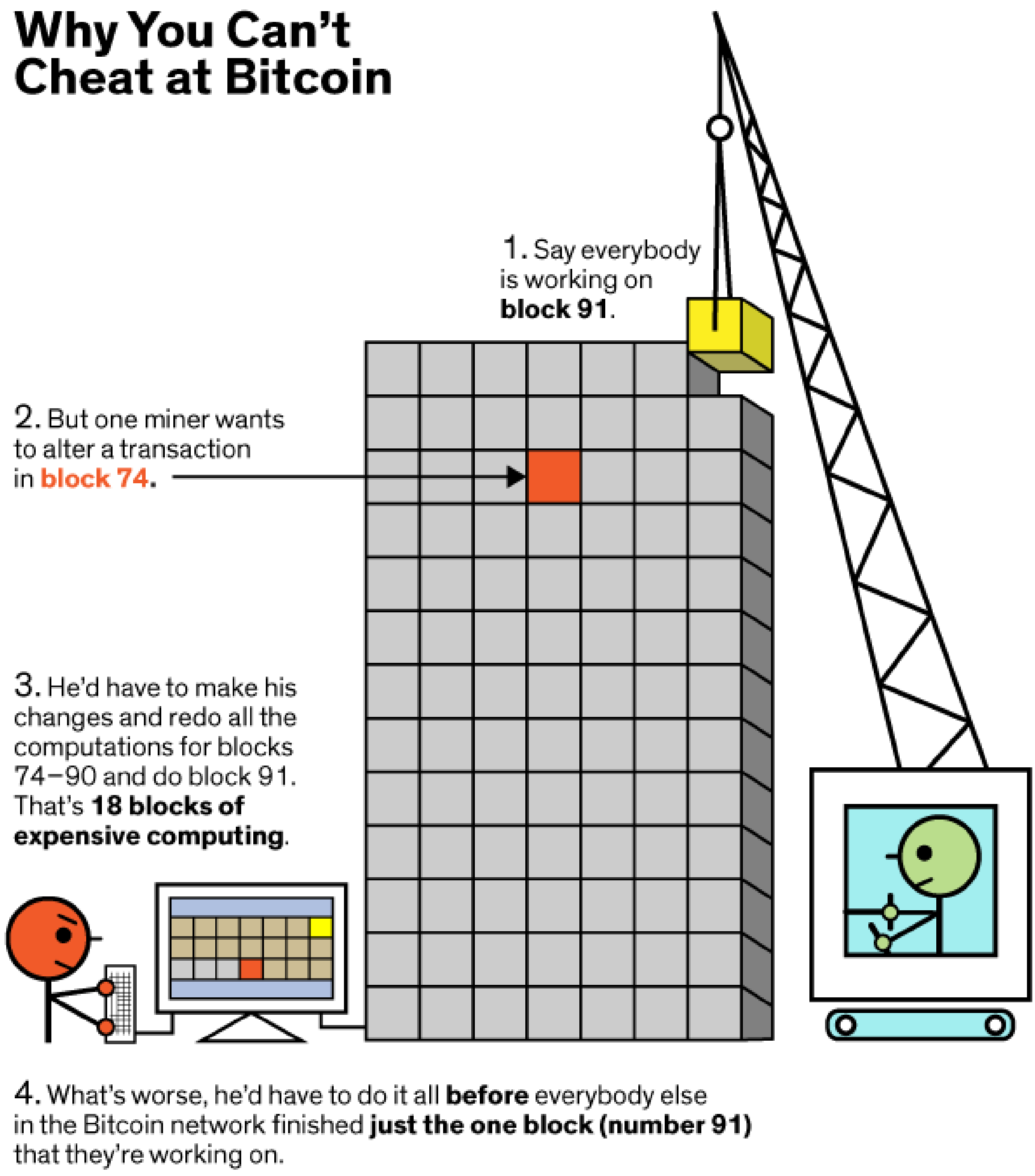
Wust, K., & Gervais, A. (2018). Do you need a blockchain?. *2018 Crypto Valley Conference* *on Blockchain Technology*, 45–54, Zug, Switzerland.

Yli-Huumo, J., Ko, D., Choi, S., Park, S., & Smolander, K. (2016). Where Is Current Research on Blockchain Technology? - A Systematic Review. *PloS One*, *11*(10).

Zwitter, A., & Boisse-Despiaux, M. (2018). Blockchain for humanitarian action and development aid. *Journal of International Humanitarian Action*, *3*(16).

Appendix

Appendix 1. Immutability of Blockchain Technology in a Graph



Source: Konstantopoulos (2017)

Appendix 2. Numerical Analysis of Scopus Scoping Study

Document Title	Authors	Publication Year	Journal Title	Country of Publication	Publication Type
A systematic literature review of blockchain-based applications: Current status, classification and open issues	Casino F., Dasaklis T.K., Patsakis C.	2019	Telematics and Informatics	Greece	Journal Article
Analysis of Blockchain technology: pros, cons and SWOT	Niranjanamurthy M., Nithya B.N., Jagannatha S.	2018	Cluster Computing	India	Journal Article
Application of blockchain technology in sustainable energy systems: An overview	Wu J., Tran N.K.	2018	Sustainability	China, Singapore	Journal Article
Blockchain and the related issues: a review of current research topics	Lu Y.	2018	Journal of Management Analytics	US	Journal Article
Blockchain applications in healthcare and the opportunities and the advancements due to the new information technology framework	Abujamra R., Randall D.	2019	Advances in Computers	United States	Book Chapter
Blockchain as a platform for secure inter-organizational business processes	Carminati B., Ferrari E., Rondanini C.	2018	Proceedings - 4th IEEE International Conference on Collaboration and Internet Computing, CIC 2018	Italy	Conference Paper
Blockchain challenges and opportunities: A survey	Zheng Z., Xie S., Dai H.-N., Chen X., Wang H.	2018	International Journal of Web and Grid Services	China	Journal Article
Blockchain for government services-Use cases, security benefits and challenges	Alketbi A., Nasir Q., Talib M.A.	2018	2018 15th Learning and Technology Conference, L and T 2018	United Arab Emirates	Conference Paper
Blockchain practices, potentials, and perspectives in greening supply chains	Kouhizadeh M., Sarkis J.	2018	Sustainability	USA	Journal Article
Blockchain technology as infrastructure in public sector -An analytical framework	Olnes S., Jansen A.	2018	ACM International Conference Proceeding Series	Norway	Conference Paper
Blockchain technology for enhancing supply chain resilience	Min H.	2019	Business Horizons	United States	Journal Article
Blockchain technology in the energy sector: A systematic review of challenges and opportunities	Andoni M., Robu V., Flynn D., Abram S., Geach D., Jenkins D., McCallum P., Peacock A.	2019	Renewable and Sustainable Energy Reviews	UK	Journal Article
Blockchain's adoption in IoT: The challenges, and a way forward	Makhdoom I., Abolhasan M., Abbas H., Ni W.	2019	Journal of Network and Computer Applications	Australia, Pakistan, US	Journal Article
Do you need a blockchain?	Wüst K., Gervais A.	2018	Proceedings - 2018 Crypto Valley Conference on Blockchain Technology, CVCBT 2018	Switzerland, UK	Conference Paper
Evaluating Suitability of Applying Blockchain	Lo S.K., Xu X., Chiam Y.K., Lu Q.	2018	Proceedings of the IEEE International Conference on Engineering of Complex Computer Systems, ICECCS	Malaysia, Australia, China	Conference Paper
Opportunities for Use of Blockchain Technology in Medicine	Radanovic I., Likic R.	2018	Applied Health Economics and Health Policy	Croatia	Journal Article
Supply chain management based on blockchain: A systematic mapping study	Tribis Y., El Bouchti A., Bouayad H.	2018	MATEC Web of Conferences	Morocco	Conference Paper
The risks and dangers of relying on blockchain technology in underdeveloped countries	Harris C.G.	2018	IEEE/IFIP Network Operations and Management Symposium: Cognitive Management in a Cyber World, NOMS 2018	US	Conference Paper
The Use of Blockchains: Application-Driven Analysis of Applicability	Rodrigues B., Bocek T., Stiller B.	2018	Advances in Computers	Switzerland	Book Chapter
Thinking Outside the Block: Projected Phases of Blockchain Integration in the Accounting Industry	Karajovic M., Kim H.M., Laskowski M.	2019	Australian Accounting Review	Canada	Journal Article
To Blockchain or Not to Blockchain: That Is the Question	Gatteschi V., Lamberti F., Demartini C., Pranteda C., Santamaria V.	2018	IT Professional	Italy	Journal Article
Using blockchain to enhance the trustworthiness of business processes: A goal-oriented approach	Johng H., Kim D., Hill T., Chung L.	2018	Proceedings - 2018 IEEE International Conference on Services Computing, SCC 2018 - Part of the 2018 IEEE World Congress on Services	US	Conference Paper

Appendix 3. Numerical Analysis of Google Scoping Study

Document Title	Authors	Publication Year	Journal Title / Institution	Country of Publication	Publication Type
Blockchain for humanitarian action and development aid	Zwitter A., Boisse-Despiaux M.	2018	Journal of International Humanitarian Action	Netherlands	Journal Article
Blockchain in Humanitarian Aid: A Way out of Poverty and Famine	de Vrij A.	2018	University of Leiden	Netherlands	Master Thesis
Blockchain for Development: Emerging Opportunities for Mobile, Identity and Aid	GSM Association	2017	GSMA and DFID	UK	Report
Blockchain: Uniting Aid and Trade? A case study of the UN Women Blockchain Project to Empower Women and Girls in Humanitarian Settings	Skogvang E.M.	2018	University of Oslo	Norway	Master Thesis
Using Blockchain to Improve Aid Transparency and Efficiency	Thompson J.	2018	Development Asia	UK	Article

Appendix 4. Numerical Analysis of References Scoping Study

Document Title	Authors	Publication Year	Journal Title / Institution	Country of Publication	Publication Type
Opportunities and risks of Blockchain Technologies in payments - a research agenda	Lindman J., Rossi M., Tuunainen V.P.	2017	Proceedings of the 50th Hawaii International Conference on System Sciences	Finland, Sweden	Conference Paper
Will blockchain transform the public sector? Blockchain basics for government	Killmeyer J., White M., Chew B.	2017	Deloitte Centre for Government Insights	US	Report
How blockchain technology could change our lives	Boucher P.	2017	European Parliamentary Research Service	Belgium	Report
A survey of blockchain security issues and challenges	Lin I.-C., Liao T.-C.	2017	International Journal of Network Security	Taiwan	Journal Article
Distributed Ledger Technology: beyond block chain	UK Government Chief Scientific Adviser	2016	UK Government Office for Science	UK	Report