Sustainable Microfinance Outreach for Farmers with Blockchain Cryptocurrency and Smart Contracts

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***Abstract*—In the process of cultivation, from the point of deciding to plant a certain crop to the point of selling harvest to the market, farmers incur many expenses at different stages of the crop life cycle. 75% of smallholder farmers around the world includes the world's poorest. Most of them face constraints in getting finance to cover such costs. Microfinance, a method of offering small loans to the marginal, has evolved as a major institutional source to provide financial facilities to such people. Although there is ample evidence showing that microfinance has a positive impact on economic activities, securing the livelihood of the marginal people by uplifting their economic status, it can be a dilemma at the same time, since the severe indebtedness caused by microfinance loans has led impoverished communities to economic, social, and environmental vulnerabilities. In this paper, we present a blockchain-based conceptual model for sustainable microfinance outreach for farmers where the microfinance institutes can dynamically adjust the loans they provide according to the farmer's actions resulting in a reduction in severe indebtedness and vulnerabilities while smoothing the crop cultivation process leading to better farm outputs and income.**

***Index Terms*—Blockchain, cryptocurrency, farmers, microfinance, smart contracts.**

I. Introduction

In the process of cultivation, from the point of deciding to plant a certain crop to the point of selling harvest to the market, the farmer incurs many expenses at different stages of the crop life cycle. These costs are categorized as transaction costs, and direct costs [1].

Transaction costs, which have been calculated as equivalent to 15.5% around the market price of the vegetable [2], are been classified into observable and unobservable transaction costs. Costs associated with transport, handling, packaging, storage, spoilage are considered as observable transaction costs while information costs, negotiation costs, and monitoring (enforcement) costs are considered as unobservable transaction costs. Searching for information about products, prices, inputs, and buyers or sellers generates costs in the form of information costs. Negotiating and writing contracts and paying for the services of an intermediary to the transaction in the physical execution of the transaction give rise to negotiation costs. Monitoring costs are associated with monitoring the quality of goods from a supplier and the behavior of a supplier or buyer to ensure that pre-agreed terms of the deal are met. The monitoring costs arise after negotiating the exchanges [3]. Direct costs such as the cost of seeds, labor, and fertilizer, are unavoidable and directly associated with the farming process [1].

Around 75% of smallholder farmers around the world include the world's poorest [4]. Most of them face constraints in getting finance to cover such costs. The lack of finance hinders the marginal farmers from cultivating high-value crops that can produce higher profits [5]. Several studies carried out in developing countries have discovered that credit constraints significantly affect the farm output and margins made by agricultural households. Guirkinger and Boucher estimate that value of the agricultural production can be raised by 26% if there are no financial constraints [6]. If a credit-constrained household is supplied with 1% of liquidity in average, there output increases by 0.04% of total output [7]. Underprivileged farmers are constrained from receiving the credit from formal banks due to minimum deposit requirements, lack of proof in identity and income, lack of collateral, unavailability of banks, and behavioral aspects such as lack of knowledge in English. Often this gap is filled by informal sources at a higher cost. Hence, microfinance, a method of offering small loans to the marginal [8], has evolved as a major institutional source to provide financial facilities to such people [9].

Studies from 2002, 2005, and 2008 in Sri Lanka have found that microfinance loans have positive impacts on economic activities, securing the livelihood of the poor people by uplifting their economic status [10]. Khandker (2005) states that at the aggregate level microfinance contributes to reducing moderate poverty by about 1% and extreme poverty by 1.3% a year [11]. Generally, most studies conclude that access to microfinance in any form, whether it is savings or loans, can affect economic activities and the lives of poor people positively [12], [13]. There is evidence that agricultural households could achieve a 9.46% higher income on average when they have access to microfinance [14].

However, microfinance can also be a dilemma for the farmers since it can lead the impoverished communities into economic, social, and environmental vulnerabilities. Rather than using the loan for income-generating activities such as agriculture, most borrowers use it for consumption smoothing. Due to the inability of fulfilling the financial needs from a single loan, they turn into several sources or borrow another loan to pay the previous loan, resulting in a spiraling level of indebtedness [15]. Severe indebtedness causes borrowers to sell their assets or use their earnings to pay back the loan, cutting out their vital consumption requirements [15], [16].

There is also evidence that the sole purpose of microfinance institutions (MFIs) is prompt repayments and often use aggressive loan recovery tactics using peer field

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workers, somebody from the same community. This also leads to deteriorated social relations with other families and tensions inside the family [15]. Moreover, microfinance is associated with higher transaction costs and interest rates. Many developing countries such as India, Sri Lanka, Uganda, Algeria, Libya, and Egypt have interest rate caps usually ranging from 25% to 35%, which is significantly higher than the banking sector interest rate thresholds for loans [17]. Severe indebtedness caused by microfinance loans and the economic burden have led to tragic incidents such as suicides. One example of such an incident from India is that a 40 years old father from Andhra Pradesh committed suicide in 2010 since he was unable to pay a micro-loan of USD 333 with an annual interest rate of 36% [18]. A newspaper article dated March 17, 2019, in Sri Lanka states that microfinance loans have forced at least 170 people to commit suicide island-wide in the previous year alone [19]. These negative impacts have transformed microfinance, which launched with the sublime purpose of motivating the poor to move out of poverty, into a hype more than a hope.

Ditcher and Harper (2005) argue that expecting rural poor to use credit from loans according to wise business decisions as incipient entrepreneurs is unrealistic [20]. Since providing loans in the name of entrepreneurship often causes exacerbating vulnerabilities, identifying the best strategies to facilitate those services is a significant challenge.

To address these issues, in this paper we present a conceptual model for sustainable microfinance outreach for farmers where farmers are constrained to spend the credit on consumption smoothing with the use of a unique blockchain-based cryptocurrency. In the proposed model, microfinance institutions can dynamically adjust the loans they provide according to the farmer's actions, facilitated by blockchain smart contracts. The ability to control the loan usage and adjusting the loans according to the agribusiness requirements can reduce the severe indebtedness caused by microfinance loans achieved in the name of entrepreneurship and the triggered vulnerabilities while smoothing the crop cultivation process leading to better farm outputs and income.

This paper is organized as follows. Section II briefly describes blockchain technology, microfinance, and usage of blockchain in microfinance, reviewing the literature. Then in Section III, we present the blockchain-based conceptual model for sustainable microfinance outreach for farmers followed by the discussion in Section IV. In Section V, we present our conclusion and discuss future works.

II. Literature Review

A. Blockchain Technology

Blockchain is the underlying technology of the renowned cryptocurrency, Bitcoin. It is a peer-to-peer (P2P), cryptographically secure, distributed ledger that is infeasible to tamper, append-only, and requires consensus of the participants for the updates [21]. The ledger, replicated among all the peer computers in the network, consists of a set of records called blocks. Each block contains a set of transactions, a nonce which is a number generated and used only once, and a cryptographic hash pointer linking to the previous block and timestamped to record the exact time of creation [22]. These timestamped and linked blocks create a chain of blocks, thus the name is blockchain [23].

The P2P nature of the blockchain facilitates direct transactions between peers without the involvement of third-party intermediaries such as banks, leading to cost savings, faster transaction speeds, and more trust. The cryptographically secure feature supports non-repudiation, data integrity, and data origin authentication using the properties of cryptography such as hash functions, public-key cryptography, and digital signatures. The append-only property implies that the blockchain only allows appending data to the ledger. The data is appended only after being validated using strict criteria and consensually agreed by all participating nodes in the network. Altering any existing data is possible only by altering all the subsequent blocks that require the consensus of more than 51% of the peers in the network, transforming it into a practically immutable ledger [21].

The nodes or peers in the blockchain are either miners or block signers. Miners do the creation of new blocks and mint cryptocurrency while block signers validate and digitally sign the transactions. When a node initiates a transaction after digitally signing it using its private key, it is verified and propagated to the network. When it is received by miners, they validate it, include it in a block, and begin the process of mining, that is solving a mathematical puzzle to satisfy the requirements of the consensus mechanism defined by the blockchain network. The first miner who solves the puzzle broadcast the newly found block to all other peers in the network. All the peers also validate and execute the block, linking to it the previous block, making the block a part of the ledger [21].

1) Smart contracts

Smart Contracts were theorized by Nick Szabo in the 1990s as "an electronic transaction protocol that executes the terms of a contract". A more comprehensive definition is "A smart contract is a secure and unstoppable computer program representing an agreement that is automatically executable and enforceable". With the introduction of blockchain, the concept of smart contracts has become an intense area in research due to the cost-saving, security, and transparency feature it provides [21].

Once a smart contract is deployed in the blockchain, it is infeasible to alter it. Thus, the smart contract is protected from vagaries of human discretion and contract breaching. Therefore, the terms of the contract are executed without any deviation, and the digital assets are transferred according to the pre-defined terms [24]. Smart contracts retrieve data from the real-world through external services called oracles, that inject the inputs into the blockchain. Oracles can be either software/hardware or inbound/outbound. The execution of a smart contract can be invoked by an oracle, thus the correct behavior of the oracles is vital [25].

B. Microfinance

Microfinance, "a method of offering small loans to the poor, high-risk individuals" is pioneered in 1976 by Mohammad Yunus, a Professor in economics and the founder of Bangladeshi Grameen Bank [8]. Since then, the industry has grown exponentially, in terms of both microfinance institutions (MFI), and clients. Convergences, an

organization that acts towards zero exclusion, carbon, and poverty, reports that there are 916 financial institution partners providing microfinance services to more than 140 million clients worldwide in their Microfinance Barometer 2019 report [26].

Despite this global reach, microfinance has not achieved its ethical target. Although microfinance has demonstrated positive impacts on impoverished communities [10]-[14], there is ample evidence that these communities are exposed to social, economic, and environmental vulnerabilities due to microfinance [15]-[19]. Researchers have proposed to integrate microfinance with mobile money since it can lead to a reduction in microfinance-associated transaction costs which is the cause for the higher interest rates. The transaction costs can be reduced by replacing costly labor for traveling to disburse the loans and collecting payments, and replacing the establishment of branches with less expensive automated technology [8]. A study done in 2008 has observed that such branchless banking strategies can reduce the cost by at least 50% [27].

1) A current scenario of microfinance

Following scenario is obtained from the study done by Banerjee and Jackson (2017) in Bangladesh [15]. It illustrates how microfinance works and its impact in one circumstance.

Shonali, the leader of 20 borrowers from 3 nearby villages, is the main contact person for the MFIs who provide micro-financial services in the area. MFIs maintain the formal documentation and primary lender-borrower relationship with Shonali. When MFI managers come to the village to disburse money or collect payments, they stay at Shonali's house. Shonali has borrowed a loan from an MFI for her husband's and son's maize crop. Shonali also has the power to recommend the borrowers from her group for receiving these services. One borrower from her group, Mrs.Delwas has borrowed a loan for her husband to grow maize and potato, because MFIs do not provide loans to male individuals. Due to the failure of gaining good income from the crops, both Shonali and Mrs.Delwas could not pay the loan back. The MFI coerces Shonali, and then she pressures Mrs.Delwas to pay the loan back, straining their relationship. Shonali asks her son's wife to borrow a loan from another MFI. She uses some of that loan to do a partial payment for the loan borrowed from the first MFI. The family's financial status has become worse than before they borrowed the first loan from the MFI.

2) Blockchain in microfinance

Blockchain has provided an attractive alternative to modern payment systems with the introduction of the first cryptocurrency, Bitcoin. From a point of a finance application, blockchain provides several benefits. The decentralization and replication feature of blockchain offers cryptographically verified full audit trials to all participants removing the need for third-party trusties. It is partition resistant since it does not rely on a central trusted institution that could fail and disconnecting several nodes does not affect the network functioning. Cryptographic integrity checks and replication of data across the network provide sturdy defense against hacking and cyber-attacks that tries to steal money or corrupt data. The smart contracts deployed in blockchain have the potential of reducing costs and making micropayments economically affordable with the power of automation in negotiation, execution, and enforcement [28].

Thus, blockchain enables new opportunities for micro-financial services [28]. Everex, a blockchain-based startup provides a range of financial services, while targeting remittances, microfinancing, and microcredit services for unbanked and under-banked individuals [29]. A Brazil-based social enterprise called Moeda offers microfinance loans to farmers and small-scale entrepreneurs from contributions around the world [30].

III. Proposed Conceptual Model

Although microfinance has a negative impact on marginal communities, the positive effect it generates is not insignificant. If there is a strategy to minimize the negative impact, according to the literature, we can conclude that microfinance can help to increase financial inclusion and alleviate poverty among rural populations. The ability of branchless banking to reduce the transaction costs by at least 50% [27], and the benefits blockchain and smart contracts bring to a finance system [28], generate a compulsive opportunity for a blockchain-based sustainable microfinance system, if integrated with mobile money. Hence, we propose a conceptual model for sustainable financial outreach based on blockchain and mobile money where the MFI and the mobile money operator (MMO) have an agreement for currency conversion via the MMO agents. Fig. 1 illustrates the diagram of the proposed model. It consists of six major components: Digital Agribusiness Ecosystem (DAE), Mobile Application, Web Site, Blockchain Network, Mobile Money Network, and Crypto Wallet. Farmers communicate with DAE via the mobile app while MFIs communicate using a website. Crypto wallet is for all users: MFIs, Farmers, Input Suppliers, Transport Providers, Machine Suppliers, and Labors, to do peer-to-peer cryptocurrency transactions in the blockchain network. Mobile Money is integrated due to the widespread availability of agents and familiarity, minimizing the upfront costs for building a ground-level agents network and increasing currency conversion accessibility for the stakeholders. However, DAE is the core that enables designing this conceptual model.

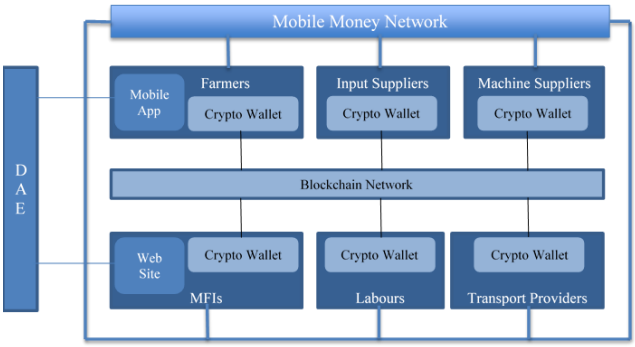

Fig. 1. Proposed conceptual model.

1) Digital Agribusiness Ecosystem (DAE)

DAE is an ecosystem that consists of a database that has quasi-static information about crops, pests and diseases, land preparation, and growing and harvesting methods. It converts this information into actionable information and provides that actionable information to farmers through mobile

applications, creating empowerment-oriented farming processes. It provides a detailed cost of cultivation and a crop calendar for each farmer for each crop according to the farmer's input. The actionable information reaches the farmer as notifications to perform the necessary tasks for optimal farm output and revenue. It also records farmer's actions according to the crop calendar. Furthermore, it has data to predict the expected harvest and expected harvesting date for each farmer for each crop [31].

Therefore, DAE generates an interesting opportunity for a system that can be developed for providing microfinance loans to farmers because it provides a crop calendar, detailed cost of cultivation, and predicts expected harvesting date and expected harvest for each crop for each farmer. If MFIs have access to this information, they can decide the amount of the loan the farmer required according to the detailed cost of cultivation and the approximate expected revenue from the harvest. They also have the awareness of the times the farmer performed certain actions that require credit and on the period where the farmer does the harvesting and selling them in the market, generating income.

2) How the proposed system will work: The enabled scenario

The farmer has the mobile app and the crypto wallet installed on his mobile phone. At the early stage of the season, he chooses the crops he is planning to grow from the list that appears on the mobile screen. Then DAE calculates the expected cost for each crop so that the farmer knows how much money he required for the whole process of cultivating, from the point of buying seeds to selling the harvest to the market. Therefore, he can decide the amount of credit he needs to obtain from an external source such as microfinance, if he does not have adequate savings from the previous season.

Now when he applied for a loan from an MFI, the MFI can request the detailed cost of cultivation and expected harvest for that farmer for the current season from DAE. So the loan amount can be estimated according to that, not exceeding the total cost. When a loan contract is established between the farmer and MFI, the MFI can transfer the money, not to the farmer but to the blockchain network which creates a new smart contract including farmer's address, MFI's address, and the amount of cryptocurrency. The smart contract will be programmed to release the cryptocurrency as partial payments according to the inputs it receives from the MFI. For example, if the farmer has performed three actions according to the crop calendar DAE provides, he can update it in the mobile app which sends those updates to DAE and DAE sends that message to MFI for deciding to release the money for the next step. If the farmer did not perform that step, credit can be held until he completes the particular action. Also, MFI will be able to check the farmer's balance before transferring the credit for a certain step, and if there is a balance, it can request the smart contract to transfer only the required amount to the farmer. This decision to release the money for the next step also can depend on how the farmer does the repayments. However, since the smart contract consists of only the granted amount for the particular farmer, once it reached that point, cryptocurrency transfers for that farmer will be terminated. Also, at the end of the process, if there is any balance in the smart contract account, that balance will be transferred to the MFI, decreasing the farmer's payable amount to the MFI.

The farmer is aware that the loan amount he receives is sufficient only for farming activities. Once the farmer receives money in his account, he can spend that as cryptocurrency if the other party is either an input supplier, machine, or transport provider. In the whole process, if there are steps that involve labors, then the amount granted for labor cost will be allowed to convert into fiat money through an MMO agent since most laborers may not be tech-savvy enough to follow any of the complex steps or may be reluctant to accept it as cryptocurrency. All the parties who receive cryptocurrency except farmers can convert it into fiat money at MMO agent locations.

IV. Discussion

According to both negative and positive impacts of microfinance on impoverished communities, it is impracticable to conclude that microfinance will harm them, pushing them into vulnerabilities or enable them to uplift their economic activities, upgrading their livelihoods. However, since microfinance has spread out globally targeting disadvantaged communities, researchers' responsibility is to discover new strategies to minimize the negative impacts while enhancing the positive impacts. Having this in mind, we proposed this conceptual model that will create benefits to almost all stakeholders in the system.

A. Expected Impact of the Proposed Model

1) Benefits for the farmer

Since DAE provides the detailed cost of cultivation for each crop, the farmer can decide the loan amount promptly, preventing him from trapping in a vicious circle of indebtedness. Although he does not possess ample financial capability, he will be able to reach an MFI for a loan to smoothen the overall cultivation process since he has proved himself as a micro-entrepreneur in the form of a small scale farmer by entering his information, farm location and have chosen the crop types to cultivate in his farm, enabling the MFI's agents to visit his farm, if necessary, before approving the loan. Although the loan is approved, the farmer will be receiving only the required portion for each step, so that he will be prevented from overusing the money. Other than paying for labors, he is not allowed to convert the cryptocurrency to fiat money, so the misusing of the credit for consumption smoothing will be minimized and most of the loan will be used for the farmer's agribusiness, which in turn returns back as a favorable farm output that creates higher revenue. While this enables the farmer to do the debt repayment, it also encourages him to do savings for the next season, restraining him from depending on future loans that can reduce the profit he generates by cultivation due to high-interest rates. Furthermore, if the farmer uses his loan wisely, and if there is a balance left in the smart contract, it will remit back to the MFI, decreasing the total loan amount, alleviating the indebtedness. Thus, the proposed system will subside the negative impacts such as severe indebtedness that lead to economic, social, and environmental vulnerabilities.

2) Benefits for the MFI

The MFI can request the detailed cost of cultivation for each crop for the farmer before estimating the loan amount,

lessening the burden on the farmer since when the loan amount is less, the repaying installments also become less while his financial requirement is fulfilled. This can lead to generating farmer's trust towards MFI and the MFI becomes a trustworthy organization that can attract more borrowers. When the farmer's income is increased due to better usage of inputs for the crops, he will do the repayments regularly, steering the money lending business more successful. Therefore, the system will assist the MFI to lessen the defame caused by the negative impacts while becoming a trustworthy and successful business.

3) Benefits for the machine and transport providers and input suppliers

In this conceptual model, we propose the payments for machine and transport providers and input suppliers to be done with cryptocurrency assuming that they are already established entrepreneurs and willing to accept the payments as cryptocurrency and convert it into fiat money later. Since the payments are done in cryptocurrency, they have the ability to verify whether the farmer has adequate credit in his account to pay for the service or product in advance. Hence, they will receive the money promptly. Furthermore, since they possess an actively operating cryptocurrency transferring account in a blockchain network, they can provide it as evidence of income for the MFI to request a loan when they are in need of money while creating more customers for the MFI.

4) Benefits for the MMO

Since the microfinance loan is provided in the form of a cryptocurrency, and the stakeholders need to convert that crypto money into fiat money, there will be a currency conversion either into fiat money or mobile money. When the stakeholders have it as mobile money, they will do more mobile money payments, increasing the number of mobile money transfers, leading to increased business for mobile money operators in the form of mobile money users and mobile money transfers.

B. Design and Implementation Implications

Since blockchain is still an emerging technology, implementing such a system would require searching for expertise in the field. Moreover, the implementation will be costly for a single MFI to carry out alone. Therefore, it will not be profitable in the short term. However, if several MFIs collaborate to build this system to achieve their targets, the cost will be distributed among them, lessening the burden. In addition to that, regulations and policies in a certain country with regards to online money transfers, mobile money, blockchain cryptocurrency, and smart contracts must be matched for a successful implementation.

Moreover, the blockchains are criticized for the issues of scalability, privacy, confidentiality, lack of regulatory authority, and high resource requirement [21]. Most of the actors in the proposed system may neither be tech-savvy enough to maintain a full node in the blockchain network or possess ample computational power for the expensive mining process. In addition, some actors of the proposed system would prefer more privacy over their sensitive data and transactions. Thus, a fully transparent public blockchain where anybody is allowed to participate as a node and in the decision making process, is preferably not the best option for the implementation of such system.

However, a private blockchain, where a group of individuals or organizations agree to share it among them [21], is a suitable approach for such implementation. There are private blockchains that support consensus protocols to validate transactions and blocks that do not require native cryptocurrency to offer mining incentives. Thus, all the participants are not necessarily need to maintain a full node or possess ample computational power for that mining process. Furthermore, private blockchains allow to store both public and private data, preserving privacy of the users. Moreover, from the context of sensitive criticisms blockchains have received, public blockchains cannot compete with private blockchains in scalability issues, privacy and confidentiality issues. Also, in private blockchains, there is a group who decides the policies in the network, making available a regulatory authority that has responsibility over the functions of the blockchain network, leading to improvement of the confidence and trust of the participants. Thus, it is an obvious implication that private blockchains are suitable for successful implementation of the proposed model.

The significant fluctuation of cryptocurrencies is another noteworthy challenge for blockchain cryptocurrency based applications since that has the ability to refrain actors from partaking in the proposed system. The notion of "stable coins" has adopted a different approach for this volatility issue in cryptocurrencies. Since stable coin is a type of cryptocurrencies tied to a stable asset such as US dollar or gold [32] and stored securely as a collateral, it is prone only to the variations of the value of that asset. Hence, if the implementation of the proposed system is integrated with the concept of stable coins, the implementation will become more efficacious.

V. Conclusion

Microfinance has become hope and hype at the same time due to both positive and negative impacts it generates for the impoverished communities. Thus, we present a blockchain-based conceptual model for sustainable microfinance outreach for farmers where farmers are constrained to spend the credit on consumption smoothing with the use of a unique blockchain-based cryptocurrency. In the proposed model, microfinance institutions can dynamically adjust the loans they provide according to the farmer's actions, facilitated by blockchain smart contracts. The ability to control the loan usage and adjusting the loans according to the agribusiness requirements can reduce the severe indebtedness caused by microfinance loans achieved in the name of entrepreneurship and the triggered vulnerabilities while smoothing the crop cultivation process leading to better farm outputs and income. The model also indirectly steers the MFI's money lending business while lessening the defame formed due to the negative influence MFIs created towards the marginal population. It provides several benefits for other stakeholders too. Thus, the model empowers a novel scenario of financial inclusion for marginal farmers, trying to minimize the adverse effects such as social, economic, and environmental vulnerabilities. Hence, an implementation of the model will boost poverty alleviation among impoverished agricultural

communities, securing their economic activities to uplift their livelihoods.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

The paper is written according to the ideas from all the authors and all authors had approved the final version.

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