FarmShare:

Blockchain Community-Supported Agriculture

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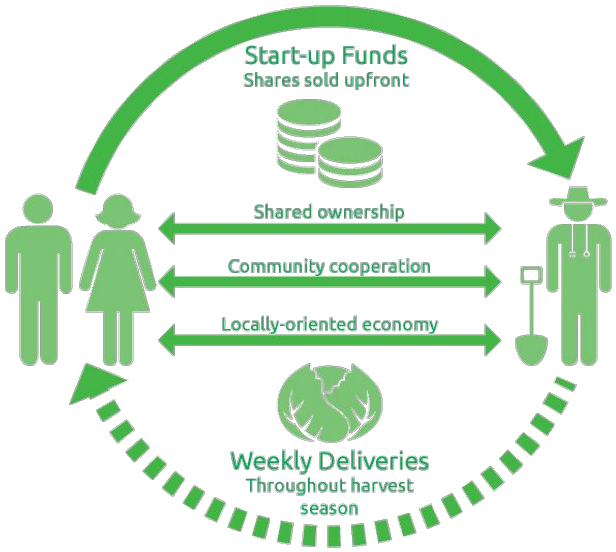
1. Introduction:

This document is intended to provide an overview of the potential application of internet-connected sensor devices and a blockchain-based alternative ownership model in the context of a rural agricultural community. The proposal builds upon the existing business model known as Community-Supported Agriculture (CSA), which aims to create mutually beneficial relationships between farmers and local communities by involving CSA members/subscribers in the production and decision-making processes.The FarmShare application serves as a platform for facilitating collaboration between farmers and shareholders, which has generally proved difficult for CSA organizations relying on traditional modes of planning and communication.

1.1 Community-Supported Agriculture



Community-supported agriculture is an alternative economic model for the production and distribution of locally grown food. It originated in the 1980s in the north eastern United States, based on the concept of biodynamic agriculture first proposed by Rudolf Steiner. CSAs operate on a shared risk-reward model, in which a community of shareholders funds the operation of a local farm at the beginning of the growing season in exchange for weekly deliveries of fresh produce and other food products (such as eggs, dairy, meats, etc) over the course of the harvesting period.
Such an arrangement is beneficial for both the farmers, who are effectively insured against risks such as potential environmental factors leading to low crop yield, and consumers, who gain the ability to influence decisions such as crop production ratios to better suit the needs of the community. Ideologically, the original CSAs promoted new forms of communal land ownership, collaborative labor relationships, and locally-oriented economies which rely on direct farmer-consumer engagement. However, as CSAs have grown in number and size, the philosophical underpinnings have given way to more practical considerations, and today many organizations see it as primarily a marketing strategy.

1.1.1 Common Issues with CSAs

Although community supported agriculture sounds like the perfect arrangement for both farmers and consumers, there are drawbacks to the model. Over-expansion is a common issue, since large farming operations require significantly more work to manage both the crops and the

community. Farmers are not typically accustomed to running consumer-facing businesses, so managing a community of concerned shareholders can be a distraction from the maintenance of the farm. It is often difficult to maintain active community engagement, and perhaps even more difficult to achieve consensus within an engaged community. Shared risk can cause frustration if the harvest is small, especially if communication is inconsistent.

1.2 Internet of Things

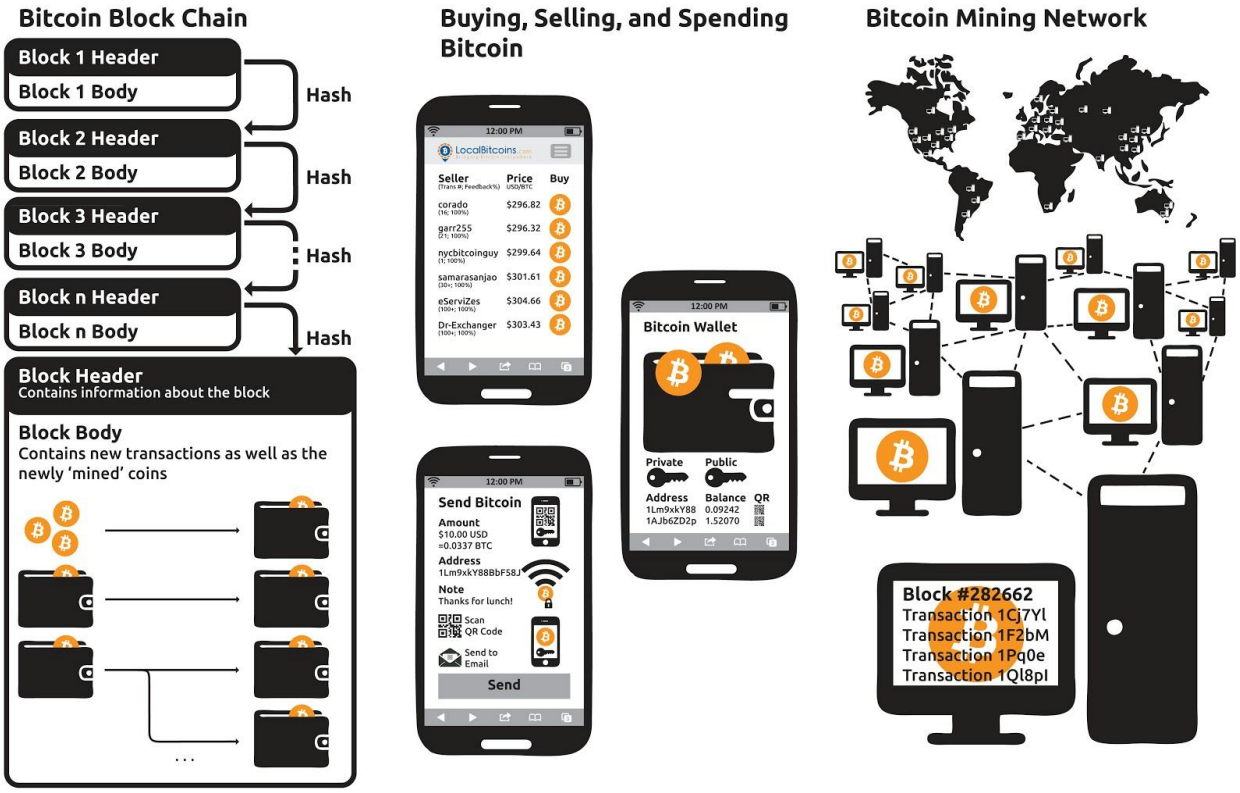
As internet-connected devices continue to become both smaller and cheaper every year, computation and information technology have seemingly infiltrated every aspect of our daily lives. There are already approximately 10 billion internet-connected devices worldwide, extending beyond smartphones to include TVs, lightbulbs, door locks, thermostats, traffic cameras, street lights, and air quality sensors. The number of connected devices is expected to reach over 100 billion by 2050.

1.2.1 Agriculture and IoT

One industry that has not been significantly affected by the proliferation of information technology is agriculture. According to a 2014 report by IBM, “Today, the sector of the economy with the lowest IT intensity is farming, where IT accounts for just 1 percent of all capital spending. Here the potential impact of the IoT is enormous. Farming is capital- and technology-intensive, but it is not yet information-intensive.” By integrating technology such as sensor arrays for monitoring soil and weather conditions, planting and harvesting processes can be optimized for maximum crop yield. However, this raises important concerns about big brother-like surveillance and reliance on large corporations such as Google who control the flow of big data. Many small- to medium-scale farmers are understandably skeptical of such technological ‘improvements’, and would rather remain locally self-sufficient.

1.3 Blockchain

The blockchain is a decentralized database system, first implemented as the underlying technological innovation behind Bitcoin. In the case of Bitcoin and other cryptocurrencies, the blockchain serves as a public ledger, containing a record of every transaction ever made on the network. The blockchain is not stored on any centralized server, but rather is maintained by a network of users, thus eliminating the need for a trusted third party to process transactions. The computational power required to add new transactions to the blockchain makes it prohibitively hard to alter or cheat the system, and a reward system is typically used to provide an incentive for users (known as miners) to maintain the system. While the blockchain was first used in the context of digital currency, there have been many subsequent projects which aim to leverage the model of distributed consensus for other applications, such as domain name registration (NameCoin), crowdfunding (Swarm), and smart property (colored coins).



1.3.1 Ethereum, Smart Contracts, and Decentralized Autonomous Organizations

One of the most ambitious projects to come out of the 'Blockchain 2.0' space is Ethereum, a platform for hosting practically any decentralized application (DApp) on a blockchain. Ethereum contains its own Turing-complete programming language, so that users can develop DApps that exist on the blockchain and can interact with other DApps. These programs are built around smart contracts, essentially contracts written in code, which can only be executed if certain conditions are met. Smart contracts can be as simple as a bet between friends (money is placed in an escrow wallet and only released to the winner based on the final score of the football game) or as complicated as entire corporations. Decentralized Autonomous Organizations (DAOs) are organizations which do not require any direct human involvement, run according to a set of business rules written in code. Typically DAOs will interact with humans to perform non-computational tasks, and can pay for such tasks with some form of internal capital, such as Bitcoin or equity shares.

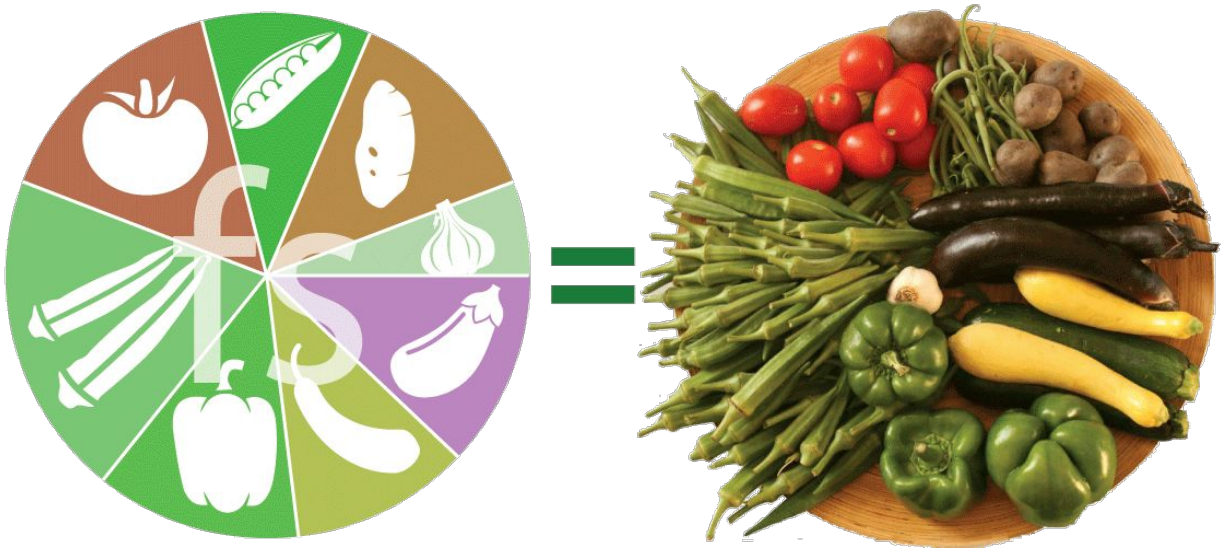
2. FarmShare

FarmShare is an evolution of the community-supported agriculture model, which takes advantage of the blockchain's potential for distributed consensus, token-based equity shares and automated governance in order to foster greater community engagement while removing some of the managerial burdens and financial risks from farmers involved in a CSA. The goal is to return to the fundamental goals of the original CSAs: to create new forms of property ownership, community cooperation, and locally self-sufficient economies. FarmShare also incorporates IoT technology in the form of biodegradable soil quality sensors, weather

monitoring devices and automated irrigation systems, providing a feedback mechanism for farmers and community members to make better decisions about land management and crop production.

2.1 FarmShare Tokens

FarmShare tokens are the currency on which the blockchain CSA model relies. At their most basic level, tokens represent shares of the harvested crop. Each participating CSA organization creates and distributes its own tokens, with FarmShare operating as the platform for hosting a blockchain CSA. Thus, the tokens serve as the equivalent of the subscription fee paid upfront by the members of a traditional CSA.



2.1.1 FarmShare Token Pricing

FarmShare tokens are used to purchase crops and other products offered by the CSA, so pricing will vary according to the number and type of products available. Farmers will determine how many products they can produce prior to the token sale, most likely using a conservative estimate of their expected output over the course of the harvest. Shareholders may buy larger or smaller shares to fit any budget, and customize their weekly deliveries by exchanging their shares for specific CSA products. The price of products on the FarmShare market may fluctuate over time according to local market forces and environmental conditions.

In addition to the cost of the crops themselves, the price of the FarmShare token may factor in the expected costs of maintaining the farm, or else additional costs may be assessed to the shareholders as they occur. In the case of the former, the funds intended for maintenance costs would be held in a community wallet and could be controlled by a smart contract which only releases the funds for payments that have been approved by a voting process (which will be covered in section 2.2). In the latter case, spending on maintenance and other services would still require that proposals pass the voting process, but members would be assessed their share of the cost each time a purchase is approved. This model would lead to lower initial token

prices, and could provide an incentive for members to be more involved in the decision-making process, as the costs of such decisions would be more directly apparent. However, it would also involve more transactions for the shareholders, and would require members either to maintain a bitcoin wallet that can be automatically charged the assessed amount, or else the implementation of a penalty (i.e. forfeiting one's shares) if a member does not pay.

2.1.2 FarmShare Marketplace and Crop Distribution

FarmShare tokens represent shares of the CSA's harvest, so the value of a token will vary based on the quantity and quality of crops produced. As in traditional CSA models, shareholders are provided fresh produce and other goods on a periodic basis, typically weekly. Each time that crop shares are distributed, a corresponding portion of each member's FarmShare tokens is spent and removed from circulation. At the end of the harvest all tokens will have been burned, and the CSA may create a new batch of tokens to be distributed at the beginning of the next planting season.

Tokens will be exchanged for weekly deliveries of fresh produce on the FarmShare decentralized market, where each farmer can offer a variety of products at varying prices. The particular selection of crops to be offered will have to be determined by the CSA organization prior to the initial token sale, since local climate and soil conditions will make certain crops unfeasible or simply impossible to grow. However, once the selection is decided upon (either by vote or executive decision), shareholders may use the token market to customize their weekly deliveries. FarmShare community members will sort the share boxes and deliver them to shareholders in exchange for tokens.

The FarmShare token exchange also provides the potential to shareholders to enter and exit the community mid-harvest by buying shares from existing shareholders or selling shares to new members. This mechanism could be used to pay for additional services through the FarmShare platform, such as advertising, tech support, or planning and hosting community activities. Service providers could be paid with FarmShare tokens from the community pool, which could either be redeemed for a share of the crop or resold on the community market. This could also be applied to a work-share membership model, in which community members assist with work on the farm in return for a discounted share. In this case members would offer to contribute their labor, which is paid out in FarmShare tokens either from the community pool or from a fee assessed to each shareholder.

2.2 FarmShare Community

FarmShare aims to reestablish community engagement as one of the primary goals of the CSA organization, and the blockchain provides an effective model for distributed consensus-driven decision-making. However, having the technology alone is not enough to stimulate the level of engagement necessary for such a project to succeed. FarmShare is a peer-to-peer network, and so its value is directly related to the number of active users. Therefore, some of the most

important challenges involve how to design complex interactions between relatively autonomous agents, and not merely processing cryptographic token transactions.

2.2.1 FarmShare Community Governance and Structure

Certain decisions regarding the overall structure of an organization might be made upfront by the creators of each farm-specific token, such as voting privileges (certain core members may be given veto rights), organizational structure (committees and sub-committees, etc), and financial management (i.e. whether to establish a community pool or assess fees for services). Community bylaws can be written in the form of smart contracts, such as multi-signature wallets for community funds and conditional voting privileges.

Once a FarmShare CSA has been established and its tokens distributed, decision-making can be handled democratically, using an application such as BoardRoom. Any shareholder may table a proposal on the FarmShare platform to be voted on by the rest of the community, with the ability to automatically enact proposals via smart contract once a predefined number of community members have approved it. The CSA may have an electable chair, add or remove members based on community consensus, allocate funds according to smart contract proposals, and revise its structure or bylaws as deemed necessary by the community.

For example, the community may vote to elect the farmer as chair of the CSA, with special permissions assigned to him on account of his experience. The CSA may then table a number of proposals to assign tasks for managing the farm, such as sorting weekly deliveries or producing marketing materials. If the community agrees upon the proposed bounties (i.e. 5 FarmShare tokens per box sorted, 25 tokens for an advertisement, provided that the community approves of the submission, etc.), then any member can enact the smart contract and define their mode of participation in the organization. Through the voluntary association of its members, the community is a self-organized alternative economy that emphasizes direct involvement in the food production and distribution system.

2.2.2 FarmShare User Experience

FarmShare relies on some pretty radical models of community organization and economics, so designing an intuitive user interface is critical to make some of the more abstract concepts tangible and easy to understand. Aspects of gamification can be implemented to assist in this, by making the process of managing a community farm more fun and engaging. The social gaming world of Farmville can be taken for inspiration, as a familiar visualization tool and community-building platform for the maintenance of a farm and its related social transactions. The game world simulates the development of a virtual plot of land, and also provides opportunities for individual Farmvillers to collaborate and form social bonds. By establishing a connection between digital interactions and physical space, the activities commonly considered as “time wasters” can be translated into actual material labor, with correspondingly real rewards.

Farmville already features an in-game currency and reputation system, which can be earned through engagement in virtual activities or purchased with actual money. It also includes a virtual market for purchasing seeds, equipment, and other personalizations, as well as a tool for sending gifts to other users. This sets up a useful conceptual framework for introducing potential users to alternative economic systems and community organization. By replacing virtual goods and services with their real life counterparts, the FarmShare app can serve both to activate the labor invested in a game like Farmville by translating it into physical labor and educate users on the practices of self-sufficiency and collaborative enterprise in a decentralized, peer-to-peer economy.

2.2.3 Tasks, Rewards and Reputation

By taking inspiration from social gaming, the process of delegating tasks can be managed by assigning rewards (or bounties) to specific tasks, in the form of smart contracts, which allow community members to collect shares of FarmShare in return for their labor. Members may compete to accomplish tasks for a smaller bounty, or may accumulate reputation for a job well done. This creates a game-like scenario, in which tokens and experience earned through active engagement incentivize further activity, and leaderboards stimulate healthy competition.

Rewards and reputation may be determined either quantitatively or qualitatively. That is, the amount of shares or reputation tokens rewarded for completing a task can be calculated based on data such as sensor readings or crop yield, or it can be determined by an assessment of quality by committee of community members. For example, watering the crops might be better gauged by soil moisture sensors, because it is easily quantified and optimized. However, attendance and participation in community workshops, or producing effective advertisements, may not be easily quantified, and therefore lend themselves to qualitative assessment.

2.3 FarmShare Product Data

By incorporating agricultural IoT and blockchain technology throughout the supply chain, FarmShare can allow users to keep track of a wide array of data about their food. Agricultural sensors can monitor the environmental conditions and nutrient levels of crops over the course of a season, and the data can be stored in the blockchain to be reviewed at any time. Additional data, such as labor or transportation information, can also be tracked on the blockchain, allowing conscientious consumers to make decisions about their food based on ethical concerns about energy sustainability or fair labor practices.

Consumers are becoming increasingly concerned about the provenance of the food that they purchase, which is one of the primary reasons that CSAs have grown in popularity over the past several decades. The local food movement grew out of a concern not just for the quality of the food but also for the energy burned and emissions caused by the transportation portion of the supply chain. The blockchain allows FarmShare users to know not only the farmer from whom

they purchased a product, but also the quality of the soil and the air on his land, the source of the seeds and the fertilizer used to grow it, and the distance it traveled to get from farm to table.

2.4 Challenges

Implementing such a project does come with certain difficulties. Agriculture is not typically a highly technology-driven enterprise, and farmers a likely to be skeptical of a system such as FarmShare. Why would a farmer take the trouble to learn about sensor arrays and cryptographic tokens when he could just operate a more traditional CSA? One of the biggest challenges is just getting past the initial hesitance of potential users, especially those who are not as tech-savvy as the typical crypto crowd.

The advantages of the Internet of Things in agriculture are more readily apparent, since the benefits to be had from automation and optimization can be understood by most farmers interested in saving money. However, there are other challenges to implementing an IoT solution for rural agriculture, such as providing a consistent internet connection in areas that do not yet have even reliable mobile service. Powering the devices is also a noteworthy challenge, although this can be overcome using low energy wireless communication. Agricultural sensor devices must be able to remain functional for years, and must be cheap enough to replace if need be. Updating software must be simple and affordable, which becomes an issue when billions of devices are deployed around the world. Because of the agricultural application, sensors must also be designed to be non-intrusive to the growing environment, so biodegradable electronics would be preferable.

The challenge of introducing the Blockchain and decentralized collaborative organizations will be significantly more difficult, because the concepts are unfamiliar and somewhat scary. One of the primary intentions of the FarmShare DApp is to introduce the notion of blockchain-based community organization in a context that has not been particularly affected by the internet, in order to highlight the real world applications of the technology. In order for blockchain technology to be accepted by the mainstream, it will require a user friendly interface and an effective community management tool. It will also require a rudimentary understanding of bitcoin and other cryptocurrencies, although it is not necessary that users fully understand cryptography or mining hardware. In order to operate smoothly, users will have to maintain a digital wallet and be able to integrate it with a variety of other blockchain platforms.

There are also legal challenges to the blockchain CSA model. CSAs in general often run into legal difficulties when dealing with volunteer farm labor, which in most situations qualifies as employment according to federal labor laws. According to the law, such volunteers must be paid at least the minimum wage. Many CSAs offer working shares, which involves volunteers doing work on the farm in exchange for a share of the harvest. While the law does allow for lodging and meals to be deducted from a volunteer’s wage, it does not allow for the deduction of groceries, such as a typical CSA share. FarmShare can help to avoid the legal issue of CSA work shares by paying volunteers in tokens with a value no less than the minimum wage.

Tokens stand in for a cash wage, and can be used to purchase groceries or sold to the community for cash. The blockchain can also help to alleviate the difficulty of record-keeping for volunteer labor by recording all wage payments and requiring cryptographic signatures to confirm labor agreements.

2.5 Use Cases

2.5.1 Proof of Concept Aquaponic System

As a proof-of-concept, FarmShare will begin with a small aquaponic system, with built in sensors and automation to make caring for the plants and fish easy. An aquaponic system is ideal because it is self-contained and highly efficient. The basic premise of aquaponics is that fish excrete in the water, providing nutrients that can used by the plants, which filter the water in the process to be returned to the fish tank. Thus the system produces both organic produce and fish with very little waste or input required. Most of the required parts are available off the shelf, and many can be 3d printed.

The aquaponic system can be automated using sensors that report data such as pH level, water level, soil moisture, temperature, and daylight exposure. That data may be used to optimize the growing environment using actuators such as grow lights, pumps and automatic feeders, and notifications can be sent to users to monitor the status of the system. Rather than relying on Amazon or Google data centers to manage the flow of data, the blockchain can be used to distribute access to the data among community members and allow such internet connected devices to communicate autonomously with users and each other, such as in the ADEPT prototype developed by IBM and Samsung.

2.5.2 Local Farm Educational Program

Callicoon, NY and the Upper Delaware River Valley region are home to a number of small farms that would be ideal case studies for testing a blockchain CSA business model. One particularly interesting application site is Apple Pond farm, which is well known in the region for its emphasis on green energy technology and educational programs. Children and their families come to the farm on weekends to learn about milking goats, grooming horses, working in the garden and collecting eggs. More advanced school groups can also learn about green energy generation, making cheese and spinning wool. The farm also offers apprenticeships.

Local farming educational programs are ideal for implementing the FarmShare system, because children are more familiar with new technology and more open to new ideas about how farming could work. Children will bring their parents along as well, which is an excellent way to get entire families involved in the community. Child poverty is a major problem in Sullivan County (28% in 2013), and FarmShare could help address concerns about malnutrition by sending families home with a weekly supply of fresh produce in return for participating in the community through such educational programs. With the right user interface, children can feel as if they are playing

a game such as FarmVille while they are learning about sustainable agriculture, with the added bonus of being rewarded for their effort with real food.

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