Blockchain technology- applications in improving financial inclusion in developing economies. Case study for small scale agriculture in Africa.

by

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<th>Description</th>
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<td>AFI</td>
<td>Alliance for Financial Inclusion</td>
</tr>
<tr>
<td>AML</td>
<td>Anti Money Laundering</td>
</tr>
<tr>
<td>ASCA</td>
<td>Accumulating Savings and Credit Association</td>
</tr>
<tr>
<td>ATM</td>
<td>Automated Teller Machine</td>
</tr>
<tr>
<td>BaaS</td>
<td>Blockchain-as-a-Service</td>
</tr>
<tr>
<td>CICO</td>
<td>Cash-in Cash out</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agricultural Organization</td>
</tr>
<tr>
<td>FICC</td>
<td>Fixed Income Clearing Corporation</td>
</tr>
<tr>
<td>FSP</td>
<td>Financial Services Provider</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>ICT</td>
<td>Information and Communication Technology</td>
</tr>
<tr>
<td>ID</td>
<td>Identity</td>
</tr>
<tr>
<td>KYC</td>
<td>Know Your Customer</td>
</tr>
<tr>
<td>MFIs</td>
<td>Microfinance institutions</td>
</tr>
<tr>
<td>RFID</td>
<td>Radio Frequency Identity</td>
</tr>
<tr>
<td>SMS</td>
<td>Short Message Service</td>
</tr>
<tr>
<td>VSLA</td>
<td>Village Savings and Loan Association</td>
</tr>
<tr>
<td>WBES</td>
<td>World Bank Enterprise Surveys</td>
</tr>
<tr>
<td>WRS</td>
<td>Warehouse receipts systems</td>
</tr>
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</table>
Abstract
Access to appropriate financial services is still a major challenge in many developing economies. Efforts to resolve these challenges are generally included in the wider financial inclusion initiatives, which aim to provide universal access to affordable, quality financial services, which targeted markets will find useful in meeting financial needs. The lack of financial inclusion is generally worse for remote communities that are normally dependent on agriculture for generating an income.

In this study, I review some of these challenges, with a particular focus on small scale farming in Africa, highlighting some of the products that these farmers may require but cannot access at the time of writing. The main focus is finance products that farmers cannot access, mostly because they lack suitable assets that banks recognize as collateral to minimize risk. Nevertheless, these farmers hold claim to assets such as livestock, land and harvests, which, unfortunately cannot be easily used as collateral.

Technology, may however, be applied to improve the way farmers may benefit from these assets. I review the potential of implementing blockchain technology to facilitate transfer of value based on the assets that farmers cannot fully take advantage of in the current financial system. I review some of the potential pitfalls to applying this technology, with a particular emphasis on the local conditions in the African markets under consideration.
1. Introduction

1.1 Introduction

Farmers in developing economies, particularly in rural communities, lay claim to valuable physical assets, such as land and livestock. Although such assets are considered very valuable according to custom, the modern financial system has not developed in such a way that facilitates widespread exchange of value based on these assets. As a result, the extent to which farmers benefit from the assets is rather limited.

An example of limitations that such assets have on farmer financial participation is most financial institutions’ inability to accept such assets as collateral for loans. This deprives the farmers of access to financial resources they would otherwise need for investment into improving their enterprises.

There is no fully developed network that enables easy and frictionless transfer of these assets, or rights to the assets, making the assets illiquid and leaving farmers less flexible in adapting to changing financial needs. The disadvantages of the status quo to farmers are many, and include:

- Poor to no access to financial products, due to the physical assets not being classified as acceptable collateral in the current financial system.

- Less flexibility in reacting to changing financial requirements, e.g. farmers may not easily sell assets to meet emergencies or in reaction to changing portfolio requirements. For example, in the event of droughts in some areas, farmers sometimes need to reduce their livestock sizes to match lower grazing, water or feedstock availability, but often fail to do so easily, resulting in losses.

- Poor physical asset value multiplication. Besides increases in assets resulting from occurrences such as multiplication of herds due to breeding, no other increases in portfolios are possible. Unlike cash, that may earn some interest when deposited with financial institutions, physical assets have few ways in which they may increase in value.

- Few applications for the physical assets as value exchange. Illiquidity often means farmers first have to sell the assets to convert them into cash. This is often done in emergency situations, and through middle men, resulting in losses from prices that are below fair value and from high transaction costs.
1.2 Study Objectives
The key objectives of the study are:

- To determine the feasibility of implementing blockchain in improving the usefulness, simplicity and transparency of transferring ownership rights to physical assets such as livestock in financial transactions, thereby improving the benefit such assets can have to owners.
- Development of high level requirements (technology, skills, partnerships, among others) for implementing blockchain in the transfer of ownership claims over such assets.
- Identifying potential hurdles and regulatory issues that may impede efforts to implement the proposed interventions, and how best to circumvent these challenges, where possible.

1.3 Study Methodology
The study was conducted through ongoing interaction with farmers and financial institutions that currently offer services to farmers who fit the profile I believe will find value in the work in this study. I also interact with teams that are working on projects which are related to the field being targeting e.g. digital identity, which I think will have applications in the work here.
Figure 1-1: Study Methodology

1.4 Expected Deliverables
The project is structured as a Feasibility Study, for which I will compile a study report answering questions related to the practicality of applying blockchain technology in the transfer of rights to physical assets in agriculture. Depending on proof of feasibility, my report will include high level implementation frameworks, laying the basic foundation upon which the technology can be successfully applied to addressing the identified gap.
2. Literature Review

2.1 Financial Inclusion in the developing world

The problems of inadequate financial services or products tailored to the requirements of rural farmers in developing economies can be viewed as a subset of the general poor financial inclusion in the emerging markets. Several definitions of financial inclusion have been brought forward. In this study, I use the multidimensional framework developed by the Financial Inclusion Data Working Group of the Alliance for Financial Inclusion (AFI). The dimensions for financial inclusion under this framework are presented in Table 2-1, below:

<table>
<thead>
<tr>
<th>No.</th>
<th>Dimension</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Access</td>
<td>Availability of formal, regulated financial services: Physical proximity Affordability</td>
</tr>
<tr>
<td>2</td>
<td>Usage</td>
<td>Actual usage of financial services and products: Regularity Frequency Duration of time used</td>
</tr>
<tr>
<td>3</td>
<td>Quality</td>
<td>Products are well tailored to client needs. Appropriate segmentation to develop products for all income levels</td>
</tr>
</tbody>
</table>

Based on the dimensions above, financial inclusion may be defined as universal access to affordable, quality financial services, which the targeted market find useful in meeting financial requirements. It is also necessary that such services be provided in a sustainable responsible manner [19].

Addressing the problem of financial inclusion involves developing measures that improve all the three dimensions, either simultaneously or in steps. Developing measures for addressing the problems of financial inclusion, however, requires an understanding of the root causes of the deficiencies under the different dimensions. Table 2-2, suggests some of the causes of inadequacies under each pillar:
Table 2-2: Common Causes for Financial Inclusion [19]

<table>
<thead>
<tr>
<th>No.</th>
<th>Dimension</th>
<th>Causes of Deficiency</th>
</tr>
</thead>
</table>
| 1   | Access    | • Lack of services due to high cost to financial institutions of providing access to less densely populated areas or to small markets  
• Low income levels to warrant use of financial services, considering the cost of using the facilities e.g. in some countries in Africa, fixed fees on a bank account are as high as 25% of GDP per capita  
• Identity issues- documentation is a major problem in many places in developing economies, particularly in Africa, making the use of financial institutions a challenge for many. This extends to aspects such as ownership records of assets that may be used as collateral for financial products. |
| 2   | Usage     | • Lack of education regarding benefits of current financial services  
• Low trust of financial institutions |
| 3   | Quality   | • Inability to provide tailored products that meet unique needs of target markets. This may be related to the cost aspects as it is sometimes expensive to customize services to meet unique market needs. When such a market is small, financial institutions have less motivation to provide custom products. |

2.2 Some measures of financial inclusion

Africa’s financial systems’ underdevelopment and its limited outreach are well documented. Low and volatile income levels, inflationary environments, high illiteracy rates, inadequate infrastructure, governance challenges, and the limited competition within the banking industry as well as high cost of banking in Africa are some of the factors used in explaining the underdeveloped financial sector and its limited outreach. However, until recently, very little was known about the actual reach of the financial sector. In what follows I examine access to finance from the point of view of individuals, and look specifically at different aspects that encompass the extent of usage of formal financial services, potential barriers, informal sources of finance, impact
on the savings behavior of individuals as well as their borrowing needs and reasons for access to credit.

Several measures have been used to determine the level of financial inclusion in geographical locations. The different metrics provide differing, but often related information that help in determining the extent to which a market has developed vis-à-vis financial inclusion. I provide data regarding two of the main cited measures; bank account penetration and formal savings by individuals.

2.3 Bank Account Penetration

Global bank account penetration, a reasonable proxy of usage of the formal banking system in different geographies is presented in Figure 2-1, below.

![Adult Account Penetration By Region](image)

Figure 2-1: Global Bank Account Penetration by Region [19]

The account penetration for the adult population in Africa is summarized in Figure 2-2, below.
2.4 Saving Behavior

Saving behavior, including the channels that individuals in different geographical regions use for saving some of their income provide indication of how financial inclusive the regions are. The choice between using formal bank systems and using other informal channels is useful in highlighting potential issues that may drive users towards one channel over the other. Poor access to formal banking systems and reluctance to use the formal system, both indicators of poor financial inclusion, may result in low participation in the formal savings channel in certain parts of the world. Figure 2-3 presents data on use of formal and informal savings channels in different parts of the world.
As may be expected, there is a positive correlation between the bank account penetration and the use of formal bank channels. This relationship is presented in Figure 2-4 below.

2.5 Financial Inclusion Metrics for Small Enterprises

The informal sector, dominated by small enterprises plays a key role in providing employment and encouraging economic participation in the developing economies. Nevertheless, the issues that
affect financial inclusion for individuals also have a bearing on the inclusion for such enterprises. Businesses such as rural farms, which are the core element of this study, tend to suffer from lack of access to suitable financial products, precluding their participation in financial markets and in many cases severely limiting their success.

I review data from the World Bank Enterprise Surveys (WBES), to get insights on the participation of small and medium enterprises in the formal financial services system and to identify existing challenges with access to financial products. Bank account penetration and access to credit lines are used as key metrics for determining extent of financial inclusion among small to medium enterprises. The data is summarized in Figure 2-5 and Figure 2-6 below.

![Business Bank Account Penetration](image)

**Figure 2-5: Business Bank Account Penetration** [19]

Access and use of bank accounts in African small companies is comparable to that in other parts of the world. This may be explained by regulatory requirements for registered businesses to have bank accounts. On another hand, it is relatively convenient for businesses to transact with other businesses when they have bank accounts, which incentivizes small businesses to get accounts. Comparison of access to financial products is made in below.
Despite comparable use of bank accounts with the rest of the world, access to credit lines for small enterprises is quite low.

2.6 Blockchain Technology

A blockchain is a technology that enables transactions to be conducted between any combinations of parties reliably and indisputably without the need of a central authority. In general terms, the technology underlying the blockchain does not differ much from that underlying databases, except for the way users interact with the database.

Four key concepts underline the technology, namely [4]:

2.6.1 Decentralized Consensus

This replaces traditional centralized consensus, where a central database controlled transaction validity. In the decentralized scheme of the blockchain, authority is transferred across a decentralized network, where nodes continuously and sequentially record transactions on a public block, creating a unique chain in the process. Each successive block will have a unique fingerprint (hash) of the previous code. Hash based cryptography is used to authenticate transaction and for providing security, eliminating the need for a central authority in the process. The combination of cryptograph and the blockchain results in no possibility of transaction duplication. A distributed network architecture of the internet is a key enabler for peer to peer interaction.

Figure 2-6: Business Loan or Credit Line Access

Despite comparable use of bank accounts with the rest of the world, access to credit lines for small enterprises is quite low.
2.6.2 Smart Contracts
These are small programs which can be entrusted with a unit value. The key attribute of smart contracts is that transactions’ governance can be administered on the blockchain, as opposed to through a centralized authority. Smart contracts are digital assets, whose ownership is linked to the blockchain, and which can be transferred through the blockchain. Smart contracts are the bedrock for transferring rights or ownership to certain assets.

2.6.3 Trusted computing
The combination of decentralized consensus, smart contracts and the blockchain, resources or digital assets may be transferred in a flat peer to peer basis, without the need for a central authority. Trust is ensured by the understanding that the blockchain will provide validation of transactions.

2.6.4 Proof of work/stake
This refers to the right to participate on the blockchain, which provides obstacles to users changing records. Any change to records would require changes to the proof of work, providing a hurdle that prevents manipulation of the underlying platform.
2.7 Benefits of Blockchain Technology

The blockchain promises a number of benefits that make it useful as a platform for performing several functions in different industries. Some of the benefits are:

2.7.1 Increased Transparency

By offering a decentralized register of ownership through recording every transaction in the system, every computer on the system stores a copy of this blockchain. As a result, each user can check that his/her version of the blockchain is in sync with all other versions in the network before a transaction can be made approved. Providing all participants with the capability of viewing all ongoing transactions improves the transparency on the blockchain. By use of blockchain, all users know who owns every block, at any time and are aware of changes or other relevant activity. Counterparty risk may also be reduced due instant feedback on transaction risks.

2.7.2 Low cost of transactions

By eliminating the need for a central authority or the middleman, blockchain technology can operate more efficiently, and at a lower cost than current systems.

2.7.3 Easier Scalability

Extending services to reach a wider audience on the blockchain is cheaper than extending services that require physical infrastructure. As a result, where appropriate blockchain can be used to meet the needs of remote, or less geographically concentrated markets, which may not be economically served with current technologies.

2.8 Blockchain Potential Hurdles

2.8.1 Regulatory Compliance

As a new approach in many industries where it is currently applied, blockchain does not fit existing regulation. Changes to existing regulation in areas such as assets transfer will be required before the technology becomes widely adopted. This may include fundamental changes to aspects of laws of economies. Since transaction may be easily done across borders, getting consensus across countries with different laws may prove challenging and time consuming.

2.8.2 Common standards across industries

Blockchain application across industries may require alignment in certain platform design issues. This will improve system interoperability across networks, an attribute that may result in higher networks effects and better scaling of the technology.
2.8.3 Operational Risks

The transition phase from current approaches to blockchain has potential to introduce operational risks. Some system redundancy will be required in many applications, for example, running blockchain with current systems operating as backup until sufficient stability has been established to facilitate complete transition.

2.9 Blockchain Technology Application in Capital markets and Banking

Blockchain intertwines value ownership and value transfer in a secure and fast system that is visible for the world to see. Out of the wide scope of applications of the technology; I consider applications in the financial markets interesting for potential adoption in improving financial inclusion, and potentially in the development of financial products that are suitable for application in meeting needs of the farming communities who are our focus of this study.

There are many possible applications of blockchain technology in banking and financial markets. Some use cases in testing mode include:

- Know Your Customer (KYC)/Anti Money Laundering (AML) data sharing
- Trade surveillance
- Regulatory reporting
- Collateral management- this is an interesting application for this study as application in this area provides opportunities for designing products that can use non-traditional collateral such as land and livestock holdings in rural farming communities.
- Trading, settlement and clearing

Blockchain supported distributed ledgers are particularly useful for complex financial assets. In such assets there is usually no clear central authority to regulate, arbitrate, and/or mitigate risk of trade or counterparty failure. Examples of products that may benefit from benefitting from the technology include Public and Private Stocks or Bonds, Fixed Income Clearing Corporation (FICC) derivatives, Syndicated loans, Corporate Bonds, Factoring, Letters of Credit, and Derivatives Margin/Collaterals [31].

The potential benefits of application of blockchain across different facets of capital market value chain are summarized below:
<table>
<thead>
<tr>
<th>Pretrade</th>
<th>Trade</th>
<th>Post-trade</th>
<th>Custody &amp; Securities Servicing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transparency and verification of asset holdings</td>
<td>Secure, real-time transaction matching, and immediate irrevocable settlement</td>
<td>No central clearing for real-time cash transactions. Reduced margin/collateral requirements. Faster novation and efficient post-trade processing. Fungible use of assets on blockchains as collateral</td>
<td>Primary issuance directly onto a blockchain</td>
</tr>
<tr>
<td>Reduced credit exposures</td>
<td>Automatic Delivery Versus Payment on a cash ledger</td>
<td>Automatic reporting &amp; more transparent supervision for market authorities</td>
<td>Auto-execution of smart contracts</td>
</tr>
<tr>
<td>Mutualization of static data</td>
<td>Automatic</td>
<td>Higher Anti Money Laundering standards</td>
<td></td>
</tr>
<tr>
<td>Simpler Know Your Customer via look through to holding</td>
<td></td>
<td></td>
<td>Richer central datasets with flat accounting hierarchies</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Common reference data Fund subscriptions/redemptions processed automatically on the blockchain</td>
</tr>
</tbody>
</table>

Figure 2-8: Blockchain Benefits in Capital Markets [5]
3. Agriculture Financing in Africa

3.1 The Agriculture Sector in Africa
More than half a billion Africans depend on small or micro-scale farming as primary source of livelihood. In some countries as much as 80% of the population is employed in the agricultural sector. Even so, Africa still depends largely on food imports to feed its population. It needs significant increases in productivity and production to turn the tide and ensure food security on the continent. Access to appropriate financial services can help unleash Africa’s agricultural potential.

3.2 Demographic Information
According to the Food and Agricultural Organization (FAO), in 2012, 63.9% of the African population lived in rural areas with only 36.1% in urban areas. The regional distribution of rural and urban population split is summarized in Figure 3-1 below:

![Africa Rural & Urban Population Distribution](image)

**Figure 3-1: Africa Rural & Urban Population Distribution by Region**

Agriculture is the primary source of income for the rural population. The regions with higher rural populations tend to have a higher dependency on agriculture as a source of income. Figure 3-2, below presents the regional share of agricultural population as a percentage of regional total population.
Figure 3-2: Africa Agriculture and Non Agricultural Population by Region

Compared to the rest of the world, Africa still has significant reliance on agriculture as a primary economic activity. Supporting this sector is therefore paramount in improving livelihoods and in achieving economic goals.

3.3 Agriculture Economic Contribution

Despite the dependency of a proportionately large fraction of the African population on agriculture, the contribution of the sector to economies is relatively low. The contribution of agriculture and other sectors to economies by region is presented below:
While the contribution of agriculture, when compared to other sectors appear low, it is worth noting that, compared to the contribution at a global scale, estimated at 2% \[^6\], the contribution in Africa is way larger, indicating the important role that agriculture still plays on the continent.

Also, Africa as a continent is currently a net importer of agricultural produce. The continent lost its position as a net exporter of agricultural producer in the 1980’s. Agricultural imports have been growing faster than agricultural exports. In 2007 agricultural exports reached a record high of $47 billion \[^{27}\], resulting in a deficit of $22 billion \[^{27}\]. For comparison’s sake, the value of agricultural exports from Thailand is as of 2013 greater than for the whole of Sub-Sahara Africa \[^{27}\]. Hence, the opportunity for further increases in the contribution from agriculture in economies in Africa is large, if the imports are substituted by locally grown produce.

A number of reasons have contributed to the status quo, some that are addressable in the long run and some that are perhaps beyond control of communities and policy makers. Some of the reasons are noted below:

### 3.3.1 Weather related issues

Frequent droughts in some parts of Africa, and excessive rains in other parts have resulted in damage to crop resulting in decreased output. Often, farmers do not have enough support to recover from loss of harvest. Also, disease, for example, the foot and mouth virus has had a profound
impact on livestock. Livestock damage significantly reducing available resources for powering animal drawn implements, while also curtailing opportunity for meat production.

3.3.2 Policy Uncertainties
Drafting of policies that encourage investment and growth in agriculture is in some African countries a major issue. There is often uncertainties in the implementation of policies, which discourages investment. Some examples include land distribution programs in Zimbabwe, tax policies in other countries, which work either to discourage investment, or promoting imports over local food production.

3.3.3 Low Knowledge Development
Most agricultural activities in Africa are still organized around subsistence; farmers primarily grow enough produce to feed their own families. Hence, no application of modern farming techniques and investment into such techniques is prevalent. This makes it difficult for farmers to work around issues such as climate change, or for farmers to actively seek opportunities for improving their operations.

3.3.4 Inadequate Financial Resources/Products
Development of modern agricultural techniques, education of farmers and managing uncertainties all include investment, for which access to financing is crucial. Financial products, such as insurance can help support farmers when dealing with uncertain weather patterns. Similarly, investment into equipment that improves productivity of farming operations requires access to sources of finance, which many farmers, especially small scale participants, in Africa cannot get.

In many cases, farmers cannot get access to financing to buy basics such as seed and fertilizer, leaving them to rely on donor organizations and in some cases government handouts. This leaves farmers in a perpetual cycle, where they cannot sufficient grow operations to become economically independent and participate fully in the development of the economies they operate in.

Lack of access to financial products not only leaves farmers unable to grow, but also unable to participate in basic commercial activities that they need to support their activities. Farmers in rural communities lack basic products such as savings accounts. This means in many cases they are unable to save and earn interest on excess financial resources they may have.

Also, besides farm implements, land and livestock, farmers do not have many assets that traditional banks consider suitable collateral for extending loans to farmers. Hence, the primary objective of this study is to determine if technology can be deployed to improving the financial
participation of rural and other small holding farmers, who currently appear underserved by the existing financial services industry.

3.4 Overview of Small Scale Agriculture Financing in Africa

Historically, particularly in the 1960s, subsidized agricultural credit programs were the popular approach to financing agriculture in Africa. These were considered a suitable approach to correcting legacy market failures, which policy makers perceived to be the cause for lower credit access in agriculture.

These programs included caps on the interest rate that financial institutions could charge. The interest rate caps, however, worked against the institutions issuing loans under the programs, most of which were affiliated to the governments, resulting in failure of the programs. The programs were replaced by a new approach which required relaxation of interest rate controls and developments at the micro, meso and macro levels [14].

At the same time, microfinance institutions (MFIs) that offered small, usually non-collateralized, and hence high interest rate loans began to gain traction. The target market for MFIs was people who lacked collateral required by traditional bank institutions. The focus of MFIs was initially the poor, particularly women. Women were targeted due to their marginalization in economic activity in Africa, and also because they are often a lower risk as they tend to be more responsible with spending. The approach was chosen as a way of providing the first step to the poor to participate in the financial markets. It was hoped these participants would gradually migrate to formal institutions as they establish a credit history and earn more income.

With time, the service scope for MFIs expanded to include savings, insurance, remittances and other financial services. Also, agricultural value-chain finance was proposed as a complementary strategy to the financial services approach, given the key role that agriculture played in the economic activity of the low income market. Due to the need to address not only the components related to the agriculture value chain of the poor, the financial inclusion consideration took center stage and grew as a broader way to address the needs for financial services.

Financial inclusion specifically referred to the need for everyone to have access to full suite of quality financial services, at affordable prices in a convenient manner with respect and dignity, delivered by competitive suppliers. The concept of financial inclusion has been discussed in Chapter 2 of this study. The key premises for financial inclusion are Accessibility, Usability and
Quality of provided services. In extreme views of the concept a cash-free economy is envisaged, given the challenges that having to deal in cash offers especially for remote communities that fit the profile for rural farmers

The quest for financial has resulted in significant interest in ideas and innovations that expand access to and use of financial services. Many of these are driven by rapid growth of ICTs. The core work that this study seeks to accomplish, that is, investigating application of blockchain technology in agriculture financing, is in line with the idea of furthering the financial inclusion initiatives.

3.5 Primary Financial Services Providers

3.5.1 Banks
Most African countries have some form of regulated local and foreign-owned commercial banks that provide savings accounts, checking accounts and loans to private individuals and businesses. Nevertheless, these tend to serve only large corporations and individuals in urban centers, excluding the rural communities and farmers who do not normally have a credit history. Also, the remote nature, and low population density for rural farming regions make it less economic to provide the infrastructure that is required to serve such populations. In some models, banks form alliances with other organizations such as postal services and grocery stores. The banks make use of these organization’s facilities to provide banking services, often limited to deposits and withdrawals of cash.

The banks report an increasing interest in agriculture although agricultural represent less than 5–10 per cent of their total portfolios. Agricultural lending is often limited to large farmers, estates, plantations, agribusinesses, out-grower schemes and export crop value chains, and is sometimes extended to well-managed cooperatives and farmer associations.

Another bank class consists of Agricultural and Development banks, often government controlled, which are set up specifically to address the needs for agriculture. Examples include Agribank (Zimbabwe) and Land Bank (South Africa).

3.5.2 Microfinance Institutions (MFIs)
These make small loans mostly to the unbanked poor, usually with few assets required as loan collateral. Some large banks operate MFIs divisions, while others downscale to serve lower-income market segments. The regulatory framework for MFIs differs significantly from country
to country. Traditionally MFIs relied on group lending, using peer screening for clients, and peer pressure to assure repayment [14]. The MFI model, however, works in densely populated areas, hence it's favorable in urban and semi-urban areas. As a result, successfully serving small farmers requires significant effort, including business model and process changes for MFIs.

Some innovations that have been tried in pursuit for rural and agricultural business include mobile units, kiosks, satellite centers and mobile vans, ATMs; point of sale devices through participating retail outlets, gas stations, agricultural supply shops and competitor banks; and smart cards issued with biometric identification [14].

In some cases, technology, including GPS-supported systems were applied to verifying plot sizes and aid in setting application rates for crop inputs and reporting yields. It is unclear if the high costs of these innovations are compensated through increased revenue or if they require subsidization. Mobile devices and ICT have potential to improve the operations of MFIs in serving the rural communities. However, the cost of innovation needs to be justified by increased business from adopting technology.

Also, to minimize risks, MFIs often limit the size, length of loans and total portfolio exposure to agriculture. Hence, the products offered are normally limited, with higher interest rates. In sub-Saharan Africa, studies indicate that MFIs have an unfavorable cost structure, with operating expenses of 19 per cent [14] compared to global levels of 14 per cent [14]. This is explained by high labor cost due to scarce skills, high costs for reaching out to remote rural farmers. Unfavorable regulatory frameworks also interfere with smooth operation of MFIs in sub-Sahara Africa.

3.5.3 Member-owned financial institutions

Member-owned institutions are a heterogeneous group that includes accumulating savings and credit associations (ASCAs), financial services associations, savings and credit cooperatives. Thousands of these FSPs with millions of members exist in Africa, and an estimated seven per cent of the African population belongs to cooperatives. Some of the advantages of member owned in serving poor and distant populations accrue from use member volunteers rather than paid employees, although they generally have not been innovative leaders for either micro or agricultural finance.

3.5.4 VSLAs

At the end of 2014, an estimated 135,000 VSLA [14] groups existed in 27 African countries with about three million members and average savings of US$30 per member [14]. The typical VSLA
has between 15 and 30 members \[^{[14]}\], usually women, who meet regularly to deposit savings in a fund for loans made to group members. The savings are normally distributed among members at the end of a predefined cycle. Some groups have developed to leverage formal FSP’s e.g. leveraging mobile banking services in many countries for depositing group savings.

3.5.5 Financial agents

Financial linkages and agents include relationships that permit FSPs to access resources and infrastructure of other businesses or organizations, which the FSPs use to offer financial services. These relationships can be between FSPs and shop owners, postal services or other organizations that have adequate penetration into the remote rural or farming communities. With the spread of electronic money, these agents often play an important role as Cash-in Cash out (CICO) agents. The agents are normally limited to deposits and withdrawals only. They do not have capacity and expertise to offer other financial products that customers would find beneficial. Despite this, they are an important resource that any service provider may consider engaging.

3.5.6 Telecom banking

The widespread adoption of telephone banking has improved access to savings and payment facilities. This has also driven many countries towards cashless transactions. Penetration of rural areas has improved significantly and so has the reduction of transaction costs. The available products are either operated by traditional banks or by mobile network operators who have the necessary authorization to conduct banking activities.

3.6 Sub-Saharan Africa investment mechanisms for agricultural and rural finance

There is growing interest in expanding the role of agriculture in Africa, and improving standards in the sector. Several strategies are currently employed, including investment in start-up agribusinesses with the potential to grow and eventually obtain funding from FSPs. Some FSPs have taken the route of forming partnerships with government, not-for-profit organizations, development agencies and private investors that increase borrower creditworthiness. Creditworthiness improves through reduction in barriers and through supplying inputs and technical services. Most investment has gone to relatively large farming enterprises, although there is an argument for supporting smallholder farmers. It is estimated that about 50 million \[^{[14]}\] such farmers exist in Africa and have a largely global demand for finance. Globally the size of the
market is estimated to be as large as US$450 billion\(^{[14]}\), of which only two percent is met by social lenders.

There are many private investors and development agencies that target value chains rather than improving financial services. The tenet for such organizations is that facilitators assist chains to obtain financing rather than provide it directly or subsidize the costs of the business. Through providing assured supply of production inputs and a market for smallholders lending risks for FSPs is reduced, allowing small farmers access to finance.

Applications of crowdfunding are another potential funding source in Africa and other developing countries. Easier connectivity over the internet makes it easier for communities to contribute towards financing community businesses. The crowdfunding initiatives are an extension of the traditional VSLAs or other family or community-based programs. Successfully implementing them depends on friendly regulations, information technology and the creation of trust between financial contributors and recipients.

### 3.7 Risk management

Several strategies are being employed in Africa to reduce and manage risk for FSPs lending smallholder farmers and households. These include, credit guarantees and warehouse receipts schemes which are implemented with the hope of encouraging FSPs to extend more credit to those in need.

#### 3.7.1 Credit life and health insurance

These products are targeted at the borrowing households, with the reasoning that improving the health of individual and offering life insurance ultimately reduces the risk on loans issues to the persons. The products are marketed directly by insurance companies or in partnership with MFIs and other organizations that work with farmers or other rural borrowers. The products are often bundled with the loans extended to borrowers.

#### 3.7.2 Crop and livestock insurance

Crop and livestock insurance is offered to safeguard farmers from potential losses resulting from climate and disease risk. Providing security against such losses benefits lenders who are assured some protection when farmers experience risk events that destroy their livestock or crop. The insurance products allow farmers to keep up with repayments for borrowed funds. However, some challenges have been experienced in implementing these programs, resulting in low uptake. It has
also proven difficult for insurers to sustain the insurance products and offer attractive premiums given the risk occurs infrequently and losses are often small for the insured. Also, significant investment in hardware and software, together with the effort of getting government authorization have challenged sustainability of the products.

3.7.3 Partial credit guarantees

Guarantees are typically issued by government related agencies. The aim of guarantees is to induce FSPs to lend to specific target groups such as rural farmers. The objective is to influence behavior that will allow lenders to become effective with lending to the designated groups with time, after which the guarantees become unnecessary. The effectiveness of credit guarantees has been questionable e.g. lenders are reluctant to extend loans due to the high possibility of losing out on the portion that is not covered by the guarantee.

3.7.4 Warehouse receipts systems (WRS)

Warehouse receipts are used for collateralizing stored commodities. The model works better with large farmers who produce and store relatively large amounts of commodities to warranty the monitoring effort required. A lot of work goes into verifying the value of declared produce, and keeping track of value of the collateral over time. For smallholder farmers, aggregation of produce from different farmers in a central location may be required to realize the scale required for the model to be viable. Models under consideration include e-warehouses that involve verification checks that use mobile phone applications and SMS updates. The value of stored commodity is shared with FSPs for evaluating loan eligibility.

3.7.5 Credit scoring

Credit scoring involves risk assessment based on statistical of factors that influence creditworthiness. This often requires experts and can be expensive when used to target smallholder farmers that have a low density in most areas. The lack of credit history for smallholder farmers makes this approach challenging. In many cases no records exist for such farmers as they have not been granted any such credit in the past. Similarly, lack of access to formal bank systems means no financial records for farmers may be easily obtained. There is no reliable source of records on farmer income and financial obligations to make it possible to verify what loans they may adequately afford based on historic income records.

3.8 Financial infrastructure
Institutions, technologies and regulations are key components that govern financial systems. A review of such infrastructure, with an emphasis on Africa, and the financing of agriculture is presented here.

### 3.8.1 Collateral registries for movable property

The value of movable property as collateral is restricted when there are no functioning laws and registries to govern secured transactions. Credit registries play a significant role of facilitating access to FSP products at better rates due to the possibility of applying movable property as collateral. Registries are normally owned and operated by government that support banking supervision and provide credit risk data. Development of registries is still lacking in many African countries. Where registries exist, the scope of assets included is often small, and excludes asset classes that are common among farmers.

Some progress has been made however, e.g. Africa’s first internet collateral registry was launched in Ghana in 2010 [25]. The registry allows small-scale entrepreneurs to list movable property as collateral. It is reported to have facilitated financing to more than 9000 SMEs and 30,000 microenterprises.

The lack of reliable or adequate central registries plays in the favor of the blockchain applications reviewed in this study. One of the key attributes of the blockchain is the ability to create distributed ledgers, where no central authority has oversight. Hence, this problems can potentially be addressed on the blockchain, significantly improving the willingness of FSPs to lend to smallholder farmers due to the ability to identify collateral.

### 3.8.2 Credit Bureaus

Credit bureaus are essential for providing financing history of borrowers. They provide accurate data on borrower history that improve accuracy of screening. By aggregating information on borrowing from multiple sources, borrower’s over-indebtedness can be kept on check. Public credit registries exist in 26 sub-Saharan African countries [14], while private credit bureaus are found in 13 countries [14]. In the context of the application of the blockchain in improving financial inclusion, credit bureaus are a starting point, but perhaps a step behind as they are essentially centralized. The blockchain may not really offer advantages when applied with credit bureaus.

### 3.8.3 Land Claims

Land claims are rather unclear in many African countries due to traditional communal ownership of land. Where ownership is clear, land is the most valuable collateral in lending for agricultural
purposes. It is not movable and does not easily change hands. Hence, improvements in land tenure can significantly improve the creditworthiness of farmers, where they are willing to offer title deeds as collateral. However, it is noted that there is a general reluctance for farmers in Africa to offer title deeds as collateral, while regulation often tends to favor farmers in the event of disputes regarding land offered as collateral. There are negative social connotations associated with an FSP, for instance, holding on to title deeds of a farmer who would have defaulted.
4. Blockchain Based Solutions to Financing

4.1 Introduction
Although blockchain technology has a host of applications to which it may be put, care is required in its use as many of the potential applications are adequately addressed with existing approaches. In these cases, blockchain technology would be more of a solution that does not really address strong pain points for end users. I take this cautionary approach in identifying problems that blockchain can address in agriculture financing in the developing world. I also give cognizance to the fact that the users in these markets are not sophisticated as far as appreciation of technology is concerned. Hence, solutions that are simple, pragmatic and hit the right points are preferred.

4.2 Gap Analysis
In the previous chapter, I highlighted some deficiencies in the financial services landscape in Africa, where technology has been or can make a difference in improving participation and benefit to farmers. I summarize some of the main challenges and identify the areas where I think the blockchain will add value, and provide reasoning for the selection.

Table 4-1: Agriculture Finance Gap Analysis

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Blockchain Value</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Checking &amp; Savings Accounts</td>
<td>Low</td>
<td>Use of internet and mobile banking sufficient for these applications. Mobile banking provides a simpler solution that is easily scalable and has been successful in many countries to date.</td>
</tr>
<tr>
<td>Farm Insurance</td>
<td>Medium</td>
<td>Blockchain can assist in improving identity of assets, thereby improving valuation of asset portfolios to determine suitable cover. This is a result of the lack of registries in most African countries, where asset values can be ascertained. By creating a distributed platform, registries can be created independently by FSPs, giving them better visibility of assets that are insured. However, this market is small. Smallholder farmers</td>
</tr>
<tr>
<td>Product Type</td>
<td>Blockchain Value</td>
<td>Comment</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>currently do not consider insurance against weather or animal disease that important as they perceive potential losses to be small and not justifying paying a recurring premium out of the small income they currently generate.</td>
</tr>
<tr>
<td>Collateralized Loans</td>
<td>High</td>
<td>Improved asset identification and flexible transfer of right to such assets as land and livestock can be achieved on the blockchain. In the absence of reliable registries, the blockchain can be used to develop such registries. Once assets are registered, smart contracts are used to transfer rights to the assets between FSPs and farmers. Getting better visibility of collateral and the ease with which collateral can be claimed induces FSPs to lend more and to do so at lower interest rates than is currently done. Peer to Peer lending may be better executed, increasing the scope of available credit.</td>
</tr>
</tbody>
</table>

The use of internet banking and mobile money has significantly improved participation of communities in Africa in the financial system. This has made services such as savings and payments more accessible to communities, even in remote areas where no physical bank branches are available. Hence, I think current solutions are adequate in this area.

Issuing of insurance is an area that may benefit from the blockchain, due to its possibility to improve asset identification, hence to improve asset valuation and determine suitable cover. Nevertheless, the market for farm insurance is relatively small, especially in smallholder farm communities and as a result, I do not consider this application a high priority. The insured value is often not large enough to induce farmers to seek cover. Rather, farmers consider the money they pay into premiums to more valuable than the potential losses.

The market for collateralized loans is the most promising, and is reasonably sized to warrant effort of developing solutions based on the blockchain in this area. Current farmer ability to collateralize assets such as land, livestock, harvest, implements and real estate is not adequate to offer access to loan facilities with financial institutions. FSPs in Africa have an interest in the
market, but may not find economically viable, and easily scalable approaches to servicing this market.

4.3 Asset Collateralization Example

I present an example of an approach that some financial institutions have tried to implement as a way of improving options for farmers seeking to use physical assets as collateral.

In 2013, a Zimbabwe based financial services firm, TN Bank set up what was referred to as a livestock trust [3]. The primary purpose of the trust was to enable rural farmers to achieve better benefit from their livestock. The bank literally accepted cattle ‘deposits’ at a central farm location. In the approach, representatives of the bank would market the facility to rural farmers. Once a farmer was interested in the facility, the representatives would conduct a valuation of the livestock, assigning monetary value. The cattle would then be transported to a ‘bank’ where they would be looked after. The bank issued farmers with a certificate of deposit, indicating the value of cattle that farmers would have deposited. TN bank paid interest on the value of cattle deposited at its facilities, with interest being in the form of cash or livestock.

The certificates of deposit could be used as proof of collateral when farmers borrowed from banks or bought goods on credit. While the approach appeared reasonable, the model had a number of questionable aspects, notably:

- **Cost** – the cost of feeding, treating and providing security for the animals in the ‘bank’ is likely to grow significantly over time. Unlike farmers who get benefit from the cattle when they have them in possession, e.g. through milking and draught power, the bank does not necessarily get any benefit that offsets the cost of taking care of the animals. This likely destroys value over time, and makes the scheme unsustainable.

- **Scaling difficulties** - expanding the program requires outreach to places far afield, and needs investments in land to cater for larger herds. Cost and availability of land may impose hurdles to scaling the program.

- **Risk management** - by keeping herds in a central location, the program literally aggregates the risk that is typically spread when farmers look after smaller herds in different locations. Spread of disease or other natural disaster is likely to be more damaging for cattle in one facility, or fewer large facilities.
Hence, simpler, technology driven solutions may be employed to improving on the above approach. I prefer an approach that does not move livestock, or other collateral from owners. This leaves owners with the responsibility of upkeep of the assets, which significantly improves the possibility of expanding the offering without incurring high cost. Nevertheless, that will have challenges of its own that require addressing, including:

- Changes to the collateral asset base may not be easily verifiable. This would be crucial for assets such as livestock, which owners may move from place to place, which may die, may be sold to other parties, or may be used as collateral for multiple loans, whose value may end up exceeding that of the collateral. Measures would need to be put in place to safeguard the lender against such risks.
5. Solution Design

In this chapter, I discuss a proposed blockchain based solution to improving securitization of farm assets to enable farmer access to loans backed by assets they own. I consider two primary asset classes as suitable for collateralization in Africa. The suitability of the asset classes may differ from country to country depending on regulations and laws on property rights. The two asset classes I will focus on are:

5.1 Landholdings

The primary advantage with using land as collateral is that it is immovable, which increases the security associated with lending against it.

Disadvantages for using land include the fact that, while in most economies, market value of land in specific areas is generally easily determined, the same may not be said of some places Africa. There are areas where land registries are still underdeveloped, making it difficult to ascertain ownership. In other places, land is owned in tribal trusts, hence no farmer may actually claim property rights to such land.

Nevertheless, I note that there is progress in this area, with registration of land claims on the blockchain already being piloted in some African countries. An example is Bitland in Ghana, being spearheaded by CCEDK, a Danish blockchain technology company [25]. Bitland’s is to provide services that allow individuals and groups to survey land and record title deeds on the Bitland blockchain – providing a permanent and auditable record – as well as acting as a liaison with the government to help resolve disputes. The project is supported by the Ghana land commission as a way of resolving transparency issues in land distribution.

5.2 Livestock

Cattle are a very important asset class for most African rural farmers. They have played a central role in value exchange for generations in Africa, hence in many places they are a currency of some form. Use of cattle as value transfer mechanism is well appreciated in Africa. However, the use of cattle as collateral may have some challenges, among these the difficulties in validating ownership. There are no specific requirements for cattle owners to register their herds with a central authority. Informal records exist, which are used by owners when accessing government sponsored subsidies for feedstock and veterinary services. These may not be very reliable to a lending institution
although they may provide a good starting point for improving identification and verifying ownership. While the lack of a central cattle registry is a potential downside, I am quick to point out that it also presents a perfect opportunity to show the benefits of blockchain. One of the tenets for blockchain adoption is the possibility to do away with central authorities, hence applying the technology to livestock provides a way out of the problem of inadequate registries for cattle. Also, cattle are easily movable from one place to another, making it difficult to track when changes in the value of asset portfolios backing certain loans changes. The risk of disease infections and death due to causes such as droughts can be significant for cattle, hence management of the exposure is perhaps a bigger issue than that for land.

5.3 System Overview

I propose a blockchain based solution that will provide the following benefits over current offerings:

- Convenient collateral registration and record keeping for financial institutions. The collateral registration is essentially a database, where records for ownership are kept and updated as changes occur. This function can be completed with existing database systems not necessarily based on a blockchain, although the distributed nature of the blockchain offers benefit in that it becomes not so essential to have a central party handling the verification process.

- Smart contracts execution capabilities. This is the central attribute of the blockchain that makes the solution different from existing offerings. Smart contracts are small programs which can be entrusted with a unit value. The unit value will be aggregated to the value of registered assets in the database above. The execution of smart contracts allows transactions' governance to be administered on the blockchain, as opposed to through a centralized authority. Since smart contracts are digital assets, whose ownership is linked to the blockchain, they can be transferred through the blockchain, essentially converting the physical assets such as land and livestock into relatively more liquid assets whose value may be conveniently exchanged on the blockchain. By transferring rights to such assets more conveniently, a wider range of possibilities in use of these assets than before opens up.
The proposed system will be comprised of field technology that can be used to register and record assets owned by farmers onto a central database, or a collateral ledger. As financial institutions seek to issue loans, the collateral ledger is referred to for determining coverage that certain persons’ assets provide for loans being extended. As each transaction is completed, smart contracts are used to transfer portions of the registered value between financial institution and farmers, creating new assets (loans) in the process. This is done remotely using mobile phones or other internet enabled devices.

The collateral ledger is therefore the most important aspect of the solution as it enables better visibility of collateral for FSPs. This raises the question on what the best way of developing the ledger is, that is, should such ledgers be developed by individual FSPs, or should a single ledger be developed that can be referred to by all FSPs? The drawbacks to developing independent ledgers are primarily the following:

- Cost- if each FSP has to develop its own registry, the cost of doing so could be prohibitive considering the need to approach farmers that are thinly dispersed in many geographies.

- Risk of over-indebtedness- independent registries imply that farmers may register assets more than once when doing so with different FSP registries. Hence, collateral is accounted more than once. Farmers may borrow against the same collateral several times, resulting in loan values that surpass the collateral base. This exposes FSPs to large risks of default.

A single registry addresses the drawbacks noted above. However, it may come with drawbacks, among them:

- Challenges with coordinating FSPs to participate. It is unlikely that all FSPs will be willing to participate at the same time. Different business priorities may imply different levels of interest in participating. Different FSPs may consider the potential value differently, making it difficult to determine what contributions each participant may need to make to the program.

- Assigning responsibility for maintaining and management of the ledger. The FSP maintaining the ledger typically incurs cost from doing so and no single FSP is willing to do so at the benefit of competitors.
Integration issues- different FSPs may have different information technology systems, which may not all integrate easily with the ledger. That makes it challenging to choose the suitable platform for use, potentially discouraging some participants if they perceive chosen platforms incompatible with own platforms.

I recommend a single registry to minimize the risk of collateral being used many times over and to minimize cost and possibly encourage participation. However, the registry may ideally be developed by an independent body that runs and maintains it, with FSPs paying fees to access it when lending. Alternatively, it can be maintained by banks that are traditionally targeted at the agriculture sector and will have a higher interest in making the scheme successful. In many African countries such banks are government controlled, which offers advantages in that they will get preferential treatment in many aspects, including regulatory approval. Governments also realize the benefit that such platforms offer in improving financial participation of the smallholder farmers and are thus willing to invest in such initiatives. Implementation efforts will involve engagement of institutions that are affiliated with governments. Other FSPs may link into the system, also at a fee when they wish to extend loans to smallholder farmers.

5.4 System Description

The proposed approach relies on field personnel who will work in smallholder farm communities to value and register assets on the collateral ledger. Training will be offered to field officers in determining value of assets such as livestock. While there could be benefit in expanding acceptable assets, the choice of using only livestock and land reduces the scope of valuation methodologies required, hence officers are trained in the valuation of only these classes. Once valuation of assets is complete, the assets are registered online, with the value at the day of registration noted. Once in agreement, farmers are issued with electronic certificates indicating their approval of the offered valuation. Where preferences favor physical certificates these may also be issued.

FSPs will have access to the registry or collateral ledger for a fee when required. This is referred to before loans are issued by an FSP. The benefit of the blockchain is in the ability to conveniently update the value of assets in the registry as changes are made. The history of assets is readily available and can be tracked backwards, which improves transparency. Smart contracts
will contain specific instructions for executing specific action e.g. transfer of ownership in the event of a default. History of borrowers is conveniently developed and verified. The approach makes for a lot more transparency and convenience than is currently possible, once assets have been registered. This should typically induce lenders to extend credit to smallholder farmers who would have assets registered. The system overview is presented schematically in Figure 5-1 below.
Field Officers facilitate asset registration. Livestock RFID tagging used for real-time tracking and verification.

Figure 5-1: Schematic Blockchain Based Collateralized Financing
5.5 System Requirements

5.5.1 Field Asset Verification and Tracking

The verification of assets in the field is the most labor intensive activity, mostly as a result of a lack of well-developed documentation of assets such as cattle. The process requires field officers to go around listing assets and verifying ownership. Given that this will be an ongoing activity, the activity may best be accomplished by working with community leadership, or training local to perform the tasks in the communities that they live in. This reduces cost of reaching out, provides job opportunities and reduces risk since officers have a background of asset ownership in communities. Since the job may not be fulltime, another approach is to use professionals who hold other jobs located in rural communities. A good option is rural teachers, who are often well educated and normally have free time outside their teaching duties. In some countries, government provides Agricultural Extension Officers, who hold up to a college diploma and can easily handle the work required. The main tasks include:

- Identifying and verifying asset ownership
- Valuation of assets such as cattle
- Registering assets and issuing formal certificates of ownership
- Uploading data related to ownership, certificates and other records onto a central location
- Installing asset tracking equipment such as RFID chips for real time monitoring of movable assets such as cattle. Each asset will be issued with a unique ID that can be used to track it real time. Technology for accomplishing this already exists and is currently used by some large commercial ranches. This includes both hardware and software required for data processing. Common manufacturers of chips and software providers are Cattletags and CattleMax respectively.

There are added incentives to farmers participating e.g. tracking of assets improves asset security for farmers, helping them mitigate theft.

5.5.2 Data Storage and Handling Facilities

All collateral data is stored in a central datacenter, typically owned and operated by the financial institution. All data transmitted by field offers will be stored in such facilities, either directly or after review by a bank official to ensure the quality of information provided is adequate.

5.5.3 Bank Asset, Cash and Securities Ledgers
Existing bank ledgers are useful in the technology, with the extension to incorporate smart contracts that are unique for the blockchain application.

### 5.5.4 Operating Platform

The blockchain platform for creating and implementing smart contracts for the exchange, transfer of value associated with physical assets or securitization of resulting financial assets is the main differentiator and enabler of proposed approach.

There are several platforms that have been developed and specifically used for certain applications. Our approach is to leverage applicable existing platforms that offer blockchain as a service (BaaS), only developing applications that are suitable for the transactions that will be handled. At the time of writing, there is a great deal of effort going towards making platforms interoperable. This is important in the case of financial services firms whose application of blockchain tends to prefer private federated blockchains. Nevertheless, regulatory requirements in specific markets will also be a key factor in dictating choices in this regard.

I follow the general selection criteria that the ideal blockchain platform should satisfy the following attributes:

- High Scalability, Reliability, Speed and Security;
- Easy to code and integrate with existing financial services provider information technology systems.

Microsoft is positioning its Azure platform to work with a number of existing platforms, thereby creating a central vehicle for interoperability across platforms. I consider this an advantage of the platform. Considering Microsoft’s presence in many developing economies, including Africa, the security levels of Azure and the wide range of other Microsoft based solutions available to financial services firms, the platform could offer a good starting point for trialing out the solution under review.

### 5.5.5 Transaction Processing

There are no expected major changes to other transaction handling requirements past the blockchain platform for executing smart contracts between lenders and borrowers. Changes may only be required if there are integration issues. Once smart contracts are executed between financial institution and borrowers, funds are transferred to borrower bank accounts, mobile wallets or other deposit facility that applies. These facilities are used for making repayments on borrowed funds.
6. Implementation

Throughout carrying out this study, I interacted with industry players to appreciate whether there will be a need for resolving the current challenges and whether the proposed route will be considered practical. Initial indications are that given the importance of agriculture in improving income in the developing countries, there is a significant interest in addressing the challenges currently experienced when lending to farmers. A number of agriculture focused FSPs, particularly MFIs are operating in Africa, which will benefit from an ability to improve collateral bases for the loans they make. Nevertheless, it is essential to review some of the implementation requirements and to discuss potential pitfalls in implementing the proposed solution.

6.1 Setting up Collateral Ledgers

The main choice is in whether each bank needs to set up own ledgers or registries. In Chapter 05, I noted that the preferred approach is to set a central, shared registry to prevent duplication of registration and to share costs of the infrastructure, labor and other resources for developing the registry. Given the dispersion of customers targeted, especially in smallholder farmers it would be expensive for each FSP to cover entire countries. The options to consider are:

- Private banks contributing human capital and expertise in setting up the registry;
- A country’s credit bureau taking the lead, with government support to set up and maintain a registry. FSPs pay to get access to the registry and verify ownership of assets or to check history of assets on the blockchain;
- Agricultural or development banks, typically government owned taking the lead and offering access to other banks at the payment of applicable fees;
- Small localized registries set up by independent parties in farm communities. These can be linked to other chains from other registries by different parties in a different location. This approach can significantly increase the ease with which registries are developed in a distributed approach, while utilizing local knowledge to get updates as and when required or changes to asset bases occur. However, it can be difficult to manage due to challenges with maintaining homogeneity across the different, local registries. Valuation of physical assets is very subjective, and having many different players can result in multiple valuation standards, potentially posing risks to the system.
The best approach, in my opinion is to work with government supported agricultural or development banks. These institutions are already involved with agriculture lending and have need to improve the way they do business. Nearly every country in Africa has such an institution in one form or another. The motivation for these institution is normally not profit but impact, hence they are more receptive to investment in long term initiatives that have a social benefit, even if it implies short term hits on profit.

6.2 Main Risks

6.2.1 Regulatory Approval

Regulatory approval is one of the main risks facing adoption of blockchain platforms in many parts of the world. Traditionally, Africa has suffered from underdeveloped and uncertain regulatory frameworks. Hence, it is likely that there will be some delays in opening up markets for widespread. An index maintained by Bit Legal tracks the evolving regulatory landscape of digital cash/bearer assets and distributed ledger technology around the world. A snapshot of the status of the regulatory approval at the time of writing is presented below.

Figure 6-1: Global digital cash/bearer assets and distributed ledger [28]
It is noted that significant uncertainty still exists in Africa, with only South Africa having a clear known position regarding the blockchain and applications. While the figure above does not necessarily reflect it, Kenya is one of the leading places in trialing blockchain initiatives, especially cryptocurrencies. This is perhaps a result of the country having led traditionally in the mobile money space, with products such as M-PESA having originated there.

While regulation has been significantly lagging in areas such as digital currency, I consider applications such as agriculture financing to be attractive to governments in Africa, given the contribution of agriculture to economies and the potential to impact poor communities that do not have many other sources of livelihood.

6.2.2 Poor Market Reception

African communities were quick to accept innovations such as mobile banking, mostly because they offered solutions where people did not really have as many options. Nevertheless, mobile banking is relatively simple and perhaps easier to appreciate for many people. The risks involved are well understood. On the other hand, blockchain initiatives are rather complex and take time for target markets to understand. Even among people with decent levels of education, the blockchain is still a mystery that takes a while to explain and get buy-in on. This partly explains some of the challenges with getting widespread acceptance in Africa and other economies. This appreciation is likely going to take more effort to cultivate among less educated average African rural farmers.

The fact that rights to assets that matter to these communities are put up as collateral on the blockchain is likely to introduce resistance among some potential borrowers. In the same vein, transferring rights to property or other assets in the event of defaults has significant social connotations that will require managing. Community engagement, education and awareness will need to be invested in to improve market reception and prevent backlash from implementing some terms of contracts entered into.

6.2.3 Cost

The risks above may both lead to excessive costs in trying to lobby for regulation, significant marketing and education to increase adoption. The cost of field work required to get assists on the blockchain is likely to be significant given this is a manual process. However, this is mostly once off for certain assets, with future costs going towards maintenance of the data and updates as
required. I do not consider cost related to technology to be a major factor. Such costs are likely to continue dropping as more participants get involved in the blockchain space.
7. Conclusions

The use of blockchain technology has potential to improve use of otherwise illiquid assets as collateral for loans issued to smallholder farmers and other borrowers who hold claim to assets that they may not adequately take advantage of in conventional financial services offerings.

Development in other technologies such as RFID, Data Analytics and improved internet coverage in Africa is making the application of these initiatives more realistic than at any point in history. I note a number of developments that are essential to make these initiatives beneficial to the average person in Africa, notably in the area of regulatory certainty.

As wider acceptance and application of the blockchain become reality, cost of implementing such initiative is likely to drop significantly, making scaling more cost effective.

From the discussion of solution development conducted in preceding sections, it is noted that the improvement of use of asset classes as collateral is reducible to solving the problem of better visibility of and improving traceability of assets, an attribute that the blockchain offers through the execution of smart contracts. When this capability is fully leveraged, otherwise poor communities have ability to maximize on the value of assets, opening up new possibilities through simplifying trade through these assets, which in most cases is currently handled through barter approaches. Additional possibilities, besides use of assets as collateral may include ease and security of conducting transactions that involve value exchange based on physical assets. The speed at which such transaction will be executed may increase, while improved visibility of assets across interested groups improves value that farmers can get due to better bidding competition. Peer to peer transactions also become reality, removing middle men and increasing value for asset holders.

Framing these initiatives in the context of the general financial inclusion effort is essential in some cases to build support and ensure success. I however, hasten to say the proposed approach is not necessarily a silver bullet to addressing the challenges, especially given the potential risks highlighted. Caution is required in trialing the proposed approach, possibly by running small pilots initially, expanding with time as feasibility is proven.
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