# Local currency networks in rural communities in Africa: A feasibility study of blockchain based community currency.

**Yifan Zhan**
Master Thesis Information Science
Vrije Universiteit Amsterdam
S2624699
y.zhan@student.vu.nl

# Table of Contents

# Abstract

This research explores the technical feasibility of a community currency based on blockchain in a low resource environment, like rural Mali. We have structured our case study based on the ICT4D 3.0 methodology and use the e3-Value methodology to assess the economic sustainability of the system. Our conceptual model is a community currency backed by the seeds stored at Cooprosem and issued on the Stellar Network. The community currency is valued similar to the national currency and is named SeedCoin. We have demonstrated the functionality on the hand of a proof-of-concept. This research provided some practical insight on how to proceed when issuing a new digital community currency based on blockchain on the Stellar Network.

# 1. Introduction

Financial inclusion is still an issue in sub-Saharan Africa region. In a 2014 study of the Worldbank, the sub-Saharan Africa only 34% of the population had access to a bank account, compared to 94% in de high-income OECD countries. In recent years there are positive development happing in the financial services, with the rise of mobile phone (Reeves, 2017).
Rural Africa communities have experienced a rapid influx of mobile devices over the past decades (Pankomera & van Greunen, 2018). Combined with an increase over 20% in 2017 of internet access across the African continent, it opens up opportunities to provide services over the internet to more remote areas, e.g. rural Africa (Pankomera & van Greunen, 2018). This development has also contributed to more financial inclusion, especially in African economies (Pankomera & van Greunen, 2018). It enables mobile money services, e.g. M-PESA Orange Money and MTN Money, which enables peer-to-peer payments.
Mobile money facilitates transaction services like deposit, transfer and withdraw funds from and to mobile phones, without the need of a bank account. Nonetheless, still 1.7 billion people of the world's population remain unable to use formal financial services, and over 50% of the poorest households continue to be unbanked (Demirgüç-Kunt, Klapper, Singer, Ansar & Hess., 2017).M-PESA is one of the most successful implementation of mobile money in Africa, with 97% of the households in Kenya having an account as of 2014 (Suri, 2017). This demonstrates that a large part of the unbanked population do have a demand for peer-to-peer payments. As Scott (2016) suggests that in the context in rural Africa, where there is a high dependency on cash and low infrastructure, - hypothetically – a quasi-bank account with digital money can be a more advantageous way to hold and transfer money.

Another issue that prohibits high level of financial inclusion are the high fees involves with banking services in these areas. According to Reeves (2017) the banking fees for people in the sub-Saharan Africa region, are four times higher compared to people in the Middle East or North America (Reeves, 2017). Therefore making it even more inaccessible for local communities. Even mobile money have made banking services more accessible in the area, in order for small amounts transfers like 100 KES, M-PESA charges 10% transaction fee. Therefore even mobile money has relative high fees.

One of the recent technologies that potentially can address the unbanked population is blockchain technology. Blockchain technology, eliminates the need for intermediary party to process the transactions (Zheng, Xie, Dai, Chen, & Wang, 2017). Furthermore, the technology is well suited for this application due to the transaction data are made immutable, and therefore cannot be tampered after it is written to the blockchain. This makes the transaction final. Moreover a peer-to-peer network based on blockchain can utilize this technology to ensure the reliability and honesty of the transaction, this in turn will increase the chance of adoption. Another beneficial property is its distributed nature, which results in no single point of failure in the network (Zheng et al., 2017). These properties suit very well for providing a decentralized peer-to-peer payment solution for the unbanked population in rural Mali. A distributed transaction platform addresses this challenge by a decentralized peer-to-peer networks like cryptocurrency (Lindman, Tuunainen, & Rossi, 2017).

Beside blockchain based peer-to-peer payment solutions, I will explore literature of community currency as well. Community currency can be defined as is an concept that complements the national currency in a specific geographic region or a community (Kim, Lough, & Wu, 2016). Community currency has a similar role of providing financial needs to individuals that are disadvantages in society, due to economically factors of societal factors (Telalbasic, 2017). Therefore community currencies address similar issues that I want to address with a peer-to-peer network, from an organizational standpoint.

There are considerable amount of community currency circulating worldwide, over 4000 systems according to a study from Kim, Lough, & Wu (2016). The existence of community currency can be justified due to the narrower scope of the use cases of the currency compared to national currency (Sartori & Dini, 2016). Beside the scope, the same research suggested that local currency also contain a belief in local social value to sustain economic activity, even in economic distressed periods (Sartori & Dini, 2016).

Community currency has an added benefit of stimulating local economy and environmental sustainability of a community (Kim et al., 2016). This can be explained due to a supply and demand mismatch in goods and services where direct barter techniques alone are insufficient (Ruddick, Richards, & Bendell, 2015). The poverty, i.e. lack of resources in national currency, can be solved by an introduction of community currency so there is an alternative medium for exchange (Ruddick et al., 2015). This means bringing people and resources together that were otherwise unused (Lietar & Hallsmith 2009).

Therefore this research will combine blockchain and community currency concepts to explore the feasibility of an local payment system. This research is going to focus on peer-to-peer payments within a community. Hence the focus on community currency. There are peer-to-peer payments that are crossing borders, like remittances, however I will not focus on these cross-border payments in this research. The main focus in my study is on local peer-to-peer payments within a community.

My contribution to the current literature is a system design for a payment network, taking in consideration of local context and requirements. One of the research gaps mentioned in the paper of Lindman et al. (2017), are the practical insights about blockchain implementation. So this research is providing some insights on practical implementation of a blockchain based payment network in the form of a community currency. Furthermore this widens the current literature about community currency in developing countries, in our case western Africa. Moreover it extends the literature about ICT4D development in low-resource environment with blockchain solutions.

## 1.1 Structure

The paper is structured in the following chapters. Chapter 2 covers the literature study of both community currency and blockchain technology. Both topics will be accompanied by an example of a practical implementation. The chapter conclude with the research questions and the motive of this research. Chapter 3 will cover the methodology used for this research. Followed by chapter 4 of the context analysis of the seed production system in Mali. The next chapters 5 and 6 elaborate on the actors of the system and use case scenarios. This leads to chapter 7, in which we will present the conceptual model for the community currency based on local seeds. The practical implementation of the community currency is presented in chapter 8. Chapter 9 will evaluate various business models for economic sustainability of the community currency. To conclude we will provide a discussion and conclusion in chapter 10 and 11.

# 2. Related research

## 2.1 Community currency

There is extensive literature on community currencies. One of the common definition of community currency is a monetary network using specific medium of exchange to complement the national currency (Kim, Lough, & Wu, 2016).

Another definition of  community currency is that its complements the national currency in a specific geographic region or a community (Kim et al., 2016).

The goal varies what they want to achieve, It can be either boost the local economy, or increase cohesion of a community or lower the barrier to employment (Sartori & Dini, 2016). Community currency can take forms like mutual credit networks, convertible vouchers, Local Exchange and Trading Systems (LETS) or time banks. This research will focus on the mutual credit networks. The reason for this focus is because of the anti-cyclical nature of the currency relative to the economy (Telalbasic, 2017). This result that these currency usually emerge in time of an economic crisis.  Several complementary currencies have been emerged during crisis. The Swiss WIR was created in the 1930's in response to recession, Barter clubs in Argentina during the 2002 recession and Sardex was establish in 2009 to combat the recession of the financial crisis that Italy was facing (Gómez, 2018). It has been proved to be an effective instrument to combat the low liquidity of fiat money, while remaining to have a demand for currency (Ruddick et al., 2015). Complementary currencies has been al sort of variations. Community currencies can be established between businesses (Cooperative WIR bank), Business to Consumers (LETS) or only consumers (Time banks, LETS) (Telalbasic, 2017). The commonality of these existence of community currency is that their financial needs of are not met by the communities, due to economic distress moments. Hence the anti-cyclical nature of the credit. Moreover these community currencies are established for and by communities that were social / economical disadvantaged, for which formal banking credit was inaccessible (Telalbasic, 2017).

### 2.1.1 Use of community currency

According to research of Telalbasic (2017), the use of community currencies is to provide financial needs to individuals and communities who are disadvantages in society, due to economic factors or societal factors. Therefore an alternative needs to be provided to those people. The local currencies is based on trust within such communities. Because the trust is safeguarded by the communal interest of all the individuals of these communities, a monetary agreements can be established. These agreements of the community currencies are based on trust and enforced by social pressures (Telalbasic, 2017).  What makes a system sustainable is the fact that behavior of community members has a positive effect on local social economy (Telalbasic, 2017). This can be explained by the preference of local consumption of goods and services due to the local currency.

In the same research of Telalbasic (2017), they looked at various community currencies from a service design perspective. They try to classified these communities currencies and looked into what the impact of the these communities currencies are. Overall the impact of the community currencies in developing economies, has brought financial inclusion and an increase of community bond which resulted in trust (Telalbasic, 2017).

Another important feature of community currencies is how to design the system so it prevents hoarding of the currency (Telalbasic, 2017). This is counterintuitive to national currency, where one of the goals is to accumulate money and save (Telalbasic, 2017). Due to the limited supply of currency, and the their purpose to mitigate the lack of liquidity in national currency, this is not beneficial for community currency. Therefore the effectiveness of the community currency is its rate of circulation, encouraging people to spend their community currencies. The literature of community currency suggest that the most effective way to recirculating money is to enable the merchants to pay their suppliers and employees. (Kim et al., 2016). Another strategy to encourage circulation of the currency consist of low or no interest rates, both for positive as negative balances.

Similar to Sardex, which is a mutual credit based community currency  in Sardine, people are more willing to spend their money when they encounter abundance of currency, compared to money scarcity (Greco Jr. ,2015). This is even more prominent during economic or political uncertainty (Telalbasic, 2017). Community currencies serve a need during economic crisis in providing short-term loans in time of economic uncertainty. Unlike formal banks, mutual credit networks utilize a model of no interest and is based on the principles of reciprocity and mutuality. Community currency are tools that can provide empowerment to communities through the creation of networks, and strengthen local knowledge and expertise based on social ties. Furthermore a community currency helps the individual to connect with their local network, that further opens their opportunities to find new customers (Telalbasic, 2017).

### 2.1.2 Impact on real economy

The theory of using multiple currencies has been established by Kiyotaki and Wrights (1989). They developed a model to perform empirical studies on secondary currencies. One of the key determinant of the use of complementary currencies was the scarcity of the national currency (Kiyotaki and Wrights ,1989). In their research of Colacelli & Blackburn (2009), the researchers used this model to evaluate the usage of alternative currencies during the Argentina's recession of 2002 in an empirical research. They found that low scarcity of national currency, like the Argentina's recession, has a positive impact on the adoption of a complementary currency called créditos. The currency is based on an one-time loan that the barter club provided to each member. Each club member needed to pay two pesos in order to join the club and in return get a one-time loan of 30 créditos, which was equivalent to roughly 15 pesos. The barter club organizes meetings where members could trade, and in order to attend those meetings, members are required to bring goods and services that they can sell. Individuals who accepted créditos  earned 100 pesos more than individuals who does not accept créditos in the study (Colacelli & Blackburn, 2009). These trades contributed to a national GDP increase of Argentina of 0.6% (Colacelli & Blackburn, 2009).

## 2.2 Sardex, the community currency in Sardinia

Sardex is a successful implementation of a complementary currency that has been established in the aftermath of the recent financial crisis in 2008. They launched it in 2009 as a response to effect on local economies from the global financial crisis. Sardex is a complementary currency, with the purpose to be a means of exchange on the island of Sardinia. It's only valid within Sardinia and it's not interchangeable with the Euro. The value of one Sardex is equivalent to one Euro, for easier adoption of the currency for the participants (Iosifidis et al., 2018). In the theoretical sense of money, Euro becomes the unit of account and Sardex the medium of exchange (Sartori & Dini, 2016). The majority of the network of Sardex consist of Small and Medium sized enterprises (SME),  with the network mainly focused on B2B trades. Nonetheless the credits are also used for personal consumption by the SME (Sartori & Dini, 2016).

As a result of financial crisis in 2008, there was an economic downturn in Sardine. This resulted in layoffs of people or a cut in their salary. Therefore people were more hesitant to spend their euros and as a result liquidity of money became more scarce (Greco Jr. ,2015). The lack of liquidity resulted in unused local resources of business because people became more hesitant to spend. This behavior is the result when people experience scarcity (Greco Jr. ,2015).

With the introduction of Sardex, the opposite occurs when trade credits became (more) available to people. The credits monetized the unused resources, creating overall more economic activity within the community. This resulted in economic expansion that led to greater availability of the trade credits, which in turn led people to spend more (Greco Jr. ,2015). This is why the complementary currency has a counter cyclical effect on the economy when there is a lack of liquidity in national currency.

Sardex is designed as a mutual credit system, where every transaction create a credit balance for the buyer and debit balance for the seller. In aggregate this result that the system as a whole has a sum of zero, resulting in no deficit of surplus within the system at any given time (Iosifidis et al., 2018). In case of Sardex this accounting is done in traditional and centralize fashion, all the transaction are recorded in a central digital ledger.

The Sardex membership

The membership of the Sardex consist of an annual membership fees based on the size of participating company (Posnett, 2015). Both fees are collected in euros an no transaction fees are charged. This makes participation in the network a fixed fee. In order to maximize the value of the network for each participant, he needs to maximize his trades. This way recirculation of the Sardex credit is encouraged (Sartori & Dini, 2016).

In order to join the network, companies do have to comply with certain rules. For instance, the price charged in Sardex must be equal to Euros and transactions below 1000 EUR needs to be accepted in credits. However blended transaction are accepted for larger amounts (Greco Jr. ,2015). Each member can leave the network, on the condition that their balance is zero. Finally on both credit and debit balances, Sardex does not charge interest. This further encourages recirculation of credit within the network (Iosifidis et al., 2018). Even though no interest is charged, credit positions towards the networks needs to be amortized by selling their goods and services within 12 months, or they need to settle their credit position with Euros (Sartori & Dini, 2016).

According to Gelleri (2009), the circulation of complementary currency is higher than national currency. This is also the case with Sardex. Sardex exchanges hands around 10 time faster than Euros (Sartori & Dini, 2016). When community currency reaches a critical mass, it can make up for the liquidity shortage of the national currency. This is not done by an increase of the money supply, but by faster circulation rate of the currency.

The network of Sardex has another additional function, it helps to establish relationships and trust with the network (Sartori & Dini, 2016). This way it provides also social ties among the members where a mix of self-interested and collaborative actions are established (Sartori & Dini, 2016).

## 2.3 Blockchain technology

The blockchain technology enables the use of a tamper-proof distributed ledger where transactions can be recorded publically in a close to irrevocable manner (Frey, Makkes, & Roman, 2018). Therefore in the literature the technology is also described as Distributed Ledger Technology. It allows to synchronized data on distributed ledger across a network of nodes (Kalmi, 2018). The combination of chaining mechanism, utilizing cryptographic properties and peer-to-peer exchanges makes it almost impossible for an individual to manipulate a transaction in the blockchain (Frey et al., 2018).

As defined by the research from Treiblmaier (2018), the key properties of the blockchain consist of distributed nature, immutable data and a consensus mechanism to record all the transaction in ledgers. The most relevant characteristics will be discussed in the following section.

*Immutability*
This is one of the key properties the blockchain technology. These transaction are recorded blocks and incrementally linked in a append-only fashion (Frey et al., 2018). Therefore making is almost impossible to manipulate a transaction recorded on the blockchain(Frey et al., 2018). The Immutability turns data that can be multiplied infinitely to units that can be valued and transferable. However this does come at the cast of that blockchain does not provide adequate ways to change data afterwards. Furthermore the public nature of distributed ledger of the blockchain can cause privacy concerns. This is due to pseudo-anonymous nature of the way transaction are recorded on the blockchain (Treiblmaier, 2018).

*Transparency*
Due to the distribution of public ledger, all the users have read-only access to the ledger. They can therefore trace all the transaction back to the genesis block and/or inspect smart contract on the ledger. (Treiblmaier, 2018). This creates an environment of transparency and accountability with a introduction of a blockchain system, where are transaction can be (re)viewed.

*Decentralization*
Decentralization is the most cited property of blockchain. This does not only apply for data storage, but as well for decision making and governance over the network. However these properties are not binary for all blockchain solutions. There are level of decentralization among blockchain solution. For instance, permissioned blockchain is a closed system where it's run by a company or a consortium of companies, therefore each nodes needs to be approved by a central party (Sylvester, 2019). This is different with a permissionless system, like bitcoin, where the ledger is public and each node is able to participate in the network without approval.

The main advantage of decentralization is the implication that it can lead to disintermediation. By eliminating the middle man, or in the absence of such a party, the network is still able to provide the services. This can lead to more efficient, and potentially more effective organization structure and as a result a reduction of transaction costs (Treiblmaier, 2018). However this can form a threat for the status quo, who holds strategic position in the current system of value networks or supply chain networks (Treiblmaier, 2018). What blockchain enables networks to accomplish is to distribute trust (Treiblmaier, 2018). By distribution of trust, the trust in a system is not necessarily in a single authority but distributed through the network itself.

*Consensus mechanism – Proof of Work*
Each network node together needs to reach consensus in order to accept a new transaction on the blockchain. Due to the distributed nature of the nodes, consensus algorithm are created, to follow certain rules and not to favor one node over the other. The most famous one, is the consensus protocol that is used for bitcoin, the Proof-of-Work(PoW) algorithm (Treiblmaier, 2018). In the Bitcoin network, a node needs to find a hash value, with the difficult level set dynamically by the network. The protocol is set to a level that there is a new

block every 10 min. The process of solving the mathematically puzzle to find the hash value is called mining (Baliga, 2017).

This consensus model works well in case of scalability for participating nodes, and operating in an all decentralized fashion. However the drawbacks are that it’s slow in transaction confirmation rate (Baliga, 2017). Also all the nodes combined consume a tremendous amount of computational power to solve these hash values.

Moreover the whole ledger needs to be verified for a transaction, due to its chained nature. A node needs to download the whole blockchain ledger in order to perform the transaction verification. The size of the block chain is over 200GiB as of Jan 2019 (Blockchain Size. (n.d.)). This can be a problem to implement on mobile devices, which have limited storage capacity.

Even though the decentralized features of the bitcoin blockchain is very appealing for our use case, the energy requirement that comes with a PoW and the storage capabilities for the blockchain is not very suitable for low resource environment like our Mali’s use case.

## 2.4 Stellar Network

Another option to use blockchain technology is based on the research done by Kalmi (2018). The study evaluated several blockchain solutions for the use of a community currency in Helsinki. The evaluation was based on the following criteria’s: usability, transparency, privacy, maturity value model, reputation system and resource consumption for several blockchain solutions. Stellar scored high on the majority of the criteria’s except reputation system relative to the other blockchain systems. This is due to the lack of such a system integrated in stellar. However on usability, transparency and resource consumption it scored very high, and these are criteria’s that are important in our case as well. This is due to low latency in transaction time, moderate resource requirements and its ability to issue and transfer customs asset on the network.

Stellar is an open-source payment system based on blockchain. It issues tokens and can setup exchanges in order to trade on the network. One of the main advantages are the quick transaction times (3-5 seconds) and the low transaction fees (fractions of a cent). These 2 properties makes it very appealing for our use case. Furthermore, the resource usage is relatively moderate due to the consensus mechanism compared to PoW consensus mechanism. These feature make is a very suited candidate for our community currency use case.

*The network*

The stellar network consist of two component. The Horizon API and the Stellar Core. The Horizon API is setup for applications to interact with stellar network (Stellar.org, n.d.1). This API is a more convenient way to interact with the stellar network, like submit transaction and accessing accounts.

Each of the horizon server is connected to the stellar core, which is called the backbone of the stellar network (Stellar.org, n.d.1). Stellar core is the software that runs a node in the network, where it’s validating, and recording each transaction according to the Stellar Consensus Protocol (Stellar.org, n.d.1). The consensus protocol used by stellar is a federated byzantine agreements. This will be elaborated in the next section. All the node together will come to a consensus about a set of transaction through the protocol. This happens at a small cost of 100 stroops ( 0.00001 XLM) which is a fraction of a cent. Lumens (XLM) are the native currency on the stellar network (Stellar.org, n.d.1).

*The consensus mechanism:*

The consensus mechanism of the stellar network is called the stellar consensus protocol (SCP). It's a variation on the Byzantine fault tolerance (BFT) consensus models called federated byzantine agreement system(FBA). Where non-federated Byzantine agreement consensus systems need to agree on the nodes list in advance, FBA does not, ensuring the decentralized nature of the network (Baliga, 2017). Compared to conventional BFT, SCP made an open-ended regarding the node participation (Mazières, Losa, & Gafni, 2019). Stellar uses a FBA, where every node chooses which nodes they trust to validate transactions. This means that transactions will be validated by nodes that run at institutions (government, banks or other well-establish institutions) that user already trust. This makes the assumption that there are certain parties within the network that we trust, and utilized these trust relationships.

In a report of Baliga (2017), SCP consist of the concepts of quorums and quorum slices. Quorum is a set of nodes that is sufficient to reach agreement. A quorum slice is a subset of a quorum that can convince one particular node on agreement. Moreover each node can exist in multiple quorum slices, called quorum intersections. SCP introduces the slices, so that each node can choose their own quorum slices, therefore facilitating open participation. By intersection of quorum slices across the network of singular nodes, called quorum intersections, and the size of quorum leads to consensus across the network.

In order to achieve consensus across the network, the quorum slice needs to reach consensus first. This is done trough federated voting (Stellar Development Foundation, 2015).

Federated voting consist of the following three steps:

1. Initial voting: Node A send out his initial vote A to the network.
2. Acceptance: There are two scenarios that can happen:

2a. The quorums voted for A because everyone else in the quorum voted for A, thus node A accepts vote A.

2b. The quorums voted for B because everyone else in the quorum voted for B, resulting that node A needs to accept vote B. Even if node A did not vote for B and has not accepted any other contradicting votes.

3. Confirmation: Node A confirms the quorum's vote if every member of the quorum has accepted vote A

In most cases these quorums or quorum slices will be chosen based on existing trust or business relationships (Stellar Development Foundation, 2015). This makes the assumption, in contrary to the proof-of-work consensus model, that there is a level of trust exist among the nodes of the network (Baliga, 2017). This consensus model does fit better with our use case as a cooperative of farmers. The assumption can be made that there is a certain level of trust and it can be leveraged by the consensus mechanism.

One of the benefits of this consensus mechanism is that only a small subset of nodes is needed for validation of a transaction. In this manner low transaction latencies can be achieved, while maintaining decentralization (Kalmi, 2018). This is very interesting properties for our use case to establish a community currency.

*Custom Asset*

Another feature of the stellar network is the fact that it can distribute any type of asset. Any account is able to issue custom assets on the stellar network. These accounts are called anchors. These anchors have a issuing account, from which they issue the tokens. As an issuer, the anchor provide an asset code to the digital asset on the stellar network (Stellar.org, n.d.2).

Similar to our community currency concepts, these digital assets are credits from the issuer. When accepting certain assets from a issuers on the stellar network, you trust that the issuer by accepting his credit (Stellar.org, n.d.2). On the stellar network, in order for a user to accepts a asset, the user must establish an trustline with the issuer's account. Similar to a bank, when issuing credit, there needs to be a certain level of trust in order to buy that credit. This way the user will explicitly express their trust in the asset(credit tokens) that the issuer issues. These trustlines are entries on the stellar ledger that tracks the amount of asset that the user holds and optionally can cap the amount of tokens an account can have (Stellar.org, n.d.2).

The ability to issue an custom asset on the stellar network, provide us the flexibility to issue a custom asset, that is not linked to valuations of global market places. The community currency will be backed by local resource and will have no external market influences. Community currency are by nature locally based, therefore issuing a local currency would better suit the needs the community, instead of using on existing crypto currency.

## 2.5 Goal and research question

In this chapter we have looked at the current literature about community currency and blockchain technology. Furthermore we dove into a concrete example of implementation community currency as mutual credit, namely Sardex. In the second part of the chapter we reviewed the properties of blockchain and further explore the feature set of the Stellar Network blockchain solution. The combination of these two implementation seems very suited for our low resource use case of a community currency in rural Mali. The low fees and the low latency of transactions is one of the requirements for an implementation of a community currency in our use case. The SCP protocol ensure the low latency of transactions (Stellar Development Foundation, 2015). Moreover the ability to issue custom assets on the network, enables communities to issue and maintain their own community currency in a decentralized and transparent manner. Furthermore it provides a digital currency alternative for the unbanked population.

The organizational features of community currency provides a very interesting proposition for local communities, especially for the unbanked population in low-resource environment like in rural Mali. One of the interesting examples of implementation of a community currency is Sardex. The mutual credit network, provide zero-interest credit to local communities, based on the capacities that each participants is willing to provide towards the network. Therefore providing a low cost and low resource alternative for a means of exchange within the community.

Thus combining the above mentioned two concepts, this research explores the feasibility of blockchain technology in a low resource environment as e.g. rural Africa for a local digital peer-to-peer payment solution. It is therefore necessary to obtain practical insights through the implementation. Therefore my research question is as followed:

*Is it possible to implement a community currency network for rural communities in Africa based on blockchain?*

In order to fully address the research question, the research project looks at two aspects: (i) the technical aspects of blockchain implementation: what the requirements are, if the service fits the complexities and barriers of the local context (ii) the organizational aspect such as: the local payment network, and how to organize such a network taking in consideration the cultural context. Hence my two corresponding sub-questions:

Technical aspect:

*Is there a blockchain implementation suited for a local payment network based on lightweight devices?*

Organizational aspect:

*Which properties of community currency are best suited for a local payment network in rural Africa context?*

# 3. Methodology

Based on the literature of Bon, Akkermans, & Gordijn (2016) this study will adopt the iterative and collaborative nature of "Low-resource aware framework for development of ICT4D services" framework. I performed the first four components of the ICT4D 3.0 framework up to 'Assess sustainability'. I used this framework to the structure the design science procedures to establish a community currency based on blockchain for the local seed cooperative Cooprosem in Mali.

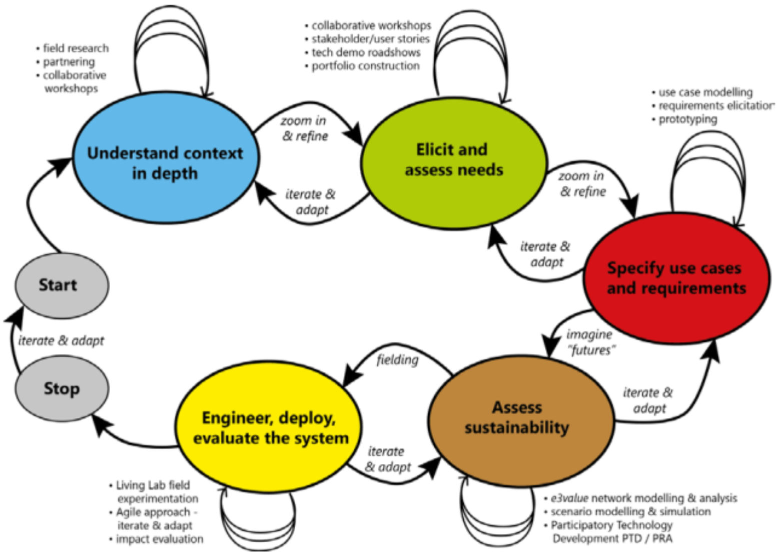


*Figure 1 : A conceptualization of the ICT4D 3.0 method, presented as a process model. Reprinted from" Community-Centered, Project-Based ICT4D Education in the Field" by Bon, A., Gordijn, J., Akkermans, H., de Boer, V., Baart, A., Shiang, C. W., & Nah, S. S. (2019).*

I performed my context analysis based on literature study on seed production in Mali and reports and interviews from the researchers who have been in Mali from the VU Amsterdam. More specifically, I conducted interviews with the researcher A. Bon who had the opportunity to visit the local community in Mali. The use case scenario are helpful to better understand how each actor interacts with the system in general, which is shown in a UML diagram. The use case description and the context analysis provided me a good indications about how such a system fits in the local context.

Based on these iterative steps of the ICT4D 3.0 methodology, it allows me to acquire enough information to design my conceptual model for a community currency for Cooprosem based on the use case scenarios. The next iteration is to develop a proof-of-concept based on the conceptual system model to showcase the technical ability of the chosen blockchain solution.

Finally I model various business models with the e3-Value methodology. These models are used to perform economic sustainability of the community currency system.

This methodology enables me structure the design steps so that the conceptual design fits the context and requirements of the low resource environment of rural Mali. This methodology allows me to have an in-depth look in a very specific social context in the rural community of Mali in relationship with the implementation of the technology.

# 4. Context analysis on the seed production in rural Mali

## 4.1 Seed production process in Mali

The context analysis is based on the trip report from the VU researchers that went to Mali in April 2019. Most of the information was regarding the seed cooperative Cooprosem. The cooperative offer four kinds of seeds: Millet, Sorgho, Maiz and Groundnut. With the groundnut mainly focused on female seed farmers. In 2017, the cooperative produces around 32 tons of seeds (Diallo, Pasqualini, & Verhagen, 2018). They have currently 88 members spread around 15 villages. The main function of the cooperative is to provide the farmers with; base seeds, fertilizers, pesticide, marketing and storage of the seeds. Moreover it host training session on various topics on best agricultural practices for seed farmers (Diallo et al., 2018). The seeds produced by the farmers are collected and stored in the warehouse in Sibi. The cooperatives from seed farmers are tasked to spread the base seeds to produce R1 and R2 seeds, certification process and the sale of R2 seeds to the farmers in the area. Currently these base seeds are distributed by the cooperative for free. R1 and R2 seeds are classification of the reproduction generation of the seeds. These are the first generations seeds that are registered and certified. See table A1 in appendix for the categories classifications used in Mali. These quality seeds opens up entrepreneurial opportunities for the farmers to sell their produce. Farmers use these base seeds to produce R1 or R2 level seeds, that they can sell either on the local markets or back to the cooperative for a fixed price of 500 CFA/kg (Bon & De Boer, 2019).

The cooperative is in contact with the national organization AOPP (Association des Organisations Paysannes Professionnelles). The AOPP is the umbrella association in Mali that represent the interest of the farmers on a national level. The work of AOPP consist of providing support to 250 farmer organizations, which in turn reaches 3 million people (Bon & De Boer, 2019). A majority of the population (70%) are small farms holders or family farms, and there is a growing demand for quality seeds for food security (Bon et al., 2019). With support of donor agencies, the AOPP manage to setup a website where the seeds are posted for sale from the cooperative (http://www.agro-mali.com/). Even though the seeds are listed on the site, not all the seed produced are sold. The cooperative is still left with the seeds from the farmers that they are unable to sell. Furthermore, the website does not solve the issue that many farmers lack literacy skills, or do not speak the French language (Bon & De Boer, 2019). The farmers usually only speaks the local languages, in this case Bambare, Peul or Bomu etc (Bon et al., 2019). Therefore it's hard raise demand for these seeds from the cooperatives.

*The seed system*

Until 2005 the formal seeds sector of Mali was restricted to the state institutions (Coulibaly, Bazile, & Sidibe, 2014). Their policies are aimed to poverty reduction through reinforcement of food security. This is achieved through promoting diversifying food production of the farmers. However up till recently, the government has allowed for decentralized seeds cooperatives and  AOPP , the umbrella organization of farmers in Mali, to emerge (Coulibaly et al., 2014).

The formal seeds system produces certified and high quality seeds from Pearl, millet and sorghum seeds. The seeds have the property to produce high yields for farmers. To ensure the quality of these seeds, seeds needs to be certified by  a specialized institution. This is currently performed by LaboSem, the state run seed laboratory (Coulibaly et al., 2014).

The AOPP seeds system forms the bridge between the local farmers and the state seed services (Coulibaly et al., 2014). The AOPP spread it's certified seeds among its cooperatives and they further spread the seeds among the farmers. This way the certified base seeds from state services, will trickle down to the local farmers. The production of the R1 or R2 seeds that are produced will be firstly sold to the cooperative members and later to other interested farmers in the area (Coulibaly et al., 2014). Another function that the AOPP provides is information to the villagers, like how to best use these kind of seeds from the state seed services (Diallo et al., 2018). In exchange, the AOPP can acquire local information from the cooperatives, that they can use as input for policy making on the national level (Coulibaly et al., 2014).

The seed farmers can receive seasonal loans for production of R1 or R2 seeds, however based on the interviews with Anna Bon, not all the seeds or financial aid is used to the fullest. The cooperative must a manage large quantities of seeds that are left unsold. This observation is also found on the study of  Coulibaly et al. (2014) with regards to pearl, millet and sorghum seeds. This can be partially due to lack of liquidity of national currency and the lack of proper communication infrastructure.

Based on this context analysis, the Cooprosem plays an central role in the distribution of the base seeds and storage of excess certified seeds produced by the farmers. Moreover both in the study of Coulibaly et al. (2014) and in the trip report from Bon et al.(2019) observed that there are large amount of R1 an R2 seeds left stored at the cooperatives. Therefore the unsold seeds of the farmers are not generating income for the seed farmers. This indicates that the produced asset (seeds) from the farmers, is unable to find customers in order to generate income for the farmers.

# 5. Summary of the key premise & Actors and Goals

## 5.1 Summary of the key premise:

The issue I try to address in this research is to see how feasible it is to implement an community currency  for locals, as a means of exchange, based on blockchain. The lack of national currency prohibits trades among community members, or they need to rely on direct barter as an alternative.

We created a digital coin that is based on the excess amount of seeds that cooperative Cooprosem has, that can be issued to the farmers as community currency. The coin is called SeedCoin. One of the benefits for using a blockchain solution is there is no intermediary party required to facilitate a transaction. Furthermore the immutability of the ledger and the public nature of the ledger, makes the system transparent and trustworthy. The system is a mutual credit system that can be implemented at the cooperative level. The participants within the community can issue and regulate their own community currency backed by the community assets that they possess. Based on these credit token, SeedCoin, the members could trade with each other as means of exchange next to the national currency.

## 5.2 Actors and goals

In order to understand each actor in the system, I have created an overview below of each actor in the system and their operational goals.

| Actor | Goals |
|---|---|
| Farmers | - To have local currency in absence of national currency as alternative means of exchange.<br>- To make use of the excess seeds that farmers have produced, but unable to sell.<br>- To have their needs met for their livelihoods based on their seed production. |
| Seed Cooperative | - To have record keeping of the stored seeds and provide this information.<br>- Store seeds of the farmers  central warehouse<br>- Support farmers in their livelihoods based on seed production. |
| SeedCoin | - To be an alternative means of exchange to national currency. |

*Table 1: system actors and their goals.*

# 6. Use case scenarios

Scenario I – The seed farmer

Awa is a seed producer, and the participant of the groupment Benkadi. The groupment consist of 40 woman and a few men (6-7). They are members of the cooperative of Koirá. Awa is a woman farmer from the village Koirá. She produces Millet, Sarho and Sesame on her 2 hectare of land. She started with 2 kg of R1 seeds and produced 100 kg in the first harvest and 50 kg in seeds in the second harvest. She sells the seeds on the local markets and have access to a mobile phone.

She currently does not have enough funds to buy tools to plough the land. However she does have a lot of seeds. As a member of the cooperative, she can store some of the seeds that she unable to sell on the local market, at the cooperative. The cooperative can then issue to her community currency based on the excess seeds she is unable to sell. Awa can use the mutual credit for her daily needs and save her national currency for potentially some new tools, for instance a wheelbarrow.

Scenario II – Peanut farmer

Pele is a peanut farmer, who produces peanuts for the weekly local markets. He need to sell his peanuts to make some money to buy produce for his family, like maize flower. However without sufficient sales on the local weekly market, Pele cannot earn enough money by selling his peanuts on the local markets. This is due to the lack of money that the community has to purchase his peanuts. Furthermore the stock of Pele has an expiration date. Therefore the stock needs to be sold before a certain time. However the maize farmer does not need peanuts, so direct barter is not an option. Therefore a mutual credit system could help introduce a means of exchange without having the problem of ‘coincident of want between 2 parties’. Pele can sell his peanuts to any other farmer who has interest in his peanuts, and by accepting the mutual credit, he can use this to buy his maize flower at the local maize flower.

*Use case diagram*

The use case diagram below shows that are two types of interactions with the system. In general the end-users will have to interact with the wallet on their smart phones.

There are two types of transactions made in the system.

1. Trade transaction between farmers within the network. For instance buying or selling goods between the farmers of the cooperative.
2. The cooperative issues currency to each individual wallet based on the amount of seeds that the farmers have deposited at the cooperative.

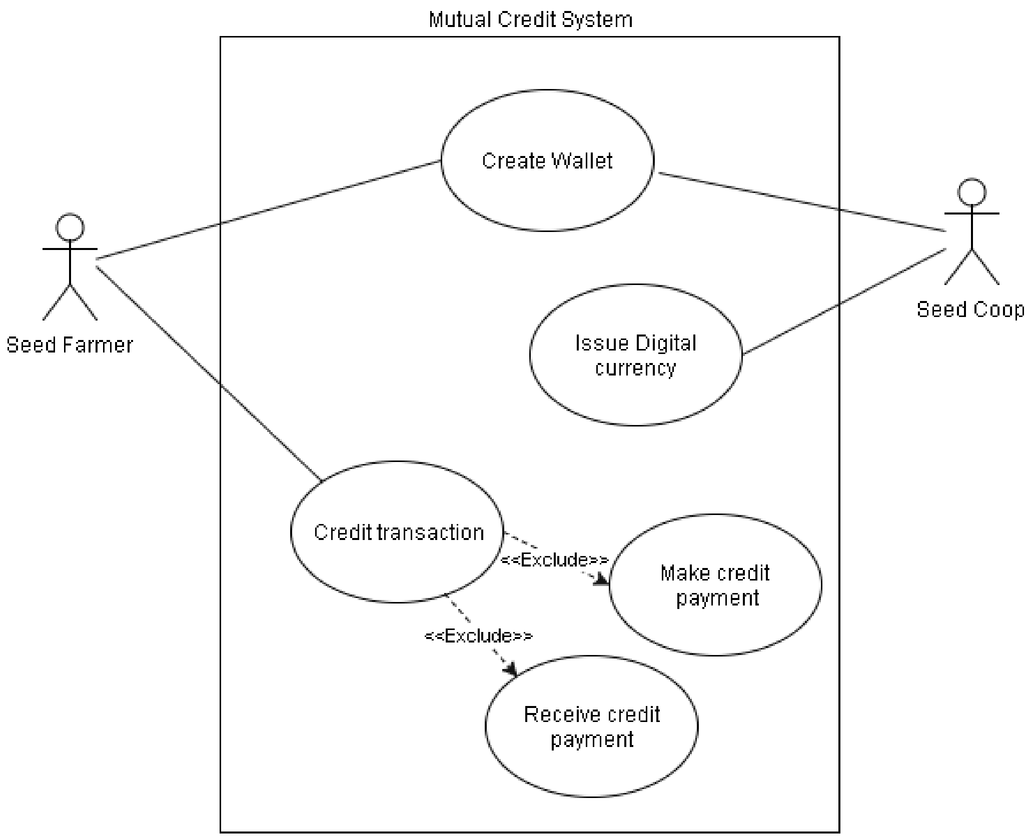


*Figure 2: Use-case diagram for a mutual credit system.*

# 7. Conceptual system model: community currency based on cooperative.

Based on the context analysis in chapter 4, we can detect parallels between the situation in Sardine and at our cooperative in rural Mali, we see that both communities have certain excess assets, that due to lack of liquidity result in lack of demand. By introducing this at the seed cooperative level, participants create a network of farmers who can trade with each other. The farmers of the cooperative have seeds stored in the central warehouse, but are unable to sell these seeds. These seeds can form a asset to back the local community currency based on mutual credit. Furthermore only 35% of the population have an transaction account in 2017 (Worldbank, 2019). Therefore the majority of the people are unbanked, and therefore do not have access to banking services, like credit. As seen at Sardex, in economic downturns, short-terms credit can mitigate the economic uncertainty. Resulting that community currency has anti-cyclical effect on the local communities in during economic distressed periods (Telalbasic, 2017).

Farmers can use these credits to trade for local goods and services that he/she might need for their daily needs. This way the community currency can mitigate between the excess of seeds and the scarcity of national currency. A similar situation has been found in Kenya, in the slums of Bangladesh. In the research of Ruddick (2015), the case was made that poverty was a result of scarcity in national currency. Therefore resulting into mismatch of unmet demand and excess of goods and services. In a local community an alternative for trade could be direct barter. That does alleviate some of the unmet demand, but it’s highly ineffective (Ruddick et al., 2015). Direct barter has the challenge of the concept of the double coincident of want between two parties (Melis, Giudici, & Dettori, 2013). This implies that both parties need to have an interest in each other services and will both gain from the transaction (Melis et al., 2013). This makes direct barter a high inefficient way to trading. It can be a challenge to find a perfect match between the parties of what you want and what you have to offer. Community currency can alleviate this issue by introducing an alternative currency to the local community.

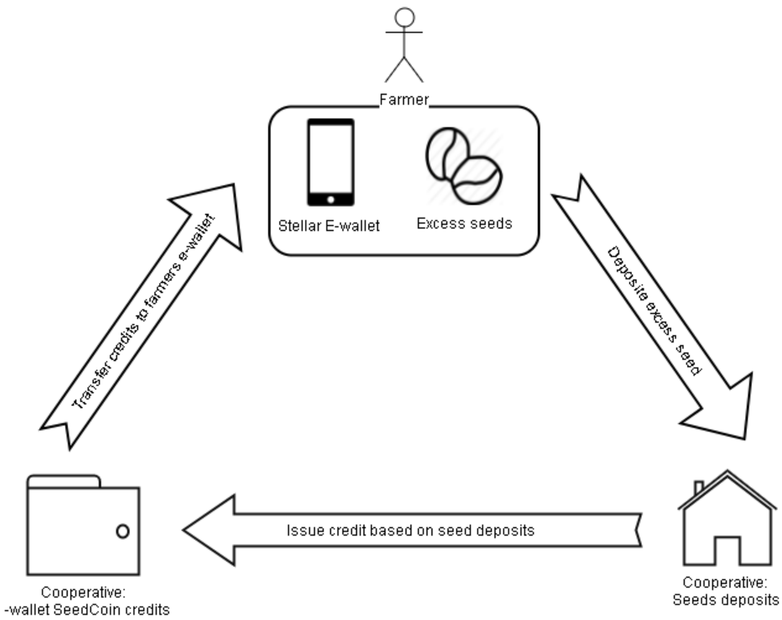


*Figure 3: SeedCoin, a digital currency based on seed deposit at the cooperative.*

The system that I am proposing does not issue ‘new’ money, it creates credit tokens that can be traded. The amount of digital tokens that the farmer receives will rely on the amount of excess seed he’s willing to deposit at the cooperative. By issuing community currency based on the excess seeds stored at the cooperative, it frees up the excess resources (seed) that can be used for the unmet demand of the farmers. By establishing this through a mutual currency credit in a form of a community currency, we introduce  an alternative means of trade, with the benefits of currency. Essentially the community currency is backed by the seeds that is stored in the central warehouse in Sibi. Furthermore community currency mitigates the lack of liquidity of the national currency not by issuing new money, but through faster circulation (Gelleri, 2009).

With an introduction of an new currency, the users will need to get used to the new currency and its value. However our community currency represent the same value as the national currency CFA. This will further ease the use of the community to community currency alongside the national currency. Additionally there is no needs for users to perform price discovery with the new community currency. A similar design has been implemented of Sardex (Sartori & Dini, 2016).

Another design feature in the conceptual model of our community currency are the roles of each participants in the system. Due to the fact that the community currency is backed by physical goods, the value of the digital asset is derived from the existence of the physical good. In the system we therefore separate the owner and the custodian roles. This means that the cooperative, who are responsible for issuing the digital currency, are only custodian of the seeds. The farmers remain the owners of the seeds. This provides assurance in the relationship between the digital asset and the physical goods, which ensure the value of the community currency. Due to division of different roles of custodian and owner, the system can provide assurance with regards to link with digital asset and it’s collateral (Ohlsson, Davison, & Chains, 2019).

# 8. Proof-of-Concept implementation:

## 8.1. SeedCoin – Proof-of-concept

In order to implement a system like a community currency on the Stellar Network, I have created a proof-of-concept setup on the stellar network. Several accounts are created to emulate various participants in the system. In this setup we created an account for the cooperative Cooprosem and two accounts that represents its member farmers. The proof-of-concept showcase the capabilities of the network and how to issue custom asset on the Stellar Network. Furthermore it demonstrate how SeedCoin is issued, and used as currency by the farmers.

I have divided this chapter in two sections. The first section represents the issue of the SeedCoin backed by the seed stored at Cooprosem. It showcase the procedure of issuing SeedCoin on the Stellar Network and distributing among the farmers. The second section illustrates how a transaction is made between farmers from their mobile wallets. This demonstrates the functionality of mobile stellar wallets, in our case the Interstellar wallet application on Android.

*Section 1: Issuance of SeedCoin.*

Each account on the Stellar Network can issue custom assets on the network. SeedCoin is our custom asset on the Stellar Network and is backed by the seeds at Cooprosem. The accounts that issue custom assets are called anchors (Stellar.org, n.d.2). The account of the cooperative is an anchor account. In order to able to make transactions with the custom assets, trustlines needs to be established between the users account and the anchor. Each account that want to make transactions with SeedCoin, needs to have an trustline established with the anchor account of cooperative Cooprosem.

In order to issue the custom asset, we need to use the stellar laboratory website for the initial setup. The website is essentially an user-interface for the horizon API. This way we can interact with the Stellar Network in very user-friendly and intuitive manner. There we can create accounts, setup trustlines to anchors. After the accounts and trustlines are setup, both the cooperative and the farmers can use one of the free stellar e-wallet that are available on Android through Google Play store. We have chosen here to focus only on the Android operating system, due to the majority (58%) of the smartphones in Mali run on the Android operating system (Statcounter, n.d.). After the setup on the stellar laboratory website, the accounts can be imported to the mobile wallet of the user by using their private key. I used a free Insterstellar wallet app on Android for the proof-of-concept. These free wallets are keeping the setup cost to a minimum. These wallets can hold both lumens and SeedCoin, so the farmers are able to receive and make payments with SeedCoin.

There are several stellar wallet apps available in the Android app store. However not all of the mobile wallets store your private key locally. Therefore to have maximize the control over the account, the private key needs to be stored locally on the users mobile device. This is called a non-custodian wallet. One of the features of the Interstellar app is that all the private keys are stored on the device locally (Interstellar, n.d.). Furthermore the wallet does not require any personal information in order to use the app, a session password is all it requires to use the application. Therefore an account is linked to the local hardware and not linked to any personal information.

The following steps are based on a walkthrough from Goodnow (2019). These steps provide the instructions in order to issue custom asset on the Stellar Network, which is in our case SeedCoin. These steps are performed on the Stellar laboratory website (https://www.stellar.org/laboratory/#?network=public).

Step 1: Account creation

The cooperative Cooprosem needs create two accounts on the Stellar network in order to issue and distribute SeedCoin. An account is a pair of a public and private key. This can be created under the ‘Account creator’ and hit ‘Generate Keypair’ on the Stellar laboratory website .

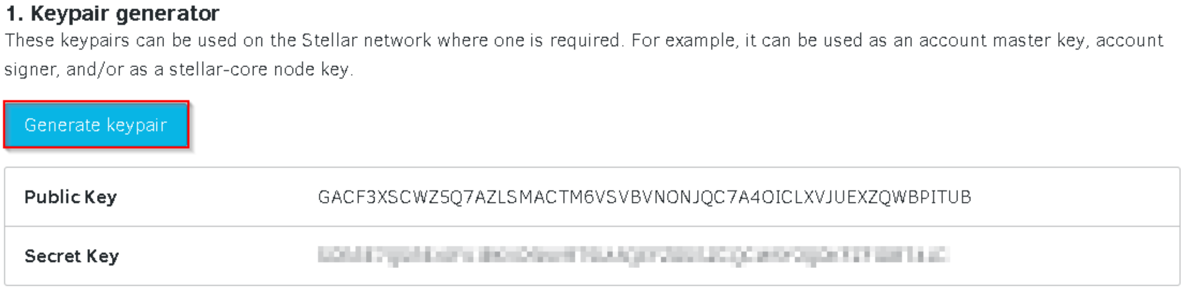


*Figure 4a: Step 1 account creation on the Stellar laboratory.*

The cooperative needs two accounts, one for issuing the custom asset and one for distribution of the custom asset. The first account is called an anchor, which issues the custom asset and establishes trustlines with other accounts. The second account is called the distribution account, this account has the function to distribute the SeedCoin among the farmers’ wallet, based on the seeds deposited at Cooprosem. All accounts need to have a minimum balance in the native token, lumens. The minimum balance is 1 lumens (XLM) (~0.11 USD) plus number of trustlines in our case. This will further be explained in paragraph 8.2. The initial lumens needs to be funded externally, In this proof-of-concept I have funded all the accounts (8 XLM) with personal funds.

Step 2: Establish trustlines

The next step in the process is to establish trustlines between the distribution account and the issue account of Cooprosem. It enables the distribution account to receive and distribute SeedCoins. This is done by making a transaction with transaction operation ‘Change Trust’.

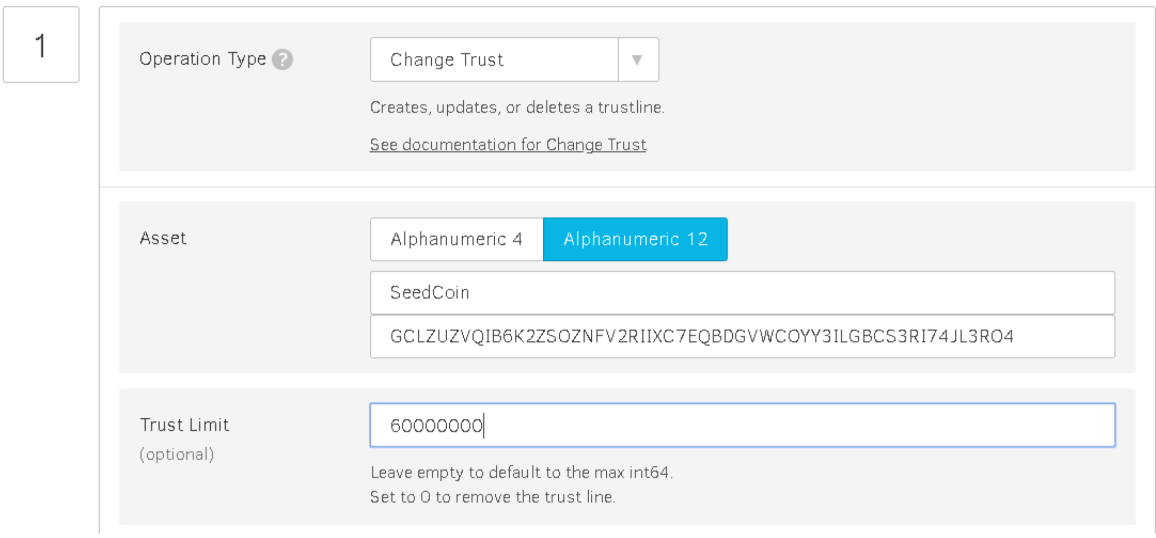


*Figure 4b: step 2 Creating of trustline between issue account and distribution account*

In the transaction builder form, select ‘Alphanumeric 12’ and name the custom asset SeedCoin. Furthermore the public address of issue account (anchor) provided. The ‘Trust limit' is set on 60,000,000 tokens. This limit represents the max amount of tokens that will be issued by the issue account. The limit is based on the max storage capacity of the warehouse of Cooprosem in Sibi. The warehouse can hold 2000 bags, each bag holding 60kg of seeds (Bon & de Boer 2019). As mentioned in chapter 7, we set the value of 1 SeedCoin equal to 1 CFA. In the same trip report of Bon & de Boer (2019), the seeds are priced at 500 CFA/kg when the cooperative buys it from the farmer. Therefore this results to a total amount of 60 million (2000*60*500) based on the capacity of the warehouse of Cooprosem. To finalize the transaction, it needs to be signed with the private key of the distribution account.

Step 3: issue of SeedCoin

After the trustlines are established, the issue account can issue tokens to the distribution account. The issue of tokens is done by a payment transaction from the issue account to the distribution account. Similar to establishing trustlines, the payment is also done at the transaction builder. However the 'Operation Type' is altered to 'Payment' and amount is set to the max supply as defined in the trustline, in this case 60 million. Further the destination is set to public address of the distribution account and the asset, SeedCoin, is defined.

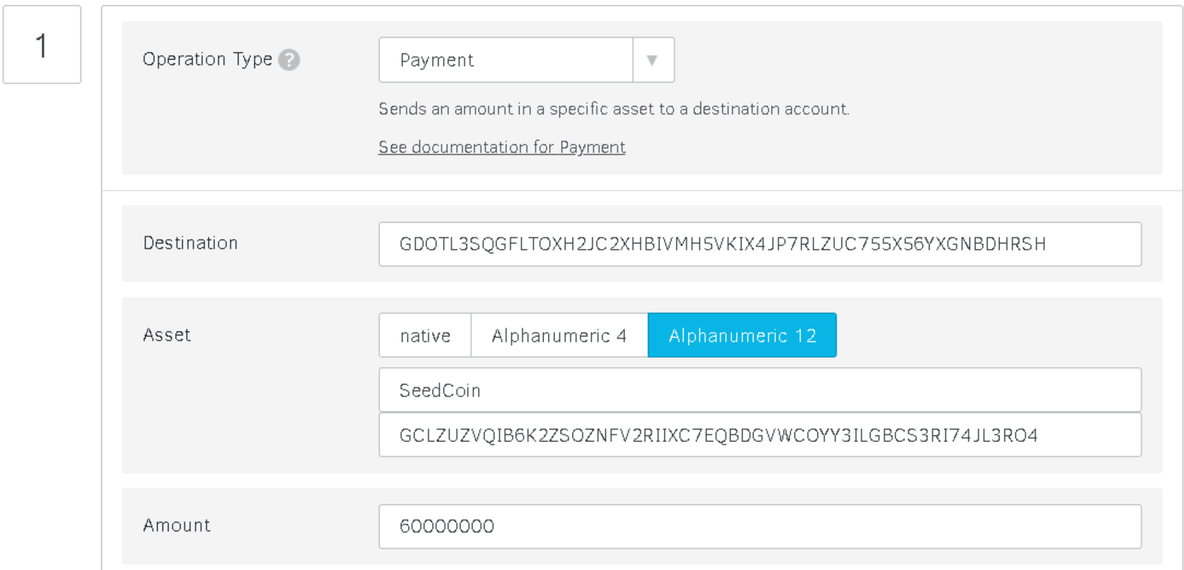


*Figure 4c: Step 3 transaction creation*

To finalize the transaction, it needs to be signed with the private key of the issue account. This transaction performs two tasks. It issues the SeedCoin in the issue account, and directly transfers the SeedCoin to the designated distribution account.

After this step, the distribution of SeedCoin can be done through a mobile wallet app, like Interstellar.

Step 3b (optional): Lock the supply of SeedCoin

After the issue of SeedCoin, it is possible to lock the supply of SeedCoin. This is one of the reason to have two accounts, in case of issuing custom assets on the Stellar Network. By locking the issue account, it freezes the supply for future SeedCoin, but the SeedCoin can be distributed to the farmers from the distribution account.

To lock the supply of the issue account, an new transaction needs to be composed in the transaction builder. Create new transaction from the issuer account with the operation "Set options” and set all thresholds  “Master Weight”, “Low threshold”, “Medium Threshold” and “High Threshold” to 0. To finalize the transaction, it needs to be signed with the private key of the issue account. After this transaction, all the weight of the keys will be removed and create a gridlock situation and renders even the master key  unable to sign for transactions. Therefore resulting in locking the account from executing future transactions and consequently limiting future supply of the SeedCoin.

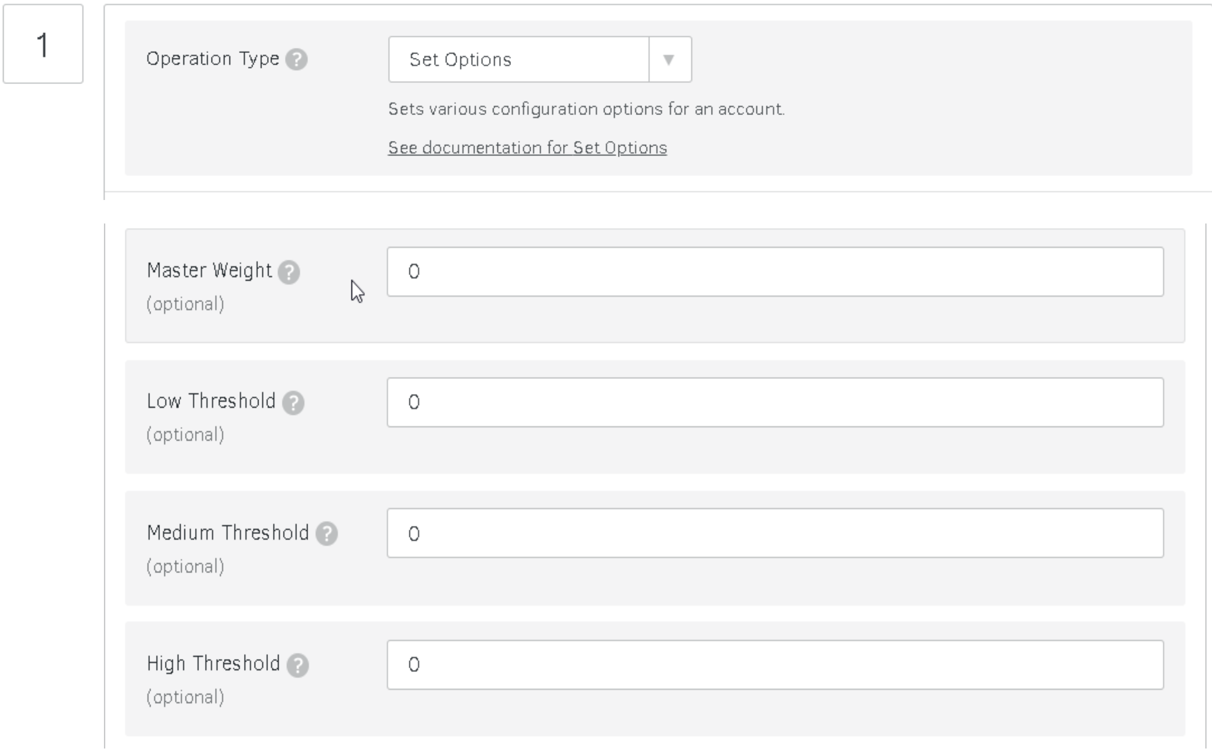


*Figure 4d: step 4 lock the issue account*

Step 4: Creating accounts for farmers and establishing trustlines.

Similar to the cooperative, the farmers need to have an account which have an trustline with the issue account on the Stellar Network in order to make transactions with SeedCoin. A farmer can create an account in a similar fashion as in step 1, but it can also create an account in the Interstellar Wallet. However, the mobile wallet does not have the feature to establish trustlines. Therefore step 2 needs to be performed for each wallet that want to make transactions with SeedCoin. This has the added benefit that SeedCoin remains local as community currency by only establishing trustline from member farmers. Like in step 2, there is a possibility to set a trust limit. This limit represent the max SeedCoin an account can hold. For this proof-of-concept I have set the trust limit to 170,000. This cap is set to the annual income that farmers earn with seeds (Bon & de Boer 2019). This cap should prevent farmers to have excessive holdings in SeedCoin. As each account/ wallet of the farmers has established a trustline with the issue account, each farmers is able to make receive and payments in SeedCoin with their mobile wallets.

A full activity diagram of each step, including the distribution of SeedCoin to farmers, can be found in the appendix in figure A3.

*Section 2: Making a SeedCoin transaction between farmers*

After the issuing of SeedCoin, each of the farmers have a wallet with SeedCoin or have at least a trustline with the issuer account. After Cooprosem have distributed the SeedCoin based on the seeds deposited, the farmers are able to trade with each other based on the SeedCoin in their wallet. The steps for two farmer to establish a transaction works as follows:

1. The buyer needs to acquire the public address of the Stellar Account of the seller. This can be exchange by QR code. The Interstellar wallet can both display and scan QR code for convenience of the user.
2. The buyer selects SeedCoin as asset in the Interstellar application.
3. The buyer fills in the amount of SeedCoin he has agree upon with the seller.
4. The buyer hit submit and the app submits his transaction to the Stellar Network.
5. The app will provide confirmation when the transaction has been processed on the Stellar Network with a green pop-up menu. This is done almost instantly, within five seconds and the transaction is final.
6. The recipient can confirm it by looking at his wallet balance for SeedCoin in his Interstellar app.

These two sections provide a walkthrough for implementation of SeedCoin at Cooprosem based on the seed deposit at their warehouse in Sibi. The proof-of-concept consist of one cooperative with two accounts, and two farmers accounts. In Figure 5 I have visually represented the proof-of-concept of SeedCoin. These accounts are visible on Steller Network, as table A4 in the appendix lists the public keys of each of the four accounts. Each account can be viewed with the Endpoint Explorer on Stellar Laboratory website. Furthermore each account is imported in the Interstellar wallet. This is where most user will use the community currency. In appendix A5, screenshots of the wallets accounts are provided.

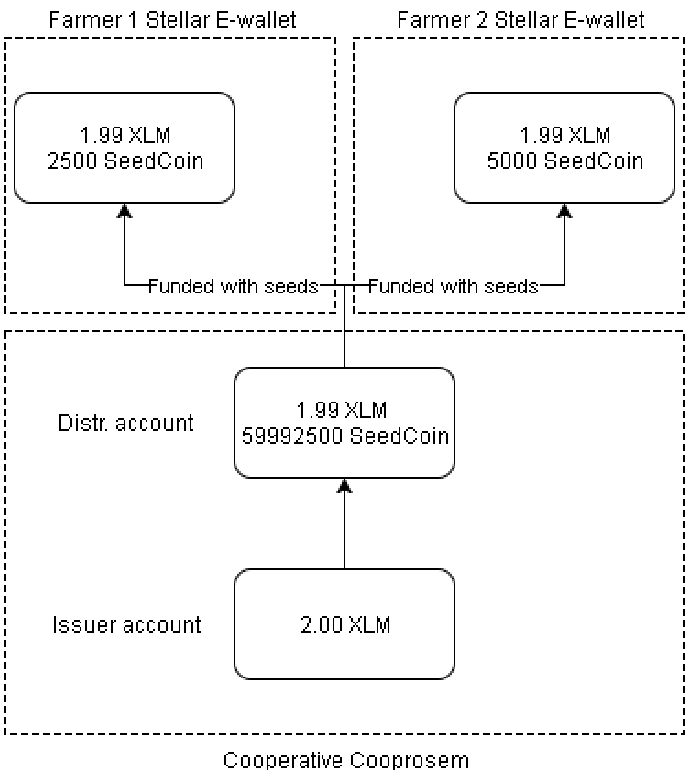


*Figure 5: Proof of Concept structure of accounts for SeedCoin.*

## 8.2 Cost of initial setup of account:

Even though issuing custom assets on the Stellar Network does not require funding, the accounts and transaction do. Each account needs to have a minimum balance in order to be operational on the Stellar Network. Both the minimum balance and transaction fees are paid in the network's native token, Lumens (XLM). Therefore initial funding is required during the setup. In table 6, I present a budget for SeedCoin on how much initial funding is requires for the setup at Cooprosem with its 88 members.

| Participants | Kind account | Fees |
|---|---|---|
| Cooperative | Source account | 1 + 0.5 = 1.5 XLM |
| | Distribution account | 1.5 + 1 = 2.5 XLM |
| | Subtotal | 4 XLM |
| Farmers | Personal wallet | 88 * (1.5 + 0.5) = 176 XLM |
| | Total | 180 XLM (~ 20 USD) |

*Table 6 Funding requirements for initial setup of the stellar accounts.*

The minimum balance is calculated by the following formula: (2 + [# of entries] ) * base reserve (Stellar.org,n.d.3). The base reserve is 0.5 XLM (approximately 1 XLM is 0,11 USD, as of 28-6-2019 on coinmarketcap.com). Entries are # of trustlines. For instance the issuance account, we have one trustline for the account, which results in a minimum account of 1,5 XLM. There are other feature that requires additional balances, like exchanges. But these are not applicable in our use case.

The initial funding does not limits to only the minimum balances. In order to make transactions on the Stellar Network, each transaction charge 100 stroops (0.00001 XLM) as a transaction fee. Therefore we budget an additional 0.5 XLM for each farmers account and the issue account in order to cover the anticipated transaction fees. This represent 100,000 transactions. That translates to a decade worth of transactions if they have ten daily transaction per account. For the distribution account we budget an additional 1 XLM, anticipating that this account will perform more transactions relative to the other accounts in the system.

The total amount required is 180 XLM lumens, (~ 20 USD) in order to make each account operational on the Stellar Network and covers the transaction fees for the foreseeable future.

# 9. Sustainability analysis:

One of the main failures of ICT projects in development countries is the absence of an business model (Bon et al., 2016). Therefore in the following chapter I will provide two business models to make the implementation of SeedCoin also economic sustainable. With regards to the implementation of this project, I do believe an initial external funding will be needed for setup. However after the setup/ implementation phase, SeedCoin needs to be self-sustaining as well. To illustrate these implementations, I will use the e3value modeling methodology to evaluate business models developed by Hans Akkermans & Jaap Gordijn (2003).

## 9.1 Third party funding:

In my proposed implementation of the community currency, SeedCoin, the cooperative Cooprosem plays a central role. It's act both as the issuer of SeedCoin as well as de deposit holder of the corresponding seeds. These additional tasks requires additional fees to fund them. One way to fund these additional activities is to sell or provide information for interested parties. One of the results of SeedCoin, is that there are digitized records of deposited seeds at the cooperative level. One of the parties interested in this information could be AOPP. As mentioned in the trip report of Bon & de Boer (2019), the AOPP wants to have certain information about what crops/ seeds are in demand for planning and for helping farmers to commercialize their seeds.

The information that is needed for issuing SeedCoin is based on record keeping of the deposited seeds. This information can also be useful for AOPP as well. If the AOPP is willing to exchange this information for money, this in turn can help to fund the cooperative for paying for the services needed to run the community credit.

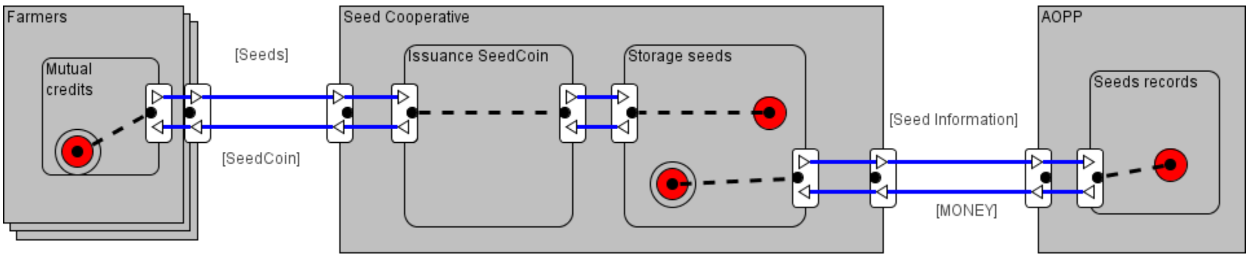


*Figure 7: e3-Value model of AOPP funding (third party funding) for SeedCoin implementation.*

In the e3-value model in figure 7, I have modeled the scenario where AOPP can provide funding in exchange for additional information that the cooperative have to record. The cooperative is tasked with two value activities, namely the issue of SeedCoin and storage of the deposited seeds. The farmers get SeedCoin in exchange for their deposited seeds at Cooprosem. In this scenario, the community currency can be funded by a third party. This is done by providing the additional valuable data from the system to a third party in exchange for funding.

## 9.2 User subscription model:

In absence of an external party that is willing to pay for the information provided by the cooperative, another option is to charge a subscription fee for participants. Similar to another community currency, like Sardex, charging a subscription fees will further encourage the use of the currency. Participants will maximize their value based on the flat fee that they paid in subscription fees. This further incentivizes participants to get to most value out of their flat fee, thus further encouraging the usage of the community currency.

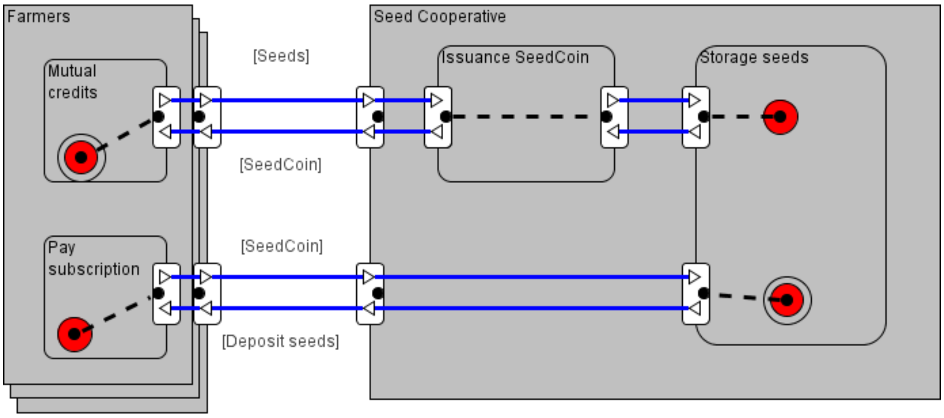


*Figure 8: e3-Value model of user subscription model for SeedCoin implementation.*

In the e3-Value model in figure 8, I have modeled this user subscription scenario. The cooperative is still responsible for the issue of SeedCoin and the storage of the seeds. The difference here compared to the third party funding is the additional payment of subscription fee. The farmers still will receive SeedCoin in exchange for their seeds. Moreover the farmers will need to pay a subscription fee, in exchange for the deposit of their seeds. So their subscription fees will cover the service of depositing seeds at the cooperative. This subscription fee is tied to the period that the seeds are deposited. The subscription fees are paid in SeedCoin. The purpose of introducing a community currency is the lack in liquidity of national currency and the access to banking services. Therefore paying the subscription fee in national currency would be counterintuitive to the problem we would like to address with community currency. Furthermore the cooperative can use community currency themselves to fund their local activity with SeedCoin. This can further help re-circulate the community currency into the community.

The final implementation of the community currency can be a hybrid model of the two models. In the ideal situation the project will be initiated with a NGO who has both the financial means and technical skills to implement it. After initial setup and implementation phase, the project can transfered to more sustainable model the above mentioned models.

# 10. Discussion

During the setup of the proof-of-concept, we encountered some limitations of using existing software solutions. Not all Stellar mobile wallet app have the same feature set. One of the required feature is the ability to make transactions with custom assets on the Stellar Network. Most Stellar wallets only had the ability to transfer the network's native token (Lumens). The Interstellar application is the only non-custodian mobile wallet app that could make transactions in custom assets.

Another feature that we missed is the ability to establish trust lines from a mobile wallet. However this option is available on desktop Stellar wallets. This difference between desktop and mobile wallets is a result of the dependency on the available software. We have finally chosen to establish trustlines via the Stellar laboratory website, because this is accessible through a mobile device. This work around is needed because we are depended on the existing wallet applications.

In addition to the wallet, another limitation is that we rely on the development of the Stellar Network eco-system. In our implementation we rely on stellar.org and their horizon API. Ideally it would be preferable if the cooperative was able to run their own node to verify the transactions of the farmers. Yet with the requirements of hardware (see: https://www.stellar.org/developers/guides/hardware.html), are relative high. The monthly fees on an AWS equivalent (c5d.Large), result in a monthly fee of 81 USD. These cost are not very feasible for a single cooperative. Therefore relying on current network and their software solutions provided by the eco-system is the most cost-effective way to potentially implement this project. This minimizes the development costs, but comes at the cost of being fully decentralized.

In addition to the resource constraints, the digital infrastructure is a challenge as well. The conceptual model is based on the assumption of having access to the internet. My proof-of-concept is also build on devices that have access to internet. This however does have to hold in rural Mali. It is however rapidly changing in Mail, with increase of smartphone uses. In a research of GSMA, the adoption rate of smartphone is 38% in 2018, however it is projected rise to 67% in 2025 (GSMA, 2019). This provides perspective for a feasible implementation of a community currency solution based on blockchain.

Next to the limitation of the low-resource environment, the blockchain technology have some limitations itself when used. In a blockchain based system, transaction data that are stored on the public ledger are immutable. This is a favorable property to have in light of data integrity. However, as many of the interactions are based on human input in our use case, one downside is that human input is notoriously inaccurate or incomplete from a data integrity perspective (Ohlsson et al., 2019). This can be solved by introducing technical solutions like QR codes on bags. Or by having a four eyes principle, when issuing the community currency credit. The immutability of data is therefore a blessing and a curse.

Beside the data integrity, there could be privacy concerns as well. Every transaction is signed with the private key of the users with the public key is published on the blockchain. Every transaction that a farmer makes can be viewed on the digital ledger. This can lead to privacy concerns, because it concerns financial data. Due to immutability of the data, having control over the data is very limited. So to be in control of your own personal data is very hard to accomplish, when data has been published on the blockchain.

# 11. Conclusion and Future work

This research explores the technical feasibility of a community currency based on blockchain in a low resource environment, like rural Mali. We have structured our case study based on the ICT4D 3.0 methodology and use the e3-Value methodology to assess the economic sustainability of the system. Our conceptual model is a community currency backed by the seeds stored at Cooprosem and issued on the Stellar Network. The community currency is valued similar to the national currency and is named SeedCoin. We have demonstrated the functionality on the hand of a proof-of-concept. This research provided some practical insight on how to proceed when issuing a new digital community currency based on blockchain on the Stellar Network.

One of the limitations of the study is lack of local testing in the field. The challenging constraints for ICT4D project is the availability of crucial infrastructure or the lack of (Bon et al., 2016). Therefore further research needs to be done with a local field testing. Furthermore a future topic is to evaluate the impact of community currency has on the community. In the research of Ruddick et al.( 2015), they found the introduction of Bengla-Pesa had a positive impact on trade within the community. Further research is needed to assess the impact that SeedCoin has on the community in Mali.

Another limitation of my research is the limited scope of my research. My main focus of this research is explore the technical feasibility of an blockchain implementation. Governance is out of scope in this research but it is a crucial component in such a system. In most community currency, a central party is in charge of the governance. Exploring the governance structure of an community currency is an interesting research area for a future study.

Finally, the blockchain environment is in rapid development, therefore future research can investigate practical setups on other blockchain platforms, that might suits other use cases. One of a potential use case that can be explored is remittances. This can further extend the financial inclusion challenges in sub-Saharan Africa, especially with the rise of mobile phone adoption.

# References


Akkermans, J. M., & Gordijn, J. (2003). Value-based requirements engineering: exploring innovative e- commerce ideas. Requirements Engineering, 8(2), 114–134. https://doi.org/10.1007/s00766-003- 0169-x

Baliga, A. (2017). Understanding Blockchain Consensus Models. Whitepaper, (April), 1–14. Retrieved from https://www.persistent.com/wp-content/uploads/2017/04/WP-Understanding-Blockchain- Consensus-Models.pdf

Bon, A., Akkermans, H., & Gordijn, J. (2016). Developing ICT Services in a Low-Resource Development Context. Complex Systems Informatics and Modeling Quarterly, (9), 84–109. Https://doi.org/10.7250/csimq.2016-9.05

Bon A., De Boer V., (2019, May 4). W4RA– project report May 2019. [pdf]. Vrije Universiteit Amsterdam.

Bon A., De Boer V., Van Aart, C., Akkermans, J. M., Gordijn, J., Lô G., Baart, A., Blankendaal, R.,

Robenhagen, A., Ferguson, J., Van der Wekken, M., Schlobach, S., Tuyp, W., Baah G. N., Wendelien Tuyp, Gyan, N., Dittoh, F., Dittoh, S., Tangara, A., Tessougué, A., Ouedraogo J., Ouedraogo, M. (2019, March 29). USE CASES /SERVICES CO - CREATED FOR / WITH FARMERS AND RADIO STATIONS IN GHANA , BURKINA FASO AND MALI. [pdf]. Vrije Universiteit Amsterdam.

Colacelli, M., & Blackburn, D. J. H. (2009). Secondary currency: An empirical analysis. Journal of Monetary Economics, 56(3), 295–308. https://doi.org/10.1016/j.jmoneco.2009.02.002

Coulibaly, H., Bazile, D., & Sidibe, A. (2014). Modelling Seed System Networks in Mali to Improve Farmers Seed Supply. Sustainable Agriculture Research, 3(4), 18. https://doi.org/10.5539/sar.v3n4p18

Diallo, Y., Pasqualini, T., & Verhagen, I. (2018). The Rise of the Seed- producing Cooperative in Western and Central Africa. Retrieved from https://www.accesstoseeds.org/app/uploads/2018/07/The-Rise- of-the-Seed-producing-Cooperative-in-Western-and-Central-Africa.pdf

Diakité, L., Sidibé, A., Smale, M., & Grum, M. (2008). Seed value chains for Sorghum and Millet in Mali : A state-based system in transition Seed Value Chains for Sorghum and Millet in Mali A State-Based System in Transition Lamissa Diakité , Institut d ' Economie Rurale Amadou Sidibé , Institut d ' Economie , (January).

Dissaux, T. (2016). Financing for development : a monetary issue in which money does not have a word. Twelfth “AFD International Conference on Development: Commons and Development, (pp. 1-2), 1– 20.

Frey, D., Makkes, M. X., & Roman, P. (2018). Dietcoin : shortcutting the Bitcoin verification process for your smartphone, (March).

Greco Jr. T., H., (2015, August 15). Sardex, a brief report [Blogpost]. Retrieved from: https://beyondmoney.net/2015/08/20/sardex-an-emerging-model-for-credit-clearing-exchanges/

Gelleri C (2009), Chiemgauer Regiomoney: Theory and Practice of a Local Currency, International Journal of Community Currency Research, 13, pp. 61-75.

Gómez, G. M. (2018). Why do people want currency? Institutions, habit, and bricolage in an Argentine marketplace. Evolutionary and Institutional Economics Review, 15(2), 413–430. https://doi.org/10.1007/s40844-018-0104-y

Goodnow, Johnny. (2019, May 23), Project Stellar | Custom Assets [GitHub repository], retrieve from: https://github.com/stellar/docs/blob/master/guides/walkthroughs/custom-assets.mdHill, Brenn. “How to Make a Custom Token on Stellar. - Brenn.” Medium,

Medium, 25 Oct. 2018, medium.com/@brenn.a.hill/how-to-make-a-custom-token-on-stellar-ae5296512a2e
GSMA, (2019). The mobile economy: West Africa 2019. Retrieved from: https://www.gsma.com/r/mobileeconomy/west-africa/
Iosifidis, G., Charette, Y., Airoldi, E. M., Littera, G., Tassiulas, L., & Christakis, N. A. (2018). Cyclic motifs in the Sardex monetary network. Nature Human Behaviour, 2(11), 822–829.https://doi.org/10.1038/s41562-018-0450-0
Interstellar (n.d.). Core Features. Retrieved from https://interstellar.exchange/#features
Kalmi, T. (2018). Comparison of Blockchain-based Technologies for Implementing Community Currencies.
Kim, S. M., Lough, B., & Wu, C. F. (2016). The conditions and strategies for success of local currency movements. Local Economy, 31(3), 344–358. https://doi.org/10.1177/0269094216637332
Kiyotaki, N., Wright, R., 1989. On money as a medium of exchange. Journal of Political Economy 97,
927–954.
Lietaer, B.A., Hallsmith, G., 2009. Community Currency Guide. Global Community Initiatives. [pdf] Retrieved from:< http://www.global-community.org/publications.htm >.
Lindman, J., Tuunainen, V. K., & Rossi, M. (2017). Opportunities and Risks of Blockchain Technologies: A Research Agenda, 1533–1542. https://doi.org/10.24251/HICSS.2017.185
Mazières, D., Losa, G., & Gafni, E. (2019, March). Simplified SCP. Retrieved from http://www.scs.stanford.edu/~dm/blog/simplified-scp.html#protocol-description.
Melis, C., Giudici, E., & Dettori, A. (2013). Revitalizing the Barter: The Case of Sardex.Net BT - Organizational Change and Information Systems: Working and Living Together in New Ways. In P. Spagnoletti (Ed.) (pp. 129–136). Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-37228-5_13
Ohlsson, B., Davison, K., & Chains, A. S. (2019). Case Study : AgriDigital Blockchain Technology in the Trade and Finance of Agriculture Supply Chains, 239–255.
Pankomera, R., & van Greunen, D. (2018). Challenges , Benefits , and Adoption Dynamics of Mobile Banking at the Base of the Pyramid ( BOP ) in Africa : A Systematic Review. The African Journal of Information and Communication, (21), 21–49.
Posnett, E., (2015, September 18). The Sardex factor. The Financial Times. Retrieve from: https://www.ft.com/content/cf875d9a-5be6-11e5-a28b-50226830d644
Reeves, M. (2017). Cryptocurrency-Remittance Transfers Futuristic Technologies & Poverty Alleviation, 46.Retrieved from http://creativematter.skidmore.edu/econ_studt_schol
Ruddick, W. O., Richards, M. A., & Bendell, J. (2015). Complementary currencies for sustainable development in Kenya: The Case of the Bangla-Pesa. International Journal of Community Currency Research, 19, 18–30.
Statcounter (n.d.). Mobile Operating System Market Share Mali. Retrieved from http://gs.statcounter.com/os-market-share/mobile/mali/#monthly-201806-201906-bar
Sartori, L., & Dini, P. (2016). From complementary currency to institution: A micro-macro study of the Sardex mutual credit system. Stato e Mercato, (107), 273–305. https://doi.org/10.1425/84070
Scott, B. (2016). How can cryptocurrency and blockchain technology play a role in building social and solidarity finance? United Nations Research Institute for Social Development (UNRISD), No. 2016-1.
Stellar.org (n.d.1). Stellar developers | Stellar Network Overview [Website]. Retrieved from https://www.stellar.org/developers/guides/get-started/index.html

Stellar.org (n.d.2). Stellar developers | assets [Website]. Retrieved from https://www.stellar.org/
developers/guides/concepts/assets.html .
Stellar Development Foundation, (2015). On Worldwide Consensus: The future is distributed: a summary of the Stellar Consensus Protocol white paper [Website]. Retrieved from: https://medium.com/stellar-development-foundation/on-worldwide-consensus-359e9eb3e949
Suri, T. (2017). Mobile Money. Ssrn. Retrieved from: https://doi.org/10.1146/annurev-economics-063016- 103638
Sylvester, G. (2019). E-Agriculture in action: Blockchain for Agricluture oppertunities and Challenges. Food and Agriculture organization of the United Nations. Bangkok. Retrieved from http://www.fao.org/publications/card/en/c/CA2906EN
Telalbasic, I. (2017). Redesigning the Concept of Money: A Service Design Perspective on Complementary Currency Systems. Journal of Design, Business & Society, 3(1), 21–44.https://doi.org/10.1386/dbs.3.1.21_1
Treiblmaier, H. (2018). Case Studies for Blockchain Use Cases: A Bottom-Up Research Agenda,(October), 1–22.
Worldbank (2019). Universal Financial Access 2020: Mali. Retrieved from http://ufa.worldbank.org/country-progress/mali
Zheng, Z., Xie, S., Dai, H., Chen, X., & Wang, H. (2017). An Overview of Blockchain Technology: Architecture, Consensus, and Future Trends. Proceedings - 2017 IEEE 6th International Congress on Big Data, BigData Congress 2017, (October), 557–564.https://doi.org/10.1109/BigDataCongress.2017.85

# Appendix

**Table 1. Improved seed terminology in French and English**

| Multiplication Generation | Designation (in Mali) | Seed Category (French) | Seed Category (English) |
|---|---|---|---|
| Panicles supplied by research institution | Lignés G0 | Matériel de départ | Breeder seed |
| 1st generation | G1 | Semence de pré-base | Foundation seed |
| 2nd generation | G2 | | Foundation seed |
| 3rd generation | G3 | Semence pré-base ou de base | Foundation seed |
| 4th generation | G4 | Semence de base | Foundation seed |
| 5th generation | RI (G5) | Semence certifiée de 1er reproduction | Registered seed, 1st reproduction |
| 6th generation | R2 (G6) | Semence certifiée de 2e reproduction | Certified seed, 2nd reproduction |

*Table A1: Seed classification used in Mali. Reprinted from "Seed Value Chains for Sorghum and Millet in Mali." By* Diakité, Sidibé, Smale, & Grum, 2008*, (February 2008).*

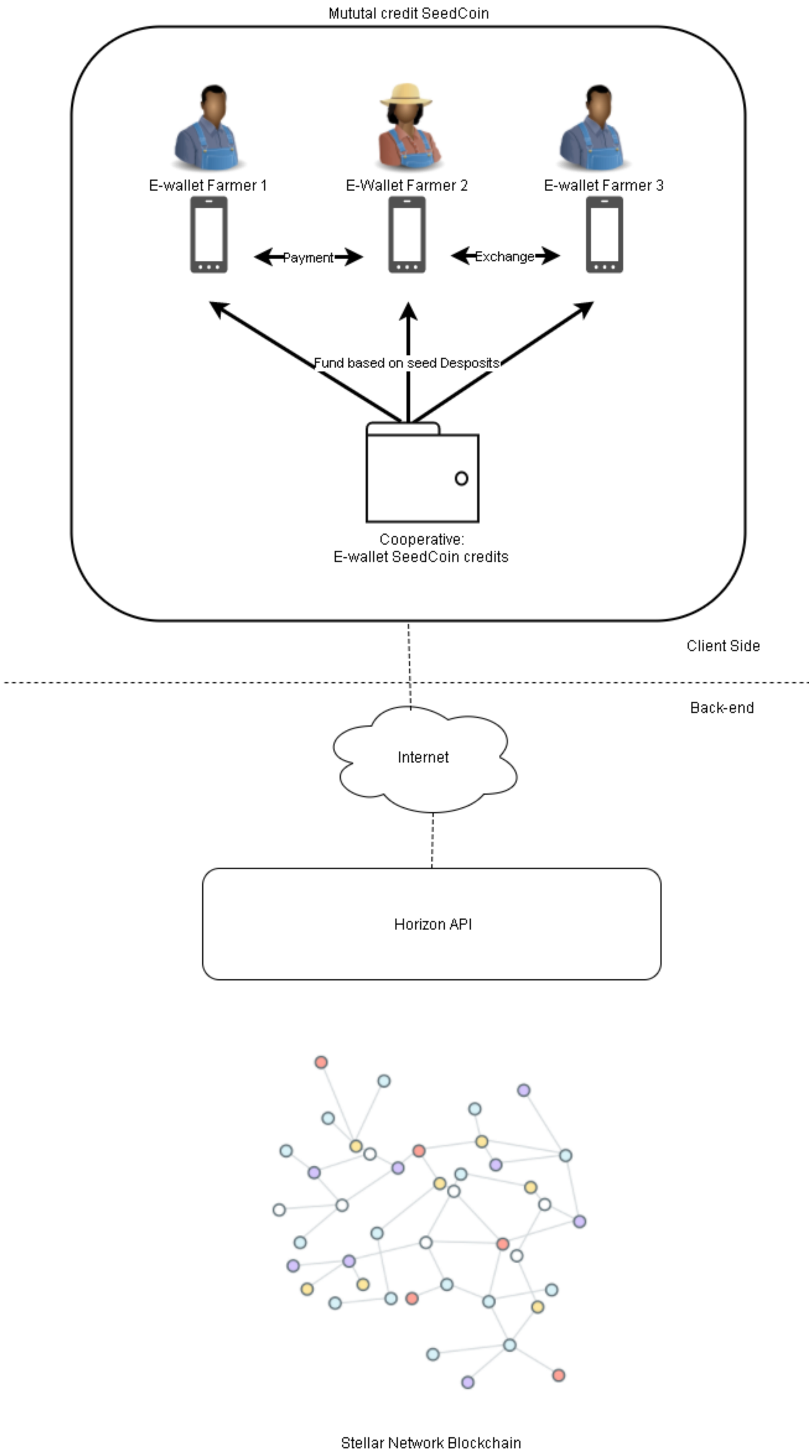


*Figure A2: Mutual credit network SeedCoin stored on the stellar network.*

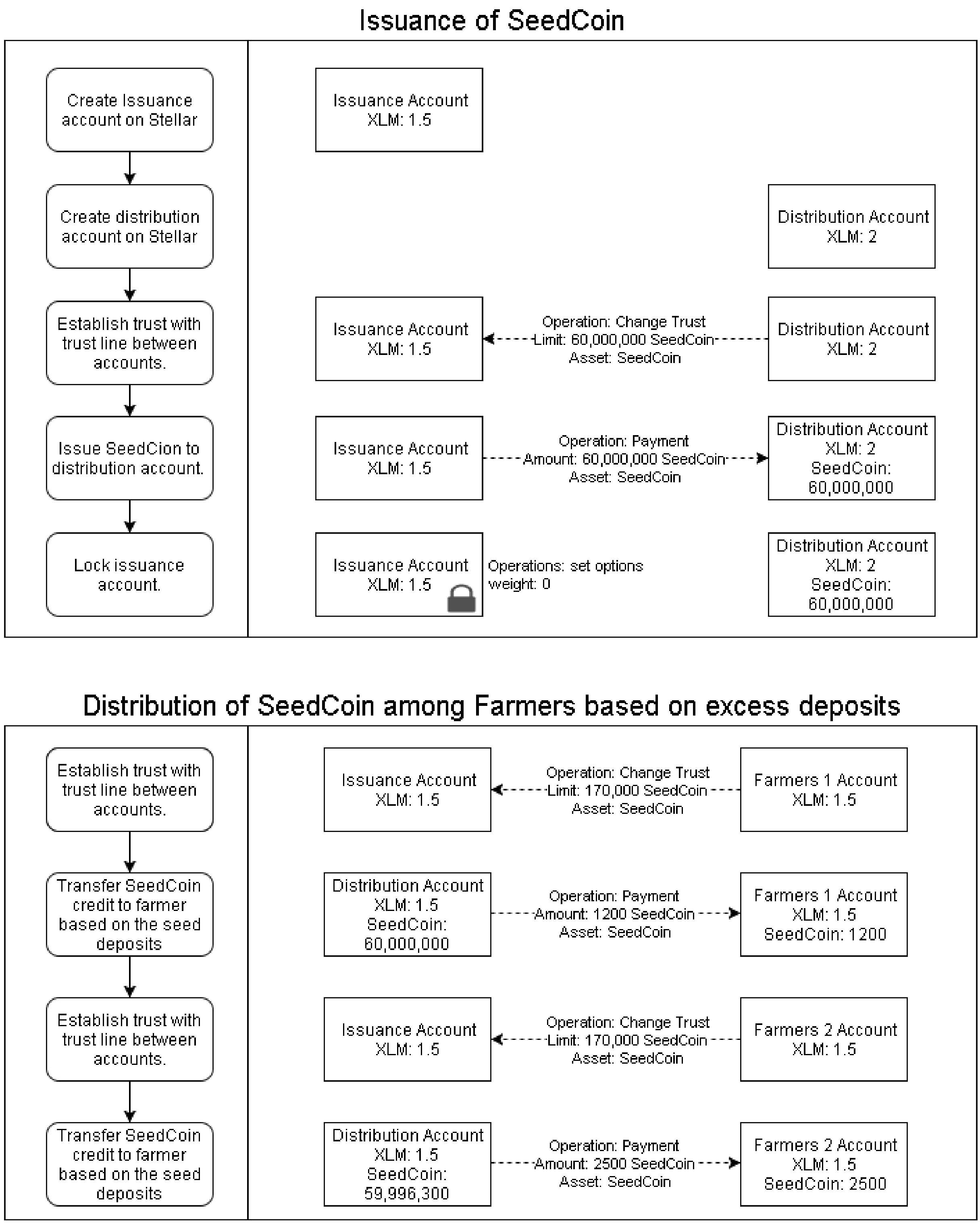


*Figure A3: Activity diagram of creating and distributing SeedCoin on the stellar network.*

| Actor | Account | Public Address |
|---|---|---|
| Cooperative | Issuing Account | GCLZUZVQIB6K2ZSOZNFV2RIIXC7EQBDGVWCOYY3ILGBCS3RI74JL3RO4 |
| | Distribution Account | GDOTL3SQGFLTOXH2JC2XHBIVMH5VKIX4JP7RLZUC755X56YXGNBDHRSH |
| Farmer 1 | Personal wallet | GDQSN46AAVE6GLPG4BACJWVJ7E5TYPXQUQNW4TC6UM35HQNNFRPW2OVN |
| Farmer 2 | Personal wallet | GBY26QUHJOXFRU3HKIUB7RXD33UYZTRLSAFAPXV3NPNZ3IOMXUJEM4UF |

*Table A4: list of public addresses of the accounts used in the proof-of-concept. Each account can be viewed by the Endpoint Explorer of Stellar Laboraty:* *https://www.stellar.org/laboratory/#explorer?resource=accounts&endpoint=single&network=public*

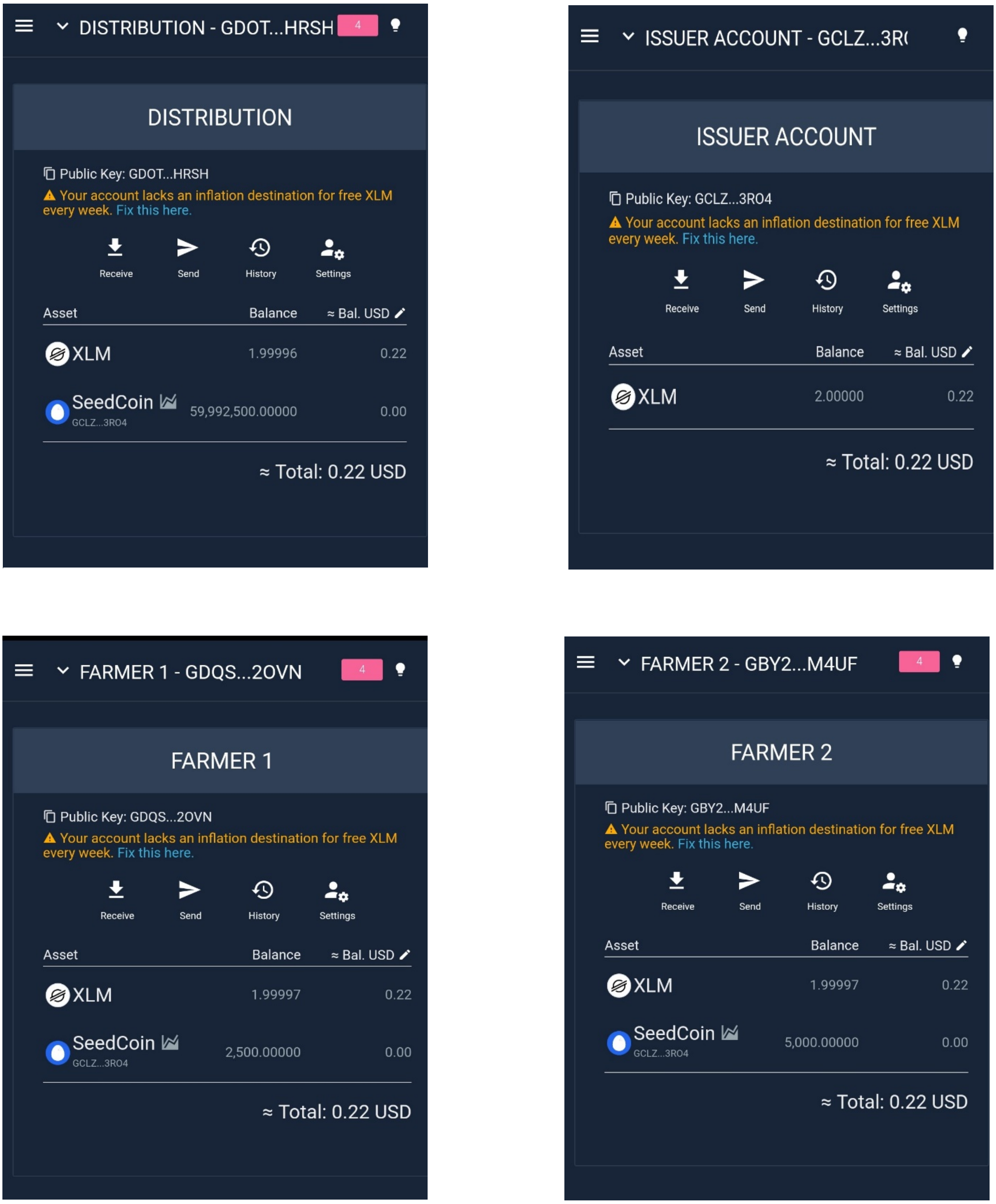


*Figure A5: Print screens of each Interstellar Wallets of each of the participants of the Proof-of-Concept*