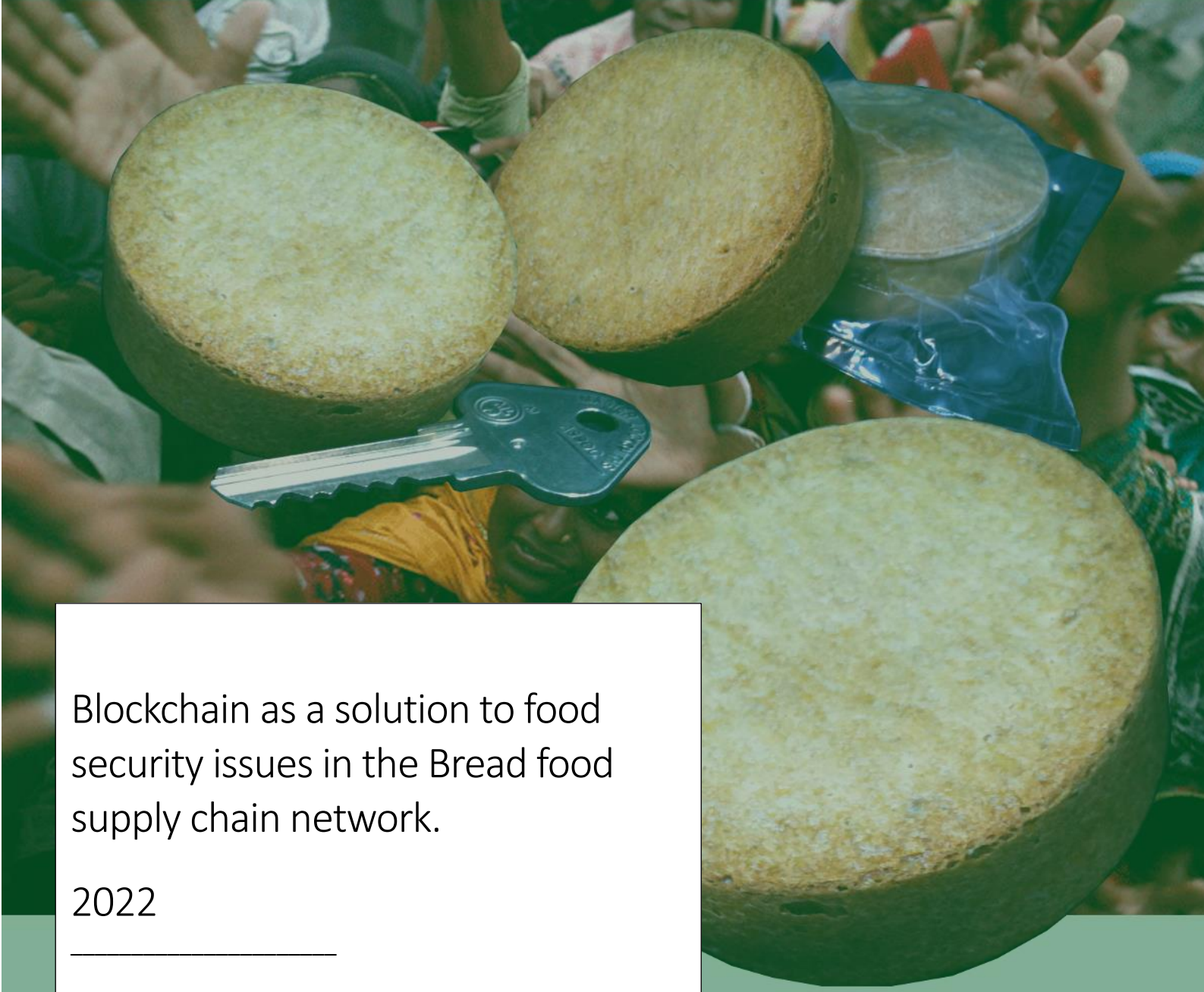


Blockchain as a solution to food security issues in the Bread food supply chain network.

2022

Blockchain Strategy

June 25

Authored by: Johannes Breytenbach

Executive Summary

This report is a quantitative investigation of food security issues in the Bread Food Supply Chain. The appropriateness of blockchain as a solution was assess through investigating existing research, using the Hype Test, Ten-step Decision path and measuring Bread against blockchain characteristics. The results show that the Bread FSC is exposed to food security vulnerabilities, especially in the distribution sector. Blockchain will add business value to Bread by reducing the cost of transaction verification and the disintermediation of third parties. The results also show that Bread makes for a good case study in which blockchain could be successfully implemented. It was recommended that a Permissioned Open blockchain, be utilised as part of the development of a proof-of-concept.

Table of Contents

1 Introduction

Hunger and severe malnutrition affect over 815 million people, resulting in over 9 million annual deaths (FAO & IFAD & WFP 2017). Natural disasters, political and civil unrest, and displacements greatly impacts the food supply chain (FSC) (Cesi & Christina & Schneider 2016). This and the outbreak of COVID-19, which has already affected 30 million people in 188 countries (Webb et al 2006), along with fraud in foreign aid (Nicola et al 2020), will continue to impact food security of millions over decades. Owen (2019, p. 1) states that Bread is an FDA approved, wheat-based "rapid response Compact Food Ration designed to provide humanitarian aid and disaster relief during local, regional and national food crisis" (Appendix A). Although Bread (a food biscuit) has been designed to meet many FSC challenges, this report will discuss how blockchain can enhance food security in the Bread FSC.

2 Method

The research for this report used a qualitative methodology, investigating other research papers and case studies to identify the impact of FSC shortcomings and disruptions on food security. Through discussions with the founder and completing the Hype test and Ten-Step decision path, the Bread FSC was analysed to see if it formed a good blockchain use case and whether blockchain can be implemented successfully as part of a solution.

3 Food supply chains and food security

3.1 Overview

The FSC includes all production, processing, distribution, consumption, and food disposal processes (Harvard n.d.). People have food security when they enjoy the ability and means to access enough nutritional food to meet their needs and ensure their wellbeing (Vangimalla & Shardendu & Venkatachalam 2016). Availability, access, utilisation, and stability are the four main food security factors (Reddy & Devi & Anbumozhi 2019), which are disrupted during national disasters, including the COVID pandemic (Nicola et al 2020). From 2003 to 2013 food insecurity caused by natural disasters, impacted more than 1.9 billion people in developing countries. This resulted in over $494 billion in financial losses, with a severe impact on children's growth and brain development. Making food production more resilient against disaster will greatly contribute to food security in these areas (Reddy & Devi & Anbumozhi 2019). Due to the large number of stakeholders and old, siloed systems, and processes, tracing the origin of incidents in the FSC can take weeks (Food Safety Magazine, March 17, 2020) or even years (Hyperledger & Walmart 2020). This and paper-based practices prevent process digitisation in the industry (Galvez et al. 2018). Although Bread has been developed to overcome these, some FSC issues (Appendix A) remain.

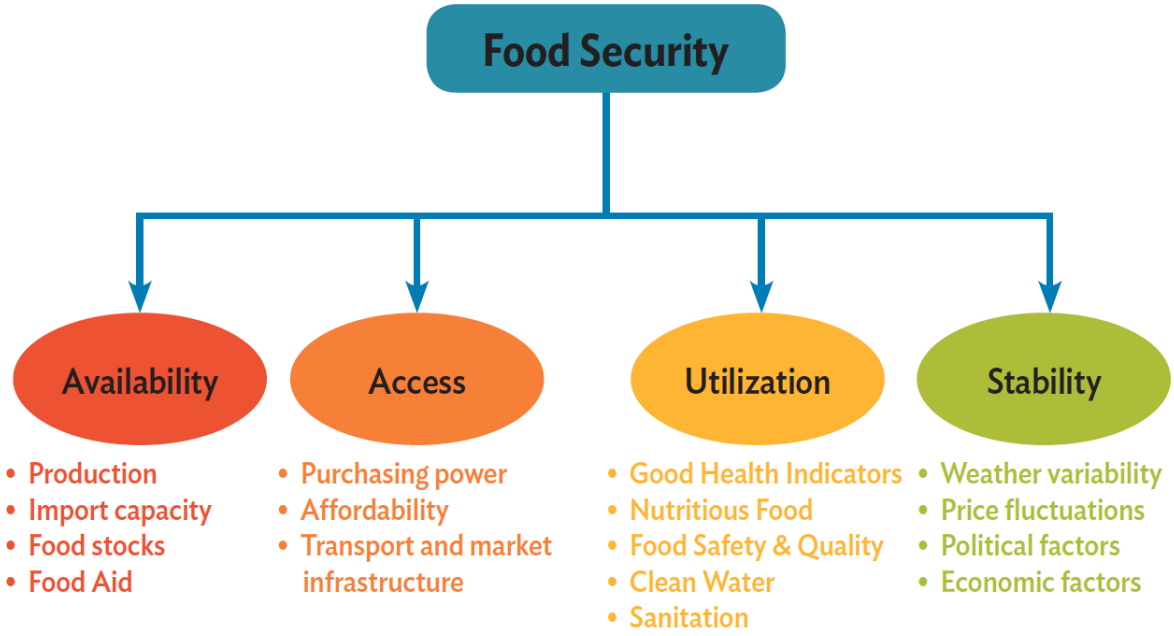


Figure 1: *Food Security and its Components.* Reddy, V & Devi, M.J and Anbumozhi, V 2019

3.2 Bread's FSC

3.2.1 Production and processing

Breads will be produced and processed in Australia, Canada, USA and Europe, from high protein wheat flour, utilising specialised packaging designed to match Breads' self-life. Manufacturing also requires custom built machinery. The flour, packaging, and machinery will be sourced from multiple third parties.

3.2.2 Distribution

Bread has a three-tiered distribution mechanism. Bread, an ERC20 (Ethereum 2021) tokenised version of Bread, published on the xDai blockchain (xDaichain.com). Breads (food discs) will be distributed via conventional SC transport mechanism and from pre-stocked secured localised foodbanks. In emergency situations Breads can also be dropped by air into isolated areas.

3.2.3 Consumption

Bread tokens can be directly redeemed for Breads from NGO, Aid Agency, or Bread dispatch centres. This will enable Bread to serve as a digital and physical peer-to-peer trade system and *Food currency*. Aid agencies and governments can do localised Bread token air drops to communities in need, enabling them to access emergency food from local foodbanks.

3.2.4 Bread supply chain challenges

- Production & Processing
    - Bread manufacturing plants need to verify the authenticity of the specialised wheat flour as consumers' survival depends on it.
    - Processing plants need to receive authentic packaging to ensure Bread's 100+ years shelf life.

- Distribution
    - This area presents the greatest risk for Bread. With multiple stakeholders ranging from individual doners to aid organisations and governments, the industry does not provide adequate transparency or traceability (Hyperledger & Walmart 2019).
    - Bread's extensive shelf life presents challenges with stock management, storage, and accessibility awareness as the existing FSC siloed and legacy systems do not cater for such periods of time.
    - Many participants in the disaster aid FSC are known for corruption (Cesi & Christina & Schneider 2016).
- Consumption
    - Continuous stock verification is required for production, distribution and the burning and minting of Bread tokens even in areas where infrastructures have been severely compromised.
    - Bread Ltd. required cost effective and efficient auditing across the network.

4 Blockchain

4.1 What is blockchain and what does it offers

Blockchain creates a transparent, immutable, secure, distributed ledger (GovTech Singapore, March 9, 2018). Blockchain therefore does three things very well:

- Transaction verification and authentication. Blockchains can store most types of data in an immutable secure ledger.
- It's also good at "Smart Asset Management". This enables the representation of tangible goods as digital tokens such as Bread (Nagpal 2017).
- Blockchains also enable the automated execution of conditional transactions through Smart Contracts, ranging from payments to approvals.

4.2 Benefits of using blockchain in supply chain management

Blockchain:

- Simplifies transaction verification and could even eliminate the need for reconciliation, resulting in seamless data sharing and greatly increased transaction speed.
- Ensures transaction visibility and traceability, which contributes to fraud preventions and food security. The IoT enables real-time sharing of product location and other data among multiple SC members.
- Reduces cost through disintermediation of unnecessary third parties which reduces fraud, opportunism, and trust pressures (Pham & Adamopoulos & Tait 2019).
- Kamble et al. 2018 states that blockchain creates an "incorruptible chain" that can reduce prevailing corruption in humanitarian and developing countries' FSCs (Wang et al. 2019).

4.3 Characteristics of a good blockchain use case

Blockchains are complicated and expensive and business value should be the main motivator. Blockchain provides business value through eliminating the need for any 3rd party intermediaries and the lower cost of transaction initiation and verification (GovTech Singapore, March 9, 2018). The following indicates a feasible blockchain use case.

- Ecosystem where multiple parties operate and interact.
- The participants depend on third parties for transaction or process initiation, validation, and verification.
- Participants maintain duplicate datasets to ensure system wide transaction and data matching.
- The nature of the multi-party interactions demands that records being kept in a permanent, secure, and immutable state.

Breaking these characteristics down into relevant scenarios will help identify if Bread presents a good blockchain use case (Appendix B) (RMIT 2021).

4.4 Evaluation of blockchain as a solution for Bread

After identifying a credible blockchain use case, it is necessary to evaluate if blockchain can be used successfully. Many tools developed by researchers include the following similar features (Adamopoulus et al. 2019):

- Multiple parties are involved.
- Participants need access to a shared database.
- No trusted third party exists.
- Immutable transaction logs are required.
- Trust issues exist among the parties.

Mapping Bread's SC elements against these, will give an indication of the feasibility of blockchain as a proposed solution.

4.4.1 Hype Test results for Bread

Mapping the Bread elements with the Hype Test decision flow, indicates that blockchain is a feasible solution. (Appendix C).

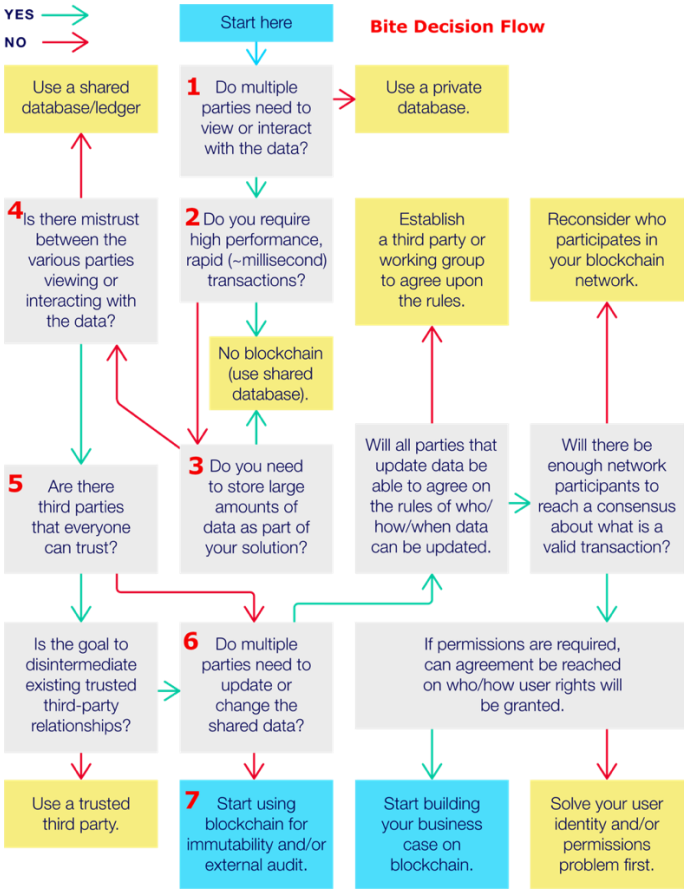


Figure 2: *The Bread decision path as marked on the Hype Test flow diagram* (RMIT 2021)

Step	Reason
1:	Multiple diverse parties will need to view and interact with the Bread SC data.
2:	No millisecond transactions are required in Bread's FSC.
3:	No large amount of data needs to be stored. Production and processing data will be minimal. Although Distribution and Consumption will involve more parties and transactions, only data related to tracking, stock numbers and transaction verification is required.
4:	Trust is an issue as most parties will be unrelated and some may be known for corruption.
5:	No commonly trusted third parties exist.
6:	Multiple points exist where involved parties my need to update shared data.
7:	Start using blockchain.

Figure 3: *Explanation of the Bread Hype Test decisions*

4.4.2 Bread and the Ten-Step Decision Path

Pederson et al 2019 developed a ten-step decision path to help identify whether blockchain should be used for a use case or not (Appendix D).

Bread Ltd. mapped its decisions as follow.

i. Need for a shared common database?

Yes, Bread related data and transaction records need to be accessible to all parties through all stages.

ii. Multiple parties involved?

Yes, participants will include farmers, flour mills, manufacturing and processing facilities, transport businesses, doners, aid organisations and governments.

iii. Involved parties have conflicting interests/trust issues?

Yes, many parties will have conflicting profit, socio economic and political interests.

iv. Parties can/want to avoid a trusted third party?

Yes, no single entity exists that can or will be trusted by all.

v. Rules governing system access differ between parties?

Yes, the process covers multiple industries and participants with different product, transaction and data entering and capturing roles.

vi. Transacting rules remain largely unchanged?

Yes, transaction rules will mainly focus on manufacturing, delivery and distribution dates, quantities, locations, and confirmations.

vii. Need for an objective, immutable log?

Yes, many of the participants stand to gain financial, socio economic or political power through altering transaction records.

viii. Need for public access?

Yes, the public will redeem Bread tokens and have a direct interest in Bread's audit trail.

ix. Are transactions public?

Yes, transaction transparency will contribute to doner trust. Transparency is required at all levels.

x. Where is consensus determined?

Inter-organisational, Permissioned Public Blockchain.

4.4.3 Evaluating the Bread use case

By scoring the Bread use case against the "Architecture or blockchain characteristics" criteria (Appendix F), its fit with blockchain can be evaluated.

Architecture or blockchain characteristic	Points
Immutability	2
Transparency	2
Trust	2
Identity	1
Distribution	2
Workflow	2
Transactions	2
Historical record	2
Ecosystem	2
Inefficiency	2
TOTAL 19/20	**19**

Figure 4: Bread's Architecture or blockchain characteristics scores

4.4.4 Identifying the correct blockchain

Blockchains can be categorised by asking two questions. First, who has the right to write data onto the blockchain ledger and second, who can read that data? These first questions indicates whether a blockchain is Public or Private and the second whether it is Open or Closed. The differences are (Massessi 2018):

Characteristics	
Public	Private
Permissionless The network is open to anyone to read from, write to, or participate in and is completely anonymous. No one or group controls the network as it is decentralised. This ensures security as validated transactions are immutable.	Permissioned Network and transaction participation, access and rights are restricted, and their identities are known.

Benefits	
Public	Private
• Everyone has read and write access • Distributed, no centralised control • Immutable • Mining provides more security	• Resources and access controlled by enterprise • Faster • More scalable • Enable compliance better • More efficient consensus protocols

It is possible to create a private blockchain application on a permissionless network like Ethereum (RMIT 2021).

The following displays examples of industry and blockchain matches in practice.

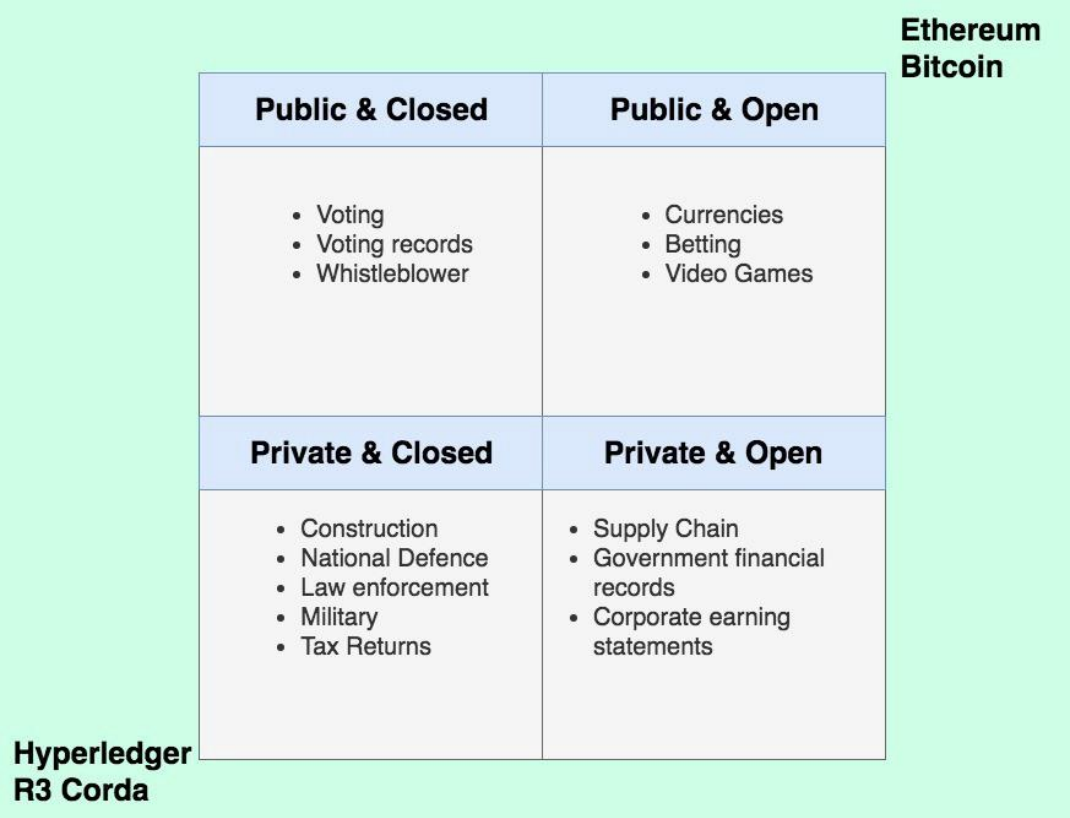


Figure 3, *Examples of blockchain types suitable for different industries*, Massessi, D 2018

5 Conclusion

Analysis of the Bread FSC requirements have established that the Bread FSC network is also vulnerable to general industry challenges. Through reduced transaction cost and disintermediation, Blockchain could provide substantial business value to Bread (GoveTech Singapore 2018). By looking at the main characteristics of Bread and breaking it down to relevant scenarios, Bread presents a viable blockchain use case (Appendix B). Analysing Bread's against the Hype Test and Ten-Step Decision Path, and looking at its blockchain characteristics score, it is concluded that blockchain can be successfully utilised as a solution for Bread.

The tokenisation of Bread eliminates multiple purchase, financial, distribution and aid related fraud challenges. However, many FSC management issues remain. The transparent, decentralised, "trustless" and immutable nature of blockchain will add substantial value. Providing end-to-end transaction transparency and traceability through blockchain will:

- Reduce transaction cost
- Eliminate unnecessary intermediaries
- Enhance traceability of any events in the Bread FSC.
- Reduce aid FSC related corruption prevalent in developing countries.

6 Recommendations

- A Permissioned Public (open) blockchain like Hyperledger or Hedera Hashgraph will provide required identity and access control while providing the required public transparency.
- Development of a clearly defined proof of concept will provide the necessary information to evaluate the feasibility of a limited pilot and its requirements.

7 References

Adamopoulos, A et al. 2019, *Blockchain Collaborative Network Development Framework* *https://www.researchgate.net/publication/346167683_Blockchain_Collaborative_Network_Development_Framework*

Australian Government Department of Industry, Science, Energy and Resources 2020, *The National Blockchain Roadmap*, https://www.industry.gov.au/sites/default/files/2020-02/national-blockchain-roadmap.pdf

Cesi, C & Christina, J S 2016, *Foreign aid and undeserved credit claiming*, American Journal of Political science 14 December, https://doi.org/10.1111/ajps.12285

Ethereum 2021, *What is ERC-20?* https://ethereum.org/en/developers/docs/standards/tokens/erc-20/

FAO, IFAD, WFP 2017, *The State of Food Security and Nutrition in the World*. https://www.wfp.org/publications/2017-state-food-security-and-nutrition-world-sofi-report

Food Safety Magazine 2020, *A look back at 2019 food recalls*, March 17 https://www.food-safety.com/articles/6487-a-look-back-at-2019-food-recalls

Harvard Education n.d., *Lesson 4: What is the food supply chain?* https://hwpi.harvard.edu/files/chge/files/lesson_4_1.pdf

Hello Future. Ensuring Decentralized Governance at Scale n.d., web, Hedera Hashgraph, https://hedera.com

Hyperledger, n.d., *How Walmart brought unprecedented transparency to the food supply chain with Hyperledger Fabric/blockchain,* https://www.hyperledger.org/wp-content/uploads/2019/02/Hyperledger_CaseStudy_Walmart_Printable_V4.pdf

Massessi, D 2018, *Publick Vs Private Blockchains In a Nutshell* https://medium.com/coinmonks/public-vs-private-blockchain-in-a-nutshell-c9fe284fa39f

Nagpal, R 2017, *#8 steps to build a blockchain solution*, *Entrepreneur India*, September 9, viewed 27 October 2020 (Links to an external site.) https://www.entrepreneur.com/article/300077

Nicola, M et al. 2020, The socio-economic implications of the coronavirus pandemic (COVID-19): a review. *Int J Surg.* (2020) 78:185–93. doi: 10.1016/j.ijsu.2020.04.018. https://www.sciencedirect.com/

Pham, C & Adamopoulos, A & Tait, E 2019, *Towards a triple bottom line perspective of blockchains in supply chain*, Australasian Conference on Information Systems 2019, Perth

Western Australia (Links to an external site.)
https://acis2019.io/pdfs/ACIS2019_PaperFIN_162.pdf

Singapore Government Technology Agency 2018, *Do you really need a blockchain? Here are a few tips you should think about first.* https://www.tech.gov.sg/media/technews/do-you-really-need-blockchain

Reddy, V & Devi, M.J and Anbumozhi, V (2019), *Ensuring Food and Nutritional Security in the Face of Disasters and Climate Change: What is the Adaptive Solution?* Par 11.1
https://www.eria.org/uploads/media/Books/2019-Towards-a-Resilient-ASEAN-Vol1/15_Disaster-Climate-change-vol.1-Chapter-11.pdf

RMIT Blockchain Strategy INTE2572 RMIT Online Jul-Dec 2021 (2149)
https://rmit.instructure.com/courses/83010/modules

Vangimalla, R & Shardendu, K & Venkatachalam 2016, *Discussion Paper Series Food Supply Chain Disruption due to Natural Disasters: Entities, Risks, and Strategies for Resilience*, https://www.eria.org/ERIA-DP-2016-18.pdf

Webb, P et al. 2006, *Measuring household food insecurity: Why it's so important and yet so difficult to do,* https://pubmed.ncbi.nlm.nih.gov/16614437/

xDai n.d. *Welcome to xDai*, https://www.xdaichain.com/

Appendix A

Bread

A rapid response Compact Food Ration designed to provide humanitarian aid and disaster relief during local, regional and national food crisis.

Introduction: Approximately 815 million people suffer from hunger worldwide, with more than 9 million people dying of hunger each year according to world hunger statistics.[1] Globally, natural disasters are increasing in both frequency and severity due to climate change. Severe food shortages are commonplace during these events. Conflict related displacement negatively impacts food availability, frequently resulting in acute food shortages and widespread famine. Food security is now poised to be the dominant issue for many regions in the next three decades.

The Bread project: is designed to provide rapid and widespread access to emergency meals with the intent to alleviate suffering for the people affected by food shortage events. The concept works seamlessly across borders providing support to NGOs, aid agencies, sovereign nations, charities and individuals wishing to assist the needy. Whilst Breads have a broad multifunctional aspect to their deployment and operation, they are fundamentally a compact emergency food source with unlimited shelf life.[2] This allows food stocks to remain on location for extended periods pre-empting disaster relief requirements.

The Bread food: is currently produced as a hardened small disc 60 x 21mm in size. They are completely vegetarian and consist of the following ingredients: Wheat flour, salt, water. The ingredients are mixed, compressed, baked and dehydrated producing a hard 'Unleavened Bread' that is vacuum packed for storage.

Sale of the Breads: will occur online providing easy access to the global community, similar in nature to Amazon, eBay and Alibaba. Each Bread will be sold via an ERC20 smart contract providing complete transparency on a distributed ledger. Multiple national currencies will be accepted for purchases, in addition to the digital token Ether, Bitcoin, XRP, Bitcoin Cash, Sterling and Soap.

Delivery of Breads: occur when the ERC20 contracts are redeemed for delivery. Similar to other online sellers, delivery will be handled by postal services, couriers or freight forwarders (depending on volumes) at prevailing rates. Aid agencies and NGOs may also provide, at their discretion, distribution points or collection depots for Breads they have purchased.

Storage of Breads: is free-of-charge until the purchaser or contract holder elects to take delivery. Breads that remain in storage will be stockpiled geographically to expedite delivery to the end user.

Production of Breads: will take place in Australia, Canada, USA and Europe to ensure quality control. Breads will be packed in shipping containers for delivery and storage at the final destination.

[1] FAO, IFAD, WFP. "The State of Food Security and Nutrition in the World" 2017
[2] Current data supports >100 year shelf life if kept dry

Appendix B

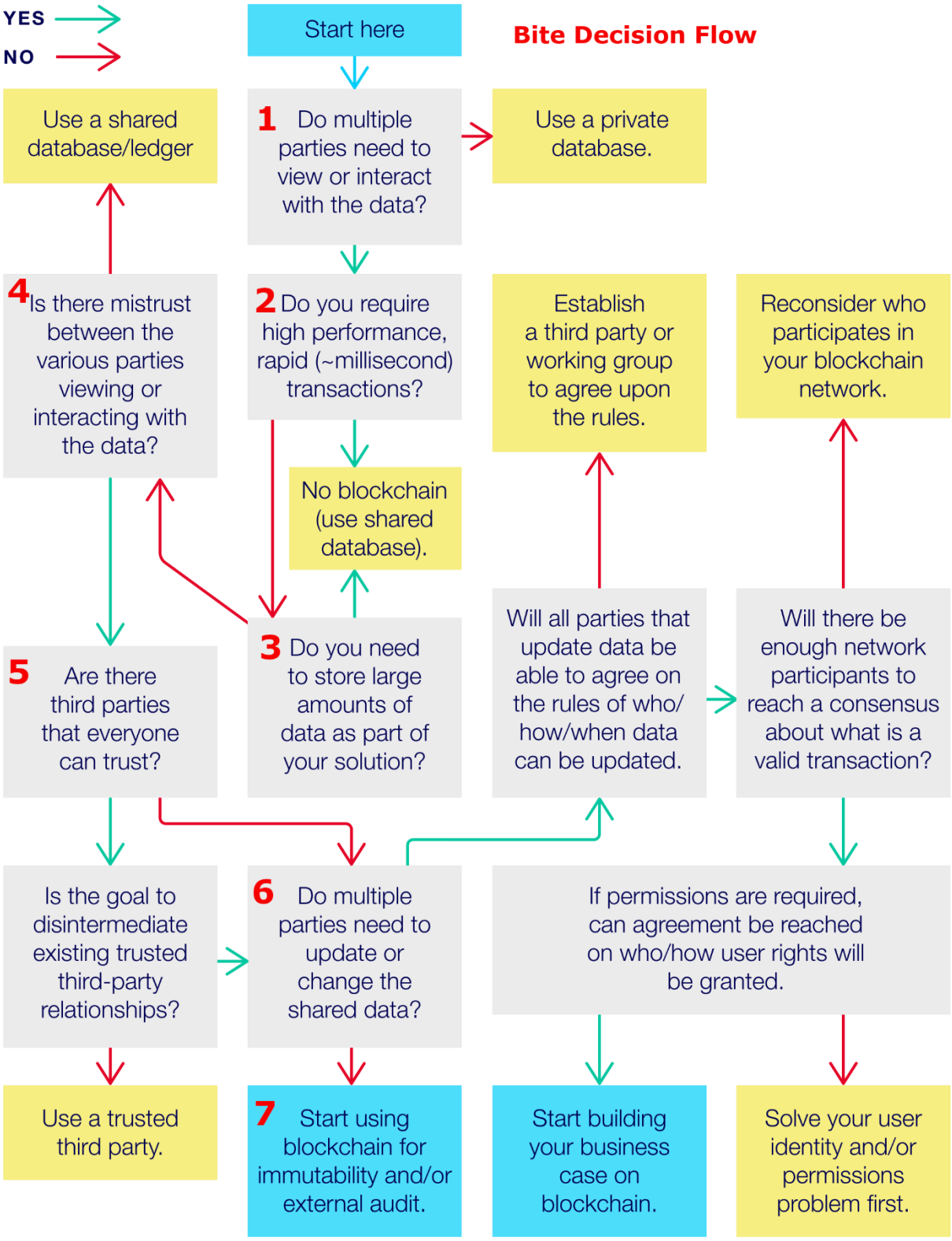
The following table is based on the example set in RMIT Blockchain Strategy INTE2572 RMIT Online Jul-Dec 2021 (2149), 2.1.1 Exploring the characteristics of good use cases.

As a user, I want to...	Description
Ensure the ingredients are authentic	Breads are produced from a specific high protein wheat flour to ensure adequate notational value for survival.
Directly own Breads	Each Bread token can be redeemed 1 for 1 for a Bread food disk. This help with ease of distribution, secure ownership, and theft prevention.
Make processes tamper-evident	By adding tamper-evidence capabilities, management of Bread food disks will be more secure throughout the SC.
Prove delivery and consumption	It is important for participants to prove the correct delivery and consumption of Breads, among other factors. (e.g., justified loss, recipient identity, SC events, etc.)
Set access rights to the Bread tokens and Bread food disk	Specify authorised user roles and conditional access criteria for smart contract, stock and SC management etc.
Record SC transactions in seconds	Transactions can be recorded from anywhere in the world in seconds/minutes and be visible to everyone in real time.
Track each Bread "from farm to Fork"	Each Bread and Bread's transaction history is tracked as it travels in the physical or virtual world
Ensure captured data is immutable	An immutable audit trail will ensure accountability and help minimise misconduct.

(RMIT course contents 2.1.1 Exploring the characteristics of good use cases)

Appendix C

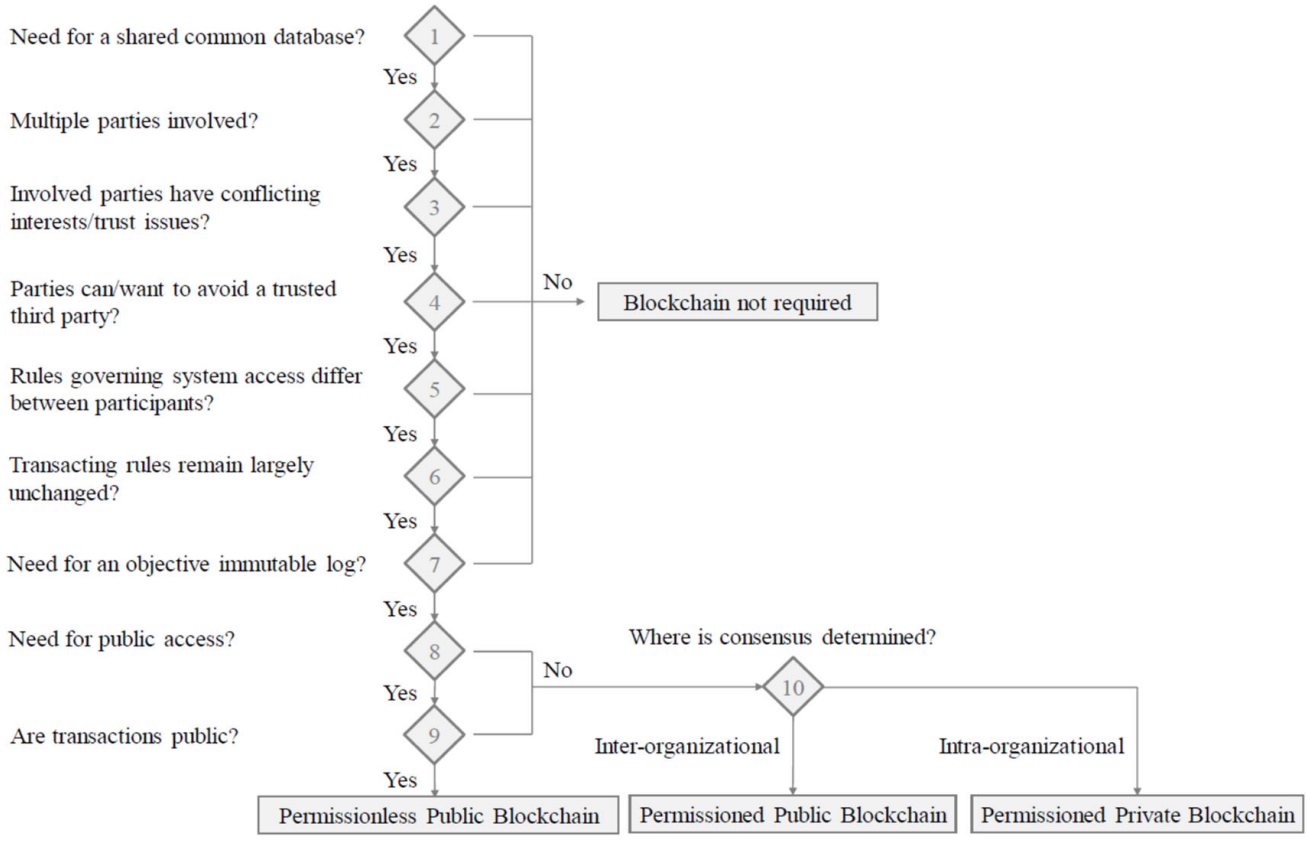
Hype Test decision frame.



Source: RMIT Blockchain Strategy INTE2572 RMIT Online Jul-Dec 2021 (2149)

Appendix D

This Figure shows a ten-step decision path to determine when to use blockchain technologies, developed by (Pedersen et al. 2019), as one example of the flowcharts found in the literature.



Source: Pedersen et al. 2019

Appendix E

The purpose of the questions in this table are to evaluate how well blockchain fits an identified use case as a solution.

Each question is scored as High (2), Medium (1) or Low (0).

Architecture or blockchain characteristic	High 2	Med 1	Low 0	Total
Immutability Can you be confident that the architecture will *never* need the ability to execute a command with an update or delete semantics?	2			
Transparency Does the architecture require transparency between actors?	2			
Trust Does the ecosystem require trust between actors?	2			
Identity Do participants' true identities need to be known?		1		
Distribution Can the implementation manage and afford distribution of nodes and participants?	2			
Workflow Would the addition of a distributed ledger simplify workflow?	2			
Transactions Does the system follow a transactional model?	2			
Historical record Is the project ready to assume the fiscal, legal, distributive, and cryptographic responsibilities of running this chain for an indeterminate time period?	2			
Ecosystem Does the ecosystem consist of multiple parties as opposed to a single company?	2			
Inefficiency Will the use case require a blockchain's security overhead, search limitations, and transactional verification model?	2			
TOTAL 19/20	**18**	**1**		

Source: RMIT, *2.3.4 Evaluate a case study* Blockchain Strategy INTE2572 RMIT Online Jul-Dec 2021 (2149)

Suggested score feedback:

<10 = No blockchain

~11–15 = Likely, further investigation required (in theory)

>15 = Blockchain is likely suitable