



Food and Agriculture
Organization of the
United Nations




E-AGRICULTURE IN ACTION:
BLOCKCHAIN
FOR AGRICULTURE
Opportunities and Challenges



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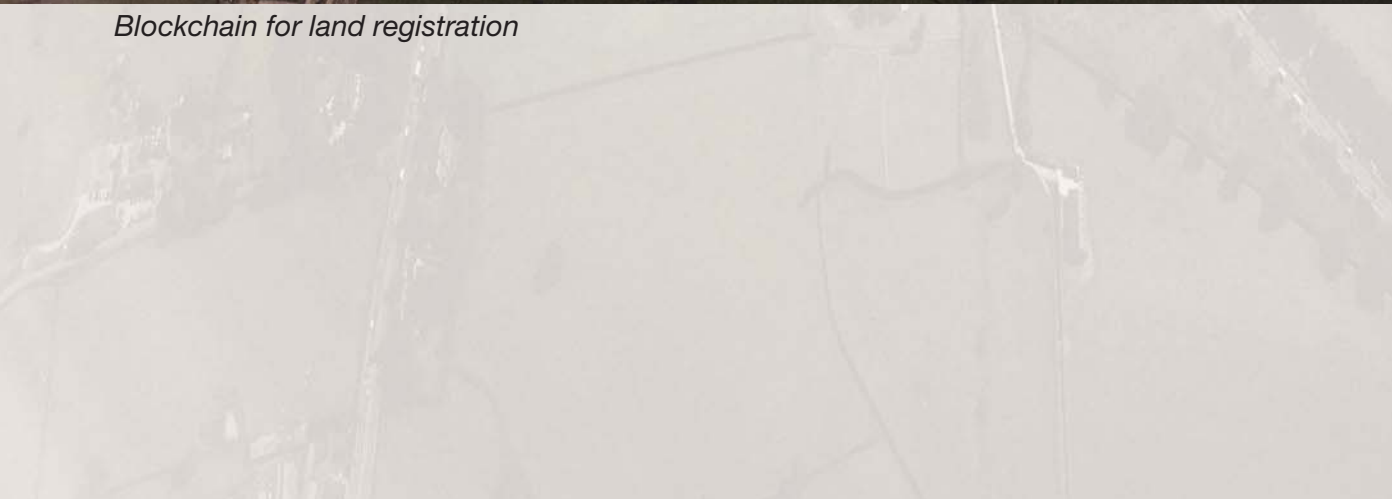
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Blockchain for land registration



Preface

The Food and Agriculture Organization of the United Nations (FAO) and the International Telecommunication Union (ITU) continue to work together to promote the use of sustainable information and communication technologies (ICTs) in agriculture.

The world faces enormous challenges when it comes to providing food for the ever-growing population, specifically: challenges from climate change, floods, drought, desertification, loss of biodiversity, pests and disease. Innovation in agriculture processes are needed to overcome some of these challenges and make agriculture attractive to and profitable for the smallholder farmers involved in feeding the world.

The Sustainable Development Goals (SDGs) provide a vision for global development and ICTs can facilitate the much-needed acceleration of development to achieve many of these goals.

The growth of ICT in the last decade has provided many opportunities to overcome some of the challenges faced in agriculture. Recent developments such as the increase in the use of mobile-broadband access devices, the Internet of things (IoT), drones, smart networks, capacity for big data analytics, and artificial intelligence have provided agriculture stakeholders with some key tools and technologies to improve production and marketing processes, for example, in agriculture and allied fields.

One of the most discussed technologies is blockchain technology. This publication aims to demystify the technology, provide some thoughts on the opportunities and challenges in implementing blockchain-based systems as well as document some case studies on the use of blockchain for agriculture.

The articles are written by the respective authors and are entirely their own views. We have tried to maintain the original narrative style of each contributor. Neither FAO nor ITU promotes or endorses any of the statements, comments and products mentioned in the articles. Thus, this is an effort to share knowledge on the use of successful ICTs for agriculture initiatives and we expect that this compilation of case studies will be read in that spirit.

This is the third in the E-agriculture in Action series of publications, which has the overall aim to promote the use of sustainable ICTs for agriculture and rural development.



Blockchain for educational records



Acknowledgements

FAO and ITU are grateful to the authors and their organizations for their valuable contributions to this publication. The importance of sharing knowledge on the use of successful initiatives cannot be overstated.

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Pixabay/sasint

Blockchain for agricultural insurance for smallholder farmers



Blockchain demystified

Distributed ledger technology (DLT), the technology that started the various cryptocurrencies in circulation today, has created quite a *buzz* in many areas in the last few years. Putting it simply, a DLT is a decentralized system for recording transactions with mechanisms for processing, validating and authorizing transactions that are then recorded on an immutable ledger. Blockchain is one implementation of DLT. It is also referred to as an “Internet of value”, meaning a secure way to store and transact value – anything from currency, stocks, contracts and even votes – from one entity to another. It is also the underlying technology powering cryptocurrencies such as Bitcoin and Ether.

According to PwC,¹ the financial sector stands to gain the most from blockchain-based service implementations, followed by industrial products and the manufacturing sector, energy and utilities and then the healthcare sector. Nevertheless, a PwC survey of about 600 blockchain-savvy executives revealed that the biggest barrier to blockchain adoption was regulatory uncertainty. Interoperability and the potential failure of different blockchains to work together were identified as major challenges.

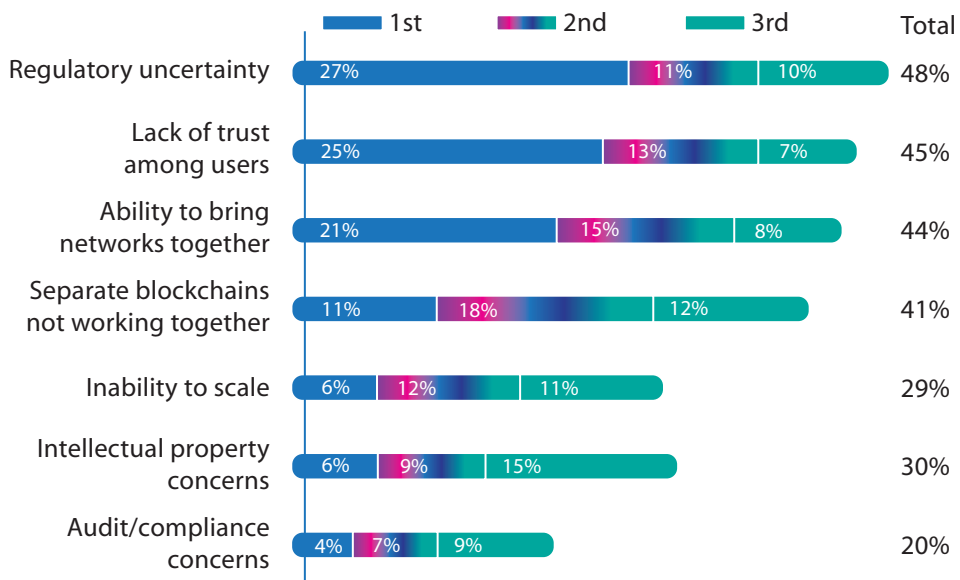


Figure 1: The biggest barriers to blockchain adoption
(Respondents' top three challenges)

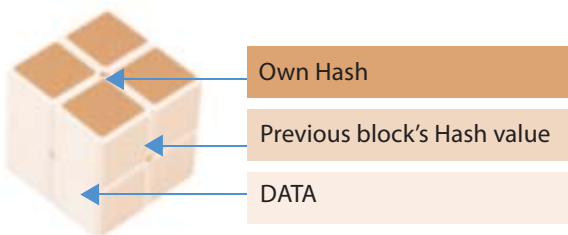
Source: PwC blockchain survey

¹ pwc.com/blockchainsurvey

The blockchain basis

In the simplest terms, a blockchain consists of a linked chain that stores auditable data in units called blocks. Many commentaries online start by explaining that a blockchain is similar to a Google document spreadsheet where multiple authors can contribute because of the mechanism of locking. Blockchain is a bit more complex than that example and has unique characteristics that make it an attractive technology for tagging, storing and tracking anything of value. Bitcoin was one of the first and most popular implementations of blockchain technology.

To begin, a blockchain consists of blocks, each block containing the data (anything of value), its own hash value (a unique cryptographic value containing characters and numbers generated through a complex computational algorithm) and a pointer to the hash of the previous block.



Example:
SHA-256 hash of the word **FAO**:
`dbf99f2954da9cfa1a9e74fb65736ce6baec9
7c00ce6a401c3556434c9725500`

Figure 2: A block

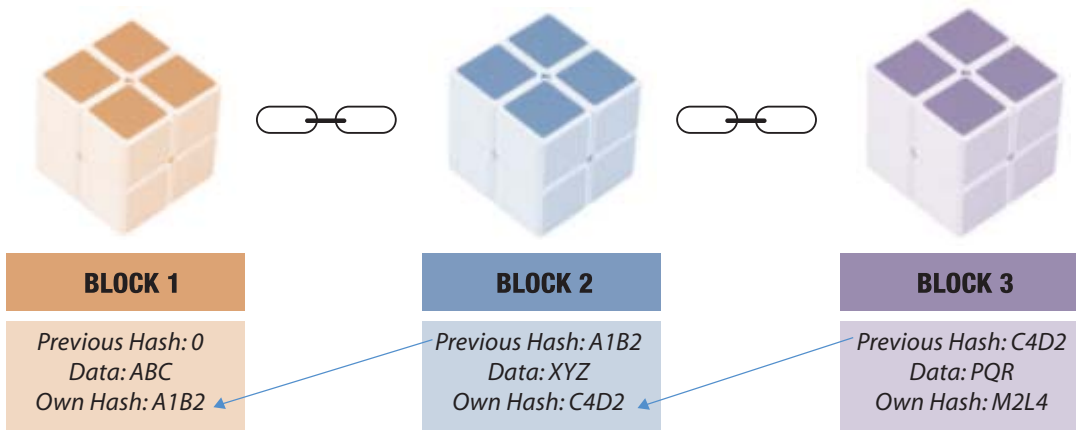
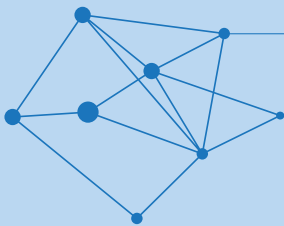


Figure 3: A blockchain

The consensus algorithm

The consensus algorithm forms one of the key mechanisms in the creation of new blocks and appending them to the blockchain. The most discussed algorithms are proof-of-work (PoW), proof-of-stake (PoS), and proof-of-authority (PoA). Blockchain uses a PoW consensus model, in which a node gets the right to publish the next block by solving a computationally intensive puzzle. The result of the computation is easy to verify and thus helps other nodes to validate and update the blockchain easily. The node that solves the computational puzzle wins the “reward” and this process is called “mining”. Because this is time and energy intensive, other alternative methods of verifying a block, such as proof-of-stake, have been developed and implemented in subsequent spin-offs.

Unlike in proof-of-work, the proof-of-stake takes away the energy and computational overheads and replaces it with a stake. The chances of a node to be the creator of the next block depends on the stake that the node is willing to lock up for a certain amount of time. However, the drawback of the PoS model is that “rich” nodes can easily put more digital assets at stake thereby earning themselves the right to create the next node and earning more assets. Delegated PoS (DPoS), built on the PoS model takes a slightly different approach in that the nodes vote to elect delegates to do the validation on their behalf. Each algorithm has its own characteristics regarding incentive/reward, requirements as well as energy cost.



Did you know?

According to the Bitcoin Energy Consumption Index (BECI) maintained by Digiconomist², every individual Bitcoin transaction eats up 275 kWh of electricity, and the latest estimate of Bitcoin’s total annual energy consumption is approximately 29.05 terawatt-hour.

Types of blockchain

Three major types of blockchain networks, each having their own characteristics are consortium blockchain, private blockchain and public blockchain.

Consortium: A consortium formed by a group of members control this blockchain. Verifying and adding records to the blockchain is based on a consensus mechanism by a pre-selected set of nodes.

Example: In regulatory related decision-making.

Private: This is controlled by a centralized entity. Only people with specific authentication and permission can be part of this network and thereby can verify and add records to the

² <https://digiconomist.net/>

blockchain. However, the blockchain could be publically viewable. Participants in this blockchain know and trust each other. Also known as a permissioned ledger.

Example: A permissioned ledger between banks to settle inter-bank fund transfers and supply chain with well-defined roles for all actors.

Public: Public or permissionless blockchain are decentralized and are visible to the public, anyone can join or leave the blockchain and anyone can verify and append transactions to the blockchain. This type of blockchain facilitates the dynamic collection of participants who may not know each other. Hence, stringent consensus mechanisms have to be implemented in this system.

Examples: Timestamping, trading of renewable energy.

Smart contracts

Smart contracts are self-executing agreements that are triggered on the basis of predefined and agreed events (for example rainfall of more than 200 mm, market price of commodity more than USD 100). The “smart” in a smart contract comes from the fact that the clauses in the contract are evaluated and the appropriate code executed without human intervention. Settlements in smart contracts are automatically triggered if the pre-agreed conditions coded into the contract are met. Imagine something along the lines of the automatic debit used by merchants to take payment from your bank account, based on pre-agreed conditions (full payment, part payment, minimum amount etc.) on a pre-agreed day or date (first Wednesday of the month, every 10 May etc.).

A key link between the physical world and blockchain is an oracle. This is a trusted intermediary and an integral part of the smart contract ecosystem and facilitates data feeds to the blockchain ecosystem. By design, a blockchain cannot access data from outside its system and thus data to make the blockchain is supplied through a predefined entity called an oracle. An oracle can be **hardware**-based, **software**-based, or **consensus**-based. Examples of hardware oracles are sensors, IoT and weather stations. Examples of software oracles are a New York Stock Exchange index, expiration date, output of some computation, etc. A consensus-based oracle works on the basis of consensus from a group of predefined nodes on a particular question. A consensus-based oracle can also source data from several other oracles to trigger an event in a smart contract. Moreover, **inbound oracles** pass external data to smart contracts and **outbound oracles** communicate smart contract-based data to the outside world.

Ethereum is the first blockchain platform that focuses on providing a Turing-complete³ smart contracts-based system and decentralized applications. Hyperledger Fabric and R3 Corda are some of the other DLTs that are used to create smart contracts.

³ A Turing-complete language means that it can approximately simulate the computational aspects of any other real world, general purpose computer language.

Some examples⁴ of the use of blockchain are:

In the **financial sector**: Disberse (www.disberse.com) provides an alternative financial infrastructure for the aid industry built on blockchain technology. It provides end to end real time tracking, providing complete and immutable data for reporting, auditing and compliance trails.

In providing a **digital identity**: Many companies have been trying to address the challenges in providing a system for decentralized identify management. IBM Blockchain Trusted Identity⁵ is working on creating a decentralized approach to identity management using blockchain built on top of open standards. BanQu (www.banqu.com) created the Economic Identity Platform that enables a secure and immutable network for creating bottom-up economic opportunities for the bottom of the pyramid.

In the **education sector**: Learning Machine (www.learnigmachine.com) creates a lifelong learning record with verifiable, tamper-proof documentation and certifications. This also facilitates instant decentralized verification. UNICEF has developed the Amply⁶ application platform to be able to replace the existing paper-based system to register children for a government funded pre-school subsidy in South Africa⁷. This blockchain application platform provides real-time service monitoring including verifiable digital identify registries for service agents and children and claims to reduce program administration costs.

In gender equality and women's empowerment: UNWomen⁸, together with partners, such as Innovation Norway, is exploring how blockchain could help refugee women on the move by storing and secure identity papers, medical records and documentation of ownership of assets.

In the **logistics sector**: companies such as Modum (www.modum.io) work by combining IoT sensors with blockchain technologies thereby providing data integrity for transactions involving physical products.

In the **health sector**: Minthealth enables patients to proactively manage their health by creating a self-sovereign health record and global unique identifier that facilitates seamless and secure transfer of clinical and behavioral data between patient-authorized stakeholders.

In the **insurance sector**: Allianz Risk Transfer and Nephila have successfully piloted blockchain technology for catastrophe swap.⁹ According to Allianz, the pilot demonstrates that transactional processing and settlement between insurers and investors could be significantly accelerated and simplified by blockchain-based contracts.

⁴ The mention of a particular initiative/company is not to be taken as an endorsement of it.

⁵ <https://www.ibm.com/blockchain/solutions/identity>

⁶ <http://www.amply.tech/>

⁷ <http://unicefstories.org/2018/04/11/unicef-innovation-fund-graduate-trustlab/>

⁸ <http://www.unwomen.org/en/news/stories/2018/2/news-event-blockchain-technology-and-humanitarian-action>

⁹ [https://www.agcs.allianz.com/about-us/news/blockchain-technology-successfully-piloted-by-allianz-risk-transfer-and-nephila-for-catastrophe-swap-/](https://www.agcs.allianz.com/about-us/news/blockchain-technology-successfully-piloted-by-allianz-risk-transfer-and-nephila-for-catastrophe-swap/)

In the **retail sector** initiatives such as the Everledger¹⁰ is working on traceability solutions built on a blockchain-based platform for the diamond industry. Similar initiatives are being piloted in the agriculture value chains to track products based on geographic indicators (GI) and other markers to empower consumers and to provide a way to encourage and reward good practices, and penalize illegal and unsustainable businesses. Blockchain-based solutions also find use in providing traceability in bringing more transparency and efficiency to agriculture value chains.

In the **energy sector**: initiatives such as the Energy Web¹¹ are working on an open-source, scalable blockchain platform that would provide a digital infrastructure for energy solutions. Power Ledger¹² is an Australian blockchain-based cryptocurrency and energy-trading platform that allows for decentralized selling and buying of renewable energy.

Given these, it is easier to see that blockchain technologies definitely have their uses in some contexts but would be simply too expensive, cause too many overheads, be unscalable and counterproductive in many other contexts. The fact that regulators around the world are actively trying to define guidelines for DLT usage further strengthens the belief that this technology can bring about a change in traditional processes if key building blocks needed to sustain the solutions are implemented.

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¹⁰ <https://diamonds.everledger.io/>

¹¹ <http://energyweb.org/>

¹² <https://www.powerledger.io/>

Agriculture: opportunities for blockchain technology

Blockchain based transactions are being piloted in many sectors including the financial, manufacturing, energy and government sectors. They are also being used in relation to agriculture supply chains, land registrations and digital IDs. Initially born out of a need for a more decentralized financial system (together with cryptocurrencies), this technology is finding innovative uses in a wide range of applications.

A blockchain by design is cryptographically secure (the content is not necessarily encrypted), it is a write once-append only, distributed and decentralized system. The statement that a blockchain is the only mechanism to build trust, reduce costs and accelerate transactions is not entirely true.

Blockchain-based implementations still suffer from traditional challenges such as a lack of or poor infrastructure, failures of interoperability, and other technology issues. Although the trend now is to try a blockchain-based implementation of traditional processes, in most cases this adds unnecessary overheads and does not yield any tangible benefits. What it does promise is to deliver a transparent, decentralized, secure transaction process and may reduce transaction costs. This brings us to the main question – what processes in the agriculture domain are suffering from a lack of transparency, would benefit from decentralization and are now affected by non-secure transaction processes.

To identify if a challenge you face could benefit from a blockchain based solution, the first step is to identify the use case, then develop the key governing principles (including regulatory requirements, stakeholders, legal framework, interoperability with existing system, scale and other key requirements) and then determine what technology or architecture would help address the challenges of that particular case. In most cases, a much simpler digital solution may be the answer.

In the agriculture domain, self-executing smart contracts together with automated payments would be the game changer. The role of smart contracts especially in agricultural insurance, green bonds, and traceability could be very effective. Agricultural insurance built on blockchain with key weather incidents and related payouts drafted on a smart contract, linked to mobile wallets with weather data being provided regularly by sensors in the field and correlated by data from proximity weather stations would facilitate immediate payout in the case of a drought or flooding in the field.

However, the framework to support such an innovation, such as high quality data, enabling policies and regulations, should be first addressed in order to ensure the maximum efficacy for smart contracts. The process of designing, verifying, implementing and enforcing smart contracts in traditional agricultural value chains is still a work in progress, with only a few pilot implementations to show proof-of-concept.

Agricultural insurance systems in the Asia-Pacific region range from major public sector programmes of India and the Philippines through to public-private partnerships in China and the Republic of Korea and finally to purely private markets encountered in Australia and New Zealand and non-formal private mutual and community-based crop and livestock initiatives in Bangladesh, India and Nepal.¹³ Low-cost agricultural insurance schemes are increasingly viewed as mechanisms for providing social protection to the increasing numbers of people affected by floods or droughts and in helping to lessen the impacts they suffer as a result of such events. However, despite the multiple benefits, the rate of adoption of insurance products by the rural poor still remains relatively low. The mechanisms that are in place to validate claims and to effect payouts are still time consuming and this is one of the reasons for index-based insurance not being chosen as the first risk mitigation strategy by smallholder farmers. Index insurance based on smart contracts can automate and greatly simplify the process thereby facilitating instant payouts to the insured in the case of adverse weather incidents. Automatic data feeds provide continuous and reliable hyperlocal data to the contract thereby eliminating the need for on-site claim assessment by the surveyor.

In **land registrations**, blockchain-based implementations could provide an incorruptible ledger of land records. Especially in the case of the rural poor, if this is linked effectively to sovereign ID/digital ID then the safekeeping of land records even in times of natural disasters or wars would not be an issue. The United Nations Development Programme (UNDP) in India is working with partners to make land registry more reliable there. At a high level, this project will capture and permanently record each transaction throughout the sale of a property. This means you achieve near real-time traceability and transparency with respect to the state of the property.¹⁴ The Swedish government's land-ownership authority, Lantmäteriet, has piloted land registry and property transaction on blockchain. They believe that this provides a safe and secure way to have digital originals and that it could reduce hundreds of millions of dollars of expenses for the government.¹⁵ The Republic of Georgia is experimenting on the use of the bitcoin network to validate property-related government transactions.¹⁶

In the case of bringing increased transparency in **agricultural supply chains**, a blockchain can assist in providing an immutable record from the provenance to the retail store of a product. This can give consumers increased trust in the products that they buy and it is also an opportunity to reward the producers who employ good agricultural practices to cultivate their produce. This would eventually lead to sustainable farming practices and responsible consumption. Italian pasta and pesto sauce manufacturer, Barilla, has teamed up with IBM to tackle transparency and traceability in its pesto production cycle.¹⁷ From the cultivation, treatment and harvesting in the field to transportation, storage, quality control to production and then to the customer, all details are tracked and made available on a blockchain system that the customer can verify by scanning the pesto's QR code. Provenance¹⁸ also works on enabling businesses to build trust in their goods and supply chain by using mobile, blockchain and open data supported software. This ensures food safety

¹³ Agricultural insurance in Asia and the Pacific region (available at <http://www.fao.org/docrep/015/i2344e/i2344e00.pdf>).

¹⁴ <http://www.undp.org/content/undp/en/home/blog/2018/Using-blockchain-to-make-land-registry-more-reliable-in-India.html>

¹⁵ <https://cointelegraph.com/news/sweden-officially-started-using-blockchain-to-register-land-and-properties>

¹⁶ <https://www.forbes.com/sites/laurashin/2017/02/07/the-first-government-to-secure-land-titles-on-the-bitcoin-blockchain-expands-project/#e4639854dcdc>

¹⁷ <https://bitnewstoday.com/market/blockchain/icons-of-italian-business-opt-for-blockchain/>

¹⁸ <https://www.provenance.org/>

and also helps in reducing food frauds and increasing brand reputation. FAO and ITU are working together with national partners in Papua New Guinea to pilot a livestock traceability system for using blockchain.



IBM's Food Trust built on IBM Blockchain platform helps Walmart track food products through its supply chain <https://www.youtube.com/watch?v=SV0KXBxSoio>

Experiments such as in India to undertake a research project to explore the use of blockchain technology for fertilizer subsidy disbursements to farmers¹⁹ have been done to streamline the distribution of subsidy payments to farmers without the need for documents or multiple points of authorization. Combining this with digital ID would assist in efficient and targeted delivery of many government-to-citizens (G2C) services by eliminating the need for multiple verification and the need to move paper documents through various offices.

In the **fisheries sector** this can be used to track and deter illegal, unreported and unregulated fishing (IUU), which poses the greatest threat to marine ecosystems. World Wildlife Fund (WWF) in New Zealand is working on a pilot project to stamp out illegal fishing and human rights abuse in the Pacific Islands' tuna industry. They have collaborated with various other organizations to track fish from vessel to the supermarket, this Blockchain Supply Chain Traceability Project uses digital technology in the fresh and frozen tuna sectors of the Western and Central Pacific region to strengthen supply chain management.²⁰

In **forestry**, Hangzhou Yi Shu Blockchain Technology Co., Ltd, a company set up by Beichuan Qiang Autonomous County of Sichuan Province and Beijing Sinfotek Group in China aims to use blockchain for forestry economic development and rural poverty alleviation. The Spanish Ministry of Agriculture, Fisheries and Food also plans to apply blockchain technology to develop the forestry industry. The operating group, ChainWood, aims to improve the traceability and efficiency of the wood supply in Spain by implementing blockchain technology in the industry's logistics. The group is set to develop a cloud-based software that would improve the transparency of forestry processes – such as the creation of solid wood, disintegration, cellulose paste, and biomass – by applying blockchain, big data, and machine learning.²¹

The pioneering efforts of the World Food Programme (WFP) with blockchain²² as a means of making cash transfers more efficient, transparent and secure and their experiences in pilots in Pakistan and Jordan are documented in this publication.

Yet another area for blockchain could be in sustainably monitoring, verifying and reporting on green or climate bonds. Green bonds were created to fund projects that have positive environmental and/or climate benefits. With the increase in bond value, it is necessary to have effective tracking, traceability and verification mechanisms to help increase investors trust in climate-smart-initiatives. Carbon credits and trading in them could benefit from the

¹⁹ <https://www.ccn.com/indian-govt-think-tank-to-trial-blockchain-for-fertilizer-subsidy-payments/>

²⁰ https://www.wwf.org.nz/what_we_do/marine/blockchain_tuna_project/

²¹ <https://cointelegraph.com/news/spain-to-develop-blockchain-tech-application-for-transparency-in-forestry-industry>

²² <https://innovation.wfp.org/project/building-blocks>

trust that a blockchain offers. Companies such as Poseidon²³ are working on a blockchain-based system to track an individual or company's carbon footprint and then providing opportunities to offset it. IBM works with Veridium to tokenize carbon credits that are verified by third parties according to international standards. These are then used to incentivize companies to be more environmentally friendly and to offset their carbon footprint.²⁴ These sorts of initiatives would greatly support the Reducing Emissions from Deforestation and Forest Degradation, plus the sustainable management of forests, and the conservation and enhancement of forest carbon stocks (REDD+)²⁵ programme, which supports developing countries in their REDD+ processes and helps them to turn their political commitments into actions on the ground.

The FAO-ICTSD issue paper on Emerging Opportunities for the application of blockchain in the agri-food industry examines public policy implications for food security and rural development in using DLTs.²⁶

In conclusion, blockchain has great potential. However, it is not a panacea for all problems. The right ecosystem and stakeholders are needed to sustain any kinds of solutions and the same goes for blockchain. Blockchain solution development without careful assessment of the existing challenges faced, including infrastructure, digital literacy, connectivity, and other overheads involved would unnecessarily increase the overheads substantially and could result in the initiative failing miserably.

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²³ <https://poseidon.eco>

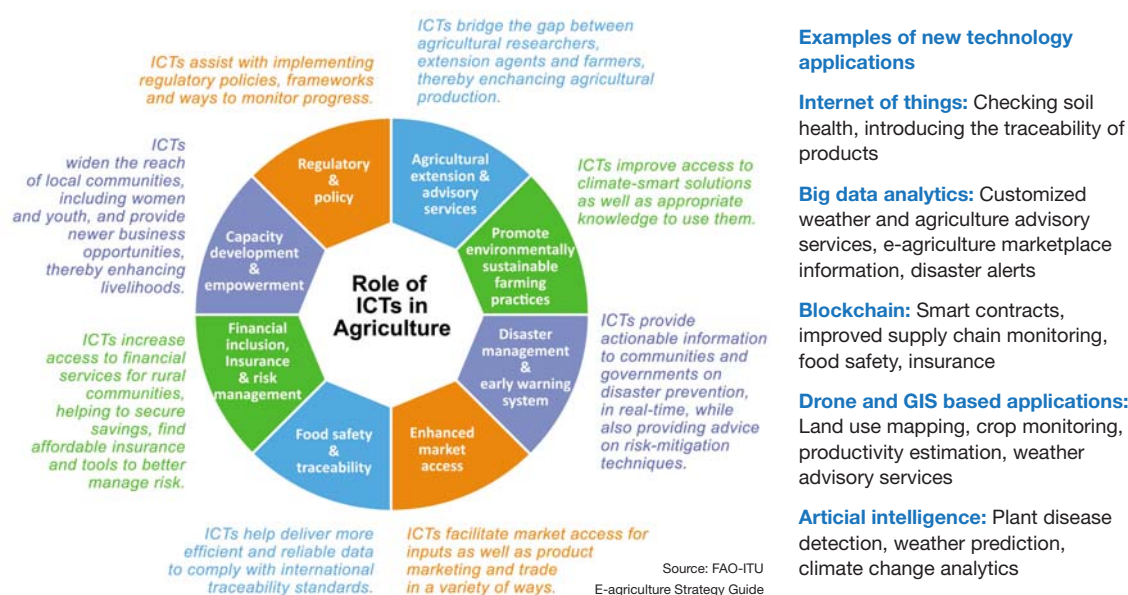
²⁴ <https://www.technologyreview.com/s/611670/blockchain-explainer-tokenizing-carbon-credits/>

²⁵ <http://www.fao.org/redd/en/>

²⁶ <http://www.fao.org/3/ca1335en/CAI335EN.pdf>

Blockchain: understanding the implementation risks

The transformative impact of information and communication technologies (ICTs) on agriculture is well recognized with the public and private sectors rapidly adopting digital solutions to address agriculture challenges (Figure 4). These technologies range from the traditional realms of mobile phone, television, radio and the Internet to the Internet of things (IoT), big data analytics and information systems, drones and remote sensing using geographic information systems (GIS), mobile applications, distributed ledger technology and blockchain (see Box 1), machine learning to artificial intelligence.



Examples of new technology applications

Internet of things: Checking soil health, introducing the traceability of products

Big data analytics: Customized weather and agriculture advisory services, e-agriculture marketplace information, disaster alerts

Blockchain: Smart contracts, improved supply chain monitoring, food safety, insurance

Drone and GIS based applications: Land use mapping, crop monitoring, productivity estimation, weather advisory services

Artificial intelligence: Plant disease detection, weather prediction, climate change analytics

Figure 4: Role of ICTs in agriculture

Box 1: Distributed ledger technology (DLT) and blockchain

A **distributed ledger** is a type of database, or system of records, that is shared, replicated, and synchronized among the members of a network.

A **blockchain** is a type of distributed ledger that is comprised of unchangeable, digitally recorded data in packages called blocks, where each block is then “chained” to the next block, using a cryptographic signature.

Working definitions used by the ITU-T Focus Group on Application of Distributed Ledger Technology (as of September 2018).

As the technology is being piloted in a large number of sectors, it creates the opportunity for agriculture to leverage those developments critical to agriculture such as finance, insurance, supply chain and logistics, e-commerce. For example, Ripple, a decentralized open source protocol, is being used by banks as a permissioned network for interbank payments; Bitcoin is a permissionless blockchain, where any user can join the network and start mining this cryptocurrency; Ethereum and Hyperledger Fabric are autonomous protocols used to implement smart contracts. They allow users to enter into and execute contractual agreements involving assets held or referenced on a ledger.

Distributed ledger technology exploits a set of well-established principles, including public key cryptography, peer-to-peer (P2P) networking, and consensus algorithms (e.g., proof-of-work (PoW), proof-of-stake (PoS), Federated Byzantine Agreement). Blockchain is a part of the DLT family, and other new technologies such as Directed Acyclic Graph (DAG) are emerging. IOTA and Hashgraph are examples of DAG-based DLTs.

Being a technology that hasn't yet reached maturity, it brings in certain implementation risks that are important to comprehend and wherever possible to mitigate before deployment. A good understanding of the risks would assist in deciding whether DLT or a centralized database would be more appropriate, and further choosing the appropriate DLT for a given scenario as the risks vary with the type of deployment, i.e. permissioned (private) or permissionless (public).

Implementation risks common to all DLTs

Is a software code mature enough to replace the law? In a DLT environment, smart contracts are agreed based on a software code and on the agreed date executed (sometimes mercilessly) as the contract itself is the law. Although this unalterable nature (or immutability) is the core strength of this technology and enhances trust amongst parties, it also needs to be mature enough to replace the law. There have been instances in the past when some of the well-known DLTs had to be “hard forked” – a phenomenon whereby the governing code has to be replaced with a new one. In 2016, for example, Ethereum had to be hard forked after long debate amongst the community as an unexpected code path allowed users to withdraw funds and an unknown user managed to withdraw USD 50 million. Not all in the community agreed with the decision, which led to different versions of Ethereum, viz. Ethereum and Ethereum Classic.²⁷ Such decision-making is not easy or quick to arrive at as it requires agreement amongst the community. Another important area is the application of the law. In instances where there are judicial decisions to reverse a smart contract for legal noncompliance, how would the prior data in the blocks be altered? In the context of agriculture, where smart contracts are very useful applications of DLTs, absence of a legal entity or a human being to interpret the code in event of a dispute is an important risk to remember. It is very important, therefore, to keep the contract simple.

²⁷ Laurence, T. 2017. *Blockchain for dummies*.

Standards are underdeveloped and not mature yet: Being at a stage of rapid technological development, there are no mature standards addressing DLT yet. At this point, there are various competing proprietary and community-managed DLT platforms and frameworks. The absence of international standards carries risks related to customer lock-in, lack of interoperability, privacy and security.

There are international efforts ongoing in these areas, including ISO Technical Committee 307 on Blockchain and Distributed Ledger Technologies and work in ITU’s standardization sector ITU-T (Table 1).

Table 1: Standardization activity in ITU-T

	ITU-T group	DLT related activity
Pre-standardization	Focus Group on Application of DLT	So far the group has identified a number of use cases (horizontal, e.g., identity management; and vertical/sector-specific) and is working on a high-level architecture, an assessment framework, and regulatory aspects. See https://itu.int/en/ITU-T/focusgroups/dlt/
	Focus Group on Data Processing and Management to support IoT and Smart Cities & Communities	Currently this group is studying the use of blockchain in the context of data processing and management. See https://itu.int/en/ITU-T/focusgroups/dpm/
	Focus Group on Digital Fiat Currency	This group is exploring blockchain as an enabler for digital currencies. See https://itu.int/en/ITU-T/focusgroups/dfc/
Standardization	Study Group 13	This is studying cloud computing requirements for blockchain as a service (BaaS). See https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=14485 Blockchain in NGN evolution. See https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=14282
	Study Group 16	This group is studying DLT and e-services. See https://www.itu.int/en/ITU-T/studygroups/2017-2020/16/Pages/results-1807.aspx#Annex%20B
	Study Group 17	This is studying various work items on the security aspects of DLT. See https://www.itu.int/itu-t/workprog/wp_search.aspx?isn_qu=6819
	Study Group 20	This is studying “Blockchain of things”. See https://www.itu.int/itu-t/workprog/wp_search.aspx?isn_sp=3925&isn_sg=3937&isn_status=-1,1,3,7&title=blockchain

Energy requirement can be high: A methodology to build consensus for entering a new data block amongst participating nodes is a core feature of blockchain. There exist several possible ways of reaching consensus, each with its own advantages and disadvantages. The one that is employed by Bitcoin and Ethereum, the most famous of blockchain implementations, is proof-of-work (PoW). It works on the principle of “hard to create, easy to verify”, which means lot of energy needs to be spent by the node to earn incentive tokens. For a large chain like Bitcoin, estimates suggest data size exceeding 100 gigabytes and electricity requirements more than the entire country of Ireland.²⁸ Although this is true for the PoW methodology, other alternatives such as proof-of-stake (PoS), Byzantine fault tolerance

²⁸ <https://powercompare.co.uk/bitcoin/>

algorithm, and delegated proof-of-stake model require less energy. However, they come with their own disadvantages, for example in the case of PoS, users with more stakes will have greater control on decision-making.

Trusting the blockchain developers and managers: A very high level of trust is placed on the developers and managers of the blockchain. It is a new technology where a large number of entities are innovating to create solutions. The focuses, owners and software implementations vary (Table 2).

Table 2: A comparison of selected distributed ledger technologies

Blockchain examples	Primary focus	Developers and managers	Tokens	Speed (transactions per second (tps))	Coding language
Bitcoin	Digital cash system	Community of code developers	Bitcoin	7	C++,
Ethereum	Smart contracts	Ethereum Foundation	Ether	15	Solidity
Ripple	Connecting different payment systems	Large venture based startup	Ripples (XRP)	1 500	JavaScript
NEO	Smart contracts	Onchain	NEO, GAS	1 000+	C#, NET
Stellar	Unbanked	Community of code developers	XLM	1 000	JavaScript
Hyperledger Fabric	Smart contracts	Linux Foundation backed project	n/a	Depending on chosen type (maximum 700)	Golang
EOS	Smart contracts	Community of code developers	EOS	3 000+	C++

Source: Jean-Marc Seigneur (personal comm.); authors

Implementations of these technologies are largely dependent on the community of developers backing the project or the owner. A decision to soft fork or hard fork a project, or to change the cryptography algorithm, will be driven by the nodes and participants in the blockchain. These decisions are driven by codes that govern the consensus and the community developing it. At the same time, it is important to build resilience into the networks so that they can be entrusted with critical data, information and services. Carrying out a risk assessment of the project is important before making a choice.

Increased responsibility on the user: By its very design, blockchain implementation does not have a central authority – at least in the case of public blockchains such as Bitcoin – which puts additional responsibility on the user. There is no entity to go to in the event of individuals losing private keys (or incurring losses as a result of revealing a private key). Also, there is no feature to restore forgotten passwords and usernames that individuals are used to. Individuals need to exercise great caution, just as on the Internet, before publishing anything. The importance of entering the correct data is very important too as it is very difficult to make corrections later.

Implementing data privacy legislation: Data protection and privacy is a major concern and initiatives to prevent their abuse are being taken by countries and regions (e.g. Association of Southeast Asian Nations (ASEAN), European Union General Data Protection Regulation (EU GDPR). For example, the EU GDPR has instituted the “right to forget” whereas the design of DLTs is oriented towards “never to forget”. Although there is a possibility of keeping identification unknown in the system, it raises security concerns largely in relation to anti-money laundering (AML) activities and know your customer (KYC) requirements.

In addition to the generic risks of blockchain technology, there are some additional risks in permissionless or public systems.

Additional risks linked with permissionless DLTs

Policy and regulatory risks: The policy and regulatory framework around blockchain is in its infancy and therefore entails high risks. The fluctuations in the price of Bitcoin and the reports of hacking of cryptocurrency have resulted in increased regulation by a number of countries and has attracted regulatory interest. These regulations vary from a complete ban on holding cryptocurrency (e.g. Bangladesh), a ban or regulation on cryptocurrency trading (China, Saudi Arabia) to a ban on holding initial coin offerings (ICOs). A number of blockchain projects, especially those dealing with currency or cross-border transactions, requires KYC/AML compliance and it is important to understand the national framework before delving into these projects.

At the same time, governments see DLTs as a high potential technology and are investing in the use of its application. A project without the use of cryptocurrency in general will have less regulatory challenges than those with it. At present, there is no international framework for cooperation amongst policymakers and regulators in this area, which means there is a lack of appropriate consumer protection in the international environment.

Speed of transaction: The speed of transaction is an important element as some of the public blockchains do not have high transaction speeds. On Bitcoin blockchain, a new block emerges on average every ten minutes but is not guaranteed; and this block time is different for every blockchain. For scalability, it is important to understand the requirement of applications in terms of speed (transactions per second (tps)) before choosing a solution. Theoretically, Visa network can handle about 50 000 tps, which is a lot more than is offered by most mature blockchains today (as shown in Table 2 previously).

Malicious users: In the absence of identification of a third party, the system is prone to risks from malicious users in systems that are pseudonymous, that is with no requirement to disclose identity. Although DLTs are designed to disincentivize malicious intent, there can be situations where malicious users have greater incentives to game the system²⁹ and at least cause harm in the short term and may call for a hard fork. These situations are more likely where they gain greater control of the system.

²⁹ To “game the system” refers to using the rules and procedures designed to protect a system to manipulate the system for a malicious purpose.

Identity and security: Public blockchains carry out transactions based on the public and private key of the individual and do not keep the mapping of the identity with the key. This raises security constraints for the law enforcers and applications where identity is important. In contrast, there are privacy concerns in disclosing identity on permissionless blockchains that require data to be public facing and transaction histories to be disclosed. Most DLTs use encryption algorithms that are hard to break by normal non-quantum computers. Going forward, where quantum computing (relying on cubits rather than bits) gains momentum and enhances computing powers, these encryptions are not secure enough. There have been a large number of successful attacks on DLTs and there are security risks associated with DLTs³⁰ (e.g. blockchain attacks, phishing, malware, cryptojacking, endpoint miners, implementation vulnerabilities, wallet theft, technology attacks, legacy attacks which have been modernized, dictionary attacks, quantum computing-based attacks).

Choosing the right DLT application platform

An important question is to ask whether a DLT (or blockchain) is appropriate for what you want to achieve. The first decision to make is whether the application requires a blockchain or would a database suffice (see Table 3 and Chart 1).

Table 3: Blockchain or database?

	Permissionless Blockchain	Permissioned Blockchain	Central Database
Throughput	Low	High	Very High
Latency	Slow	Medium	Fast
Number of readers	High	High	High
Number of writers	High	Low	High
Number of untrusted writers	High	Low	0
Consensus mechanism	Mainly PoW, some PoS	BFT protocols	None
Centrally managed	No	Yes	Yes

Source: Wüst, K. and Gervais, A. no date.³¹

The use and maintenance of blockchain-based solutions come with their own costs and risks. The cost of developing, operating and maintaining applications that use blockchain technology is relatively high in terms of computational and human resources. Does the nature of the transaction really require having so many copies stored in the global blockchain? Adding to that, the fact is that in general performance will be affected and slowed down. Writing to blockchain is intentionally hard and as a result, it is relatively slow.

³⁰ Presentation by Dr Leon Perlman (see <https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/Pages/ITU-Asia-Pacific-CoE-Training-on-Distributed-Ledger-Technologies-%28Blockchain%29-Ecosystem-and-Decentralization.aspx>)

³¹ Wüst, K. & Gervais, A. no date. *Do you need a blockchain?* (Available at <https://eprint.iacr.org/2017/375.pdf>).

A careful analysis of the requirements is highly recommended before selecting blockchain as a technology of choice. If high performance is necessary for your application, a relational database, not blockchain, may be the better choice. A way to balance performance issues while leveraging the benefits of blockchain is not to store the full data records in the blockchain but simply to store a cryptographic hash of the record. This will serve to determine with a high level of confidence whether data have been compromised and can resolve any dispute issue. This approach is used, for example, in the case of electronic health records.

Failing to make a sound decision might lead to the risk of making an unnecessary high-cost investment. Cost savings from disintermediation, that is by having the network as the trusted party might not balance out the costs to support and maintain a blockchain-based application.

A number of flowcharts are available that are used to make this decision. For example, the United States Department of Homeland Security (DHS) uses a flowchart as provided in Chart 1 below.

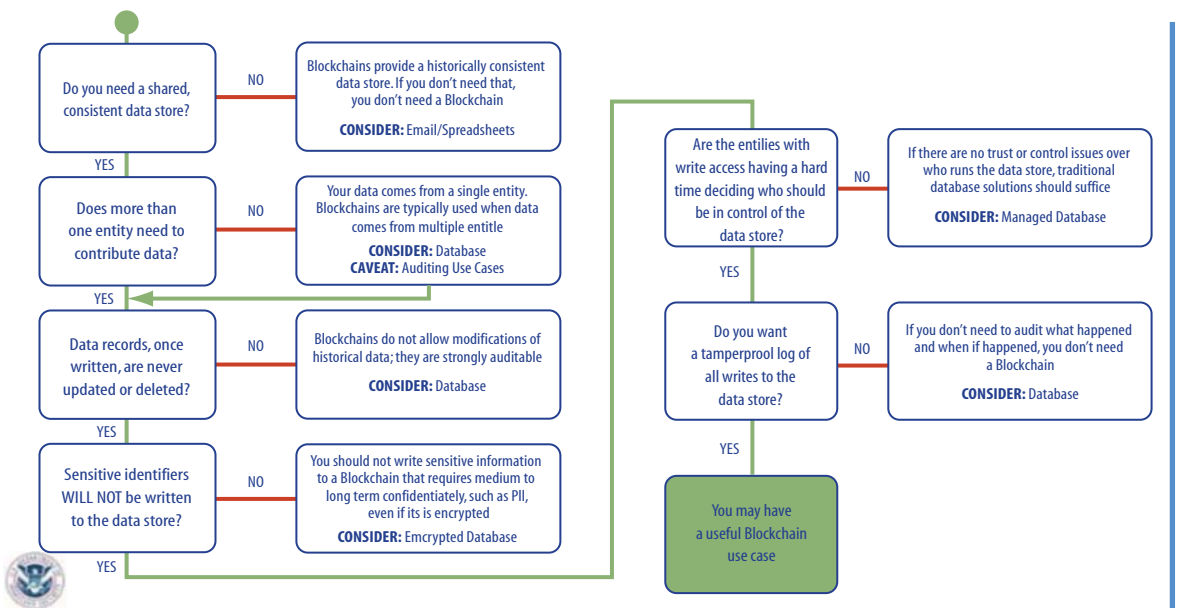


Chart 1: How to make a decision about using blockchain or a database

Source: United States Department of Homeland Security Science & Technology Directorate³²

³² Adapted from the original flowchart created by Department of Homeland Security Science & Technology Directorate by J.-M. Seigneur and presented at the ITU Asia-Pacific Centre of Excellence Bangkok 2018 DLT Training, 2018. The original is reproduced by D. Yaga, P. Mell, N. Roby, and K. Scarfone, "Blockchain technology overview," National Institute of Standards and Technology, Gaithersburg, MD, NIST IR 8202, 2018 (available at <https://doi.org/10.6028/NIST.IR.8202>).

Mitigation measures and the way forward

Given the importance of DLT and its great potential, some of the key risks can be mitigated by developing an assessment framework looking at the critical elements from the perspective of data layer, network layer, consensus layer, contract layer and application layer and standardizing the requirements. This would enable greater adoption and ecosystem development to mainstream the DLT.

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International Telecommunication Union

FARMS: financial and agricultural risk management for smallholders

Providing new risk coping strategies for smallholder farmers

Introduction

Despite the efforts of insurance companies, brokers and governments, millions of smallholder farmers in Africa remain unprotected against financial and agricultural risk and the associated fluctuations in household income. Smallholder farmers have limited awareness of and access to insurance products, and those who can access insurance still favour traditional, often informal, means of risk management over insurance, with the cost of insurance and limited cover being two of the main reasons. At the same time, insurance companies have no incentive to put real effort into developing and marketing demand-driven agricultural micro-insurance products. In countries such as India, Uganda or Kenya premium subsidies have helped to scale agricultural insurance to a certain extent, but without subsidies, costs and premiums remain too high and most products are financially unsustainable.

The majority of agricultural insurance products for smallholders insure the events that lead to crop failure, rather than insure the actual crop failure. The latter (called indemnity-based products) are only suitable for large farmers as determining damage and the remaining value of the crop require the deployment of agricultural insurance specialists, which is unsuitable for large numbers of smallholder farmers that pay low premiums. This is why micro-insurance products (characterized by low premiums, low pay-outs, high numbers) often use a drought-index and satellite data or weather stations to determine if a farmer in a given area is likely to be affected by a lack of water. Although this excludes other types of risk such as pests and diseases, it is a valuable approach as in countries where drought does play a role in agriculture (for example, in many African countries), drought actually accounts for 80 percent of total crop losses.

With a group of key players along the agricultural micro-insurance value chain, ICS (a Dutch-based NGO that develops market-based solutions to socio-economic problems in Africa), Agrics (an East African social enterprise serving 30 000 farmers in Kenya, Tanzania and Uganda with quality agricultural products and services on credit) and EARS (a Dutch-based remote sensing company with ten years of experience in designing and implementing drought index-insurance solutions in Africa) started out in early 2017 to research intensively the potential of developing a low-cost drought-index insurance product supported by blockchain technology. Starting from the hypothesis that blockchain would enable significant cost reduction and scalability by far-reaching automating of insurance and payment processes and reducing the complexity in the chain, different product options were explored and a simple proof-of-concept algorithm was developed together with a major technology company. However, it was eventually recognized that the agricultural micro-insurance value chain as well as the cost of risk that comes with insurance leave too little room for cost reduction, even through the use of ICTs such as distributed ledger technology, smart contracts and mobile money. A new approach was required.

If farmers are unable and/or unwilling to pay for insurance, the solution may not be to keep pushing insurance products to make the leap from traditional risk coping strategies (for example, collecting money from relatives, taking a loan, consuming less), but to support smallholders in gradually changing their mix of strategies.

This conclusion led to the idea of a drought-index savings product that helps farmers to grow into the concept of insurance. Like insurance, a savings product allows smallholder farmers to balance their income across good and bad years. However, a savings product will not only bring lower cost than an insurance product, it is also easier to understand as many smallholders are familiar with savings through, for example, savings and credit cooperative organizations (SACCOs) or community-based savings groups. With this idea, a start was made to work out the concept in more detail together with COIN22, a fintech company providing a blockchain-based mobile wallet platform, and its agent Dodore Kenya, which specializes in implementing mobile financial services in East Africa.

The FARMS concept

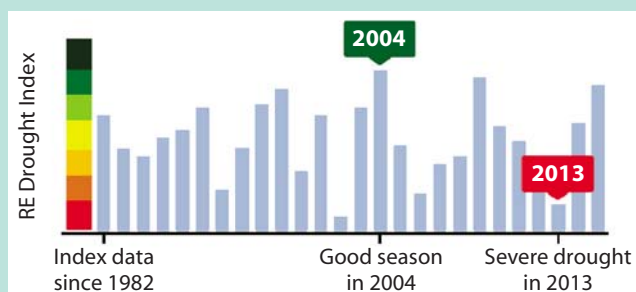
FARMS offers an easy entry to formal financial risk management while increasing farmers financial literacy. Research has shown that it takes farmers without agricultural insurance four years longer to recover from a bad season compared to farmers with insurance. At the same time insurance uptake remains low as mentioned previously. The FARMS scheme lets farmers grow into an insured state in three stages: exploring, gained trust and fully covered.

First stage: exploring

When joining the FARMS scheme, farmers provide details on for example, land size, location, crops grown, average yield and household income. Based on this information and historic drought data, a short message service (SMS) is used to suggest to the farmer an amount to set aside in their mobile wallet each year in order to mitigate their risk. This amount is a suggestion only and farmers are free to set aside any amount. At the end of the season, based on satellite drought data and the defined index, all or part of the amount may be released and withdrawn by the farmer. Funds are released when the index is at least 20 percent lower than an average year, however farmers may be advised to keep money in their mobile wallet for really bad years (which occur once every 15 years on average). Amounts are released in such a way that they optimally mitigate risk, and the amount of funds released increases with the intensity of the drought (see Box 2 “How a drought index works”). Although the release of funds is primarily based on the index, it may also be based on the occurrence of other events that lead to reduced crop yield, such as pests. Major pests such as the Fall Armyworm are monitored by research and government institutions and often well documented on social media, and as such do not require agronomic experts to determine actual damage. In this stage farmers will try out the service – put aside some money, and withdraw some money when possible to see if it works.

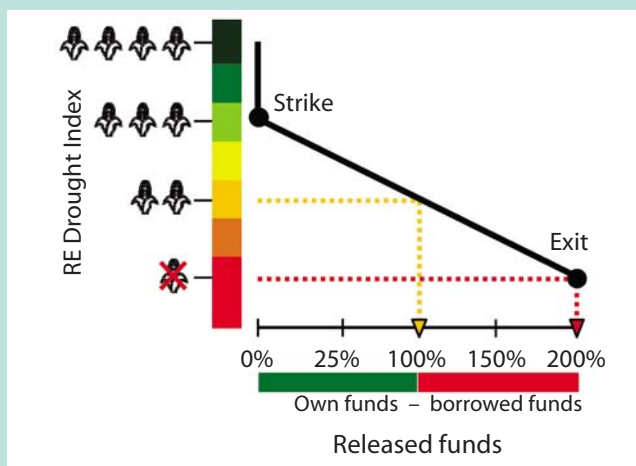
Box 2: How a drought index works

A drought index represents drought and growing conditions. It indicates declining water availability and resulting crop yield losses, both for current conditions as well as historic events. The drought index (below) shows drought severity from year to year in a sample location.



Credit: EARS

During the growing season the index tracks drought severity throughout the areas of interest. If the index drops below average, then it indicates the onset of a drought. When the index reaches the strike level then yield losses are imminent and funds are unlocked for that location. The exit marks the point where 100 percent of funds are unlocked (total crop loss).



Credit: EARS

Second stage: gained trust

When farmers have had their first positive experiences with the scheme, they will start following the suggestions from the SMS. If they do so, they will be able to use the mobile wallet's overdraft against favourable terms based on their savings history. The maximum potential loan (overdraft limit) will increase over the years from 25 percent of their savings to 100 percent. Like withdrawing saved amounts, the loans are available based on the season's drought situation.

Third stage: fully covered

When farmers have been participating in the FARMS scheme and have been saving according to the suggested amounts for a few years, they have a positive balance (even if they made small withdrawals in the previous years) and the possibility to borrow up to 100 percent of their mobile wallet balance. This will provide access to sufficient funds to mitigate the results of a very bad agricultural season. Should farmers want to leave the FARMS scheme because they need their balance for other purposes, they can withdraw their full balance at the end of the season. They are welcome to rejoin the scheme in the following years, but they will need to start afresh and as such cannot borrow too much at the start.

Lessons learned from agricultural index insurance initiatives show that aggregators are crucial to bridge the “last mile” to the farmers. Aggregators such as Agrics, as well as processors with an outgrower scheme, cooperatives and NGOs, have a trusted and often financial relationship with smallholders. This makes them a crucial distribution channel that can add tremendous value in terms of marketing, capacity building and relationship management, and in supporting farmers in moving through the stages. White label³³ FARMS products can be combined with input bundles or other products/services, and help farmers to save, for example, when they monetize their harvest, as part of an input bundle that they buy, or by making a mobile money payment. This is why the FARMS initiative will target different types of aggregators and work with them to develop/test different options. A comparison of index-based drought insurance and the FARMS scheme is shown in Table 4.

Table 4: A comparison of index-based drought insurance and the FARMS scheme

Index-based drought insurance	FARMS scheme
Premiums paid are non-recoverable. Premiums are often seen as “investment” rather than cost of input, and as such farmers expect benefits from the money they have paid, yet in good years they will not receive anything.	Funds remain in the possession of the participant and can eventually be taken out of the scheme.
“All or nothing” approach – either you are insured or you are not.	Gradual approach – protection is limited at first but increases with each year of participation.
Farmers lack trust in large financial service providers such as insurance companies.	The FARMS scheme will allow white labeling through aggregators, building on an existing, trusted relationship with farmers.

The technology solution

The FARMS concept is enabled by a blockchain-based virtual currency platform integrated with remote sensing (satellite) data and mobile money solutions, which ensures transparent secure transactions and “earmarking” of funds, automated payment and information dashboards.

³³ White label FARMS products are produced by one company then “packaged” and distributed by other companies under varying brand names.

Farmers set aside money by buying virtual currency “drought coins” or “drought vouchers” (a voucher being a concept that many are familiar with) that are kept in their personal COIN22 mobile wallet account. When farmers want to withdraw funds, they redeem their drought coins/vouchers (Figure 5). The value of the coins mimic the local fiat currency, for example 5 000 Kenyan shillings represent 5 000 coins. All transactions are communicated to the farmer, and participants can check their balance at any given moment, through a universal SMS. The actual money flows into a trusted bank account (risk pool), and through full systems integration all transactions are real-time.

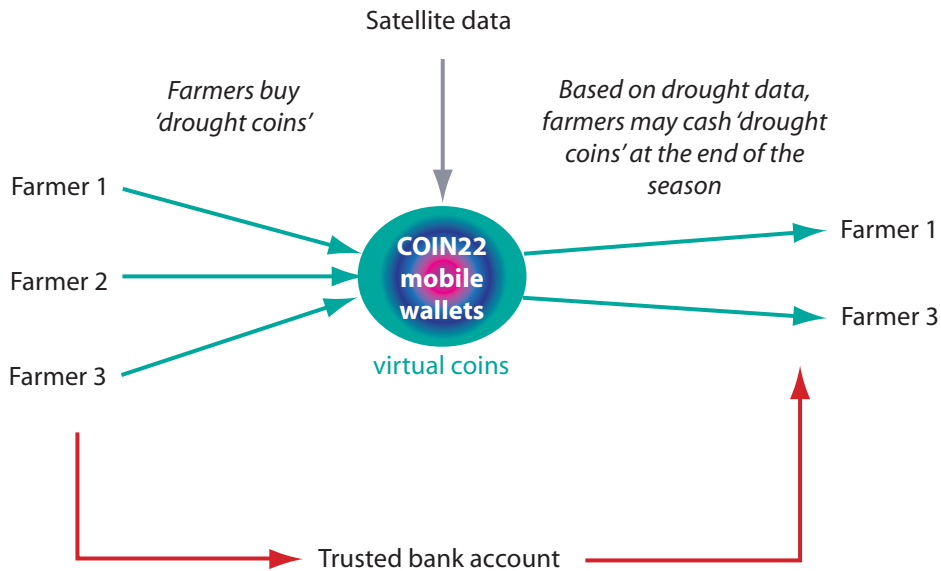


Figure 5: Overview of the FARMS technology solution


Source: COIN22

Implementation

Funding is now being secured in order to make sure COIN22 can start implementing before the end of the second quarter of 2018. The aim is to test the product with farmers in the Kenyan “long rains” season 2019 with Agrics as the launching customer. Before this, efforts will be targeted at testing the concept in different forms with the target group, connecting with other aggregators, and tailoring the COIN22 solution to the FARMS concept.

Evidence so far suggests that by creating a product that remains close to the experiences of the farmer – a product that they can easily relate to – and by stepping away from the complexity of the traditional micro-insurance value chain, a financially sustainable solution is within reach.

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© Agrics

Checking for the latest information on a smartphone.

AgriDigital: blockchain for agri-supply chains

Introduction

Since 2016, AgriDigital has pioneered, non-commercially so far, the use of blockchain across agricultural supply chains. Conducting the world's first proof-of-concept (PoC) algorithm with leading agricultural businesses, AgriDigital has deep domain expertise in blockchain technology and applies blockchain and related technologies to solve the embedded agri-supply chain challenges.

The company operates primarily along grains supply chains. As its founders have over 80 years combined experience in the Australian grains industry, this was the natural first market. AgriDigital is expanding rapidly into the global grains industry, and across commodities with initial trials underway in the rice and cotton industries.

AgriDigital has a cloud-based commodity management solution in marketing for the global grains industry. It connects grain farmers, buyers, site operators and financiers through a single platform, allowing them to contract, deliver and make payments securely and in real time. Although the AgriDigital platform is cloud based, it is also blockchain enabled, meaning it acts as a user interface with the blockchain protocol layer. With the launch of a commercial blockchain protocol for agriculture, the AgriDigital platform will operate as the primary application layer for users to interact with the blockchain.

The company has developed a library of smart contracts operating on the blockchain protocol, allowing users to trade, finance and trace agri-commodities. At the core of AgriDigital's solution is the creation of digital assets. Using digital assets, AgriDigital brings together the trade, finance and data flows that are often disparate in traditional, paper based agri-supply chains. This provides users with a more informed and robust view of their assets and the supply chain, and improves liquidity, transparency and security for all supply chain participants including farmers, traders, producers, financiers and consumers.

The company is dedicated to building a robust digital infrastructure that connects the physical commodity to the digital representation at every stage along the supply chain. In doing so, AgriDigital uses the Internet of things, sensors and integrations with machinery such as weighbridges wherever possible.

AgriDigital is an Australian company based in Sydney. The company's blockchain solution has been trialed at a number of locations across Australia including Dubbo in New South Wales and Bordertown in South Australia. The customers are grain farmers, buyers, site operators and financiers. The initial target market for the company's commodity management solution is the global grains industry. However, the blockchain solution is designed to operate for a full range of commodities and the company works across grain, rice, cotton and livestock.

The company has worked closely with a number of major participants in Australian agriculture to test the blockchain protocol and the smart contract library. These include: Fletchers International Exports; CBH Group, Australia's largest exporter of grain; and Rabobank, the largest global agri-bank.

AgriDigital's award-winning SaaS³⁴ platform has a network of 1 300 active grain supply chain users with a broader network of over 4 500 total users. To date, over 1.6 million metric tons of grain have been transacted by these participants on the AgriDigital platform (since November 2016). These users will be transitioned to using the blockchain protocol once it is launched commercially.

AgriDigital was founded in 2015 with a vision to solve three key challenges across agri-supply chains:

1. farmers are not paid for the commodities they produce when they deliver them;
2. buyers don't have access to flexible supply chain finance to pay farmers, as financiers lack visibility and control when financing commodities; and
3. consumers don't really know where their food and fibres come from thus restricting their ability to make informed purchasing abilities.

Buyers and sellers along agri-supply chains cannot operate with confidence, knowing that they will be paid and can access the finance necessary for business stability and growth. This finance is often limited to highly reputable borrowers with bricks and mortar security, and is often only accessible for commodities where the risk price can be hedged. This results in settlement latency, with title transferring months before payment is made. This introduces enormous counterparty risk that most often falls on the producer at the start of the supply chain.

Supply chain participants are vulnerable to fraud, with global food fraud costing USD 40 billion annually and global trade in fake goods accounting for a staggering USD 500 billion annually. Without verifiable and data rich assets, counterfeit goods move in large quantities across supply chains. The real cost of this to the end consumer is abundantly evident, with food security a growing issue. Indeed a number of high profile food contamination cases have had global impacts.

AgriDigital is addressing these challenges by providing a digital infrastructure that brings trust and transparency to supply chain participants. The company started with the first transaction along many supply chains, with the sale from the farmer to the buyer.

Blockchain technology was immediately identified as a tool for building creative and innovative solutions to solve these problems. However, blockchain is only a piece of a larger digital infrastructure, one that allows users to easily access the protocol layer and that ensures the information that is recorded truly represents the state of the physical commodity in the real world.

³⁴ SaaS or "software as a service" is a software distribution model in which a third-party provider hosts software applications and makes them available to customers over the Internet.

So far AgriDigital has conducted three key blockchain pilots:

1. AgriDigital and Fletcher International Exports, December 2016.
2. AgriDigital and CBH Group, July 2017.
3. AgriDigital and Rabobank, December 2017.

AgriDigital and Fletcher International Exports

A beta version of the AgriDigital platform was launched in 2016 which functions as the application layer for users to interface with the blockchain. The AgriDigital platform streamlines and automates business processes for farmers and buyers, seamlessly capturing valuable data about the physical commodity and facilitating data transfers and reconciliations. The platform itself has offered an enormous leap forward in commodity management software, which, as a cloud-based platform, is a huge step up from spreadsheet and paper based systems or large enterprise solutions otherwise used.

AgriDigital's team of software engineers and agribusiness professionals have designed a platform that caters for the intricate needs of grain traders and farmers. Using the platform, the company's users can create contracts, deliveries, make payments, generate invoices and manage on-site inventory. Developing this platform required a lot of hard work and testing. The company's beta customer, Fletcher International Exports, played a critical role in testing the platform in its very early stages. Ensuring the blockchain protocol and platform integrate seamlessly has had its challenges, in particular making certain that AgriDigital is making the most of the comparative advantages each technology offers.

Blockchain technology has developed enormously over the past few years, and AgriDigital has been continuously updating its solution in line with the latest developments.

In December 2016, the company executed the world's first settlement of a physical commodity on a blockchain. It set out to use blockchain technology to provide real-time settlement, that is payment on title transfer for physical grain deliveries to a selected buyer. The pilot ran on a private instance of the Ethereum network.

A smart contract from the proprietary AgriDigital library auto-executed the settlement by first valuing the delivery, then verifying that the buyer had sufficient funds to pay the grower, and then securing the funds in the grower's name pending delivery. Once the grower made the physical delivery at site, title to the grain transferred from the grower to the buyer as the grower payment was simultaneously created from the reserved funds. For this pilot, although the transaction settlement occurred on the blockchain, the grower received the payment in local currency using traditional banking methods: a message was sent out as a bank file for the buyer to upload and pay, on the same day, via existing mechanisms with its bank. Typically, payment terms in the Australian grains industry range from two to five weeks, and it is these terms that pose counterparty or credit risk to growers.

AgriDigital and CBH Group

AgriDigital and CBH Group, Australia's largest exporter of grain, conducted a pilot to test the application of blockchain in the Australian grain industry at CBH's wholly owned subsidiary,

Blue Lake Milling, an oats processor in Bordertown, South Australia.³⁵ Three scenarios were conducted using the AgriDigital commodity management platform and blockchain application.

Throughout this pilot there were two key objectives:

1. to generate digital title to a physical commodity and execute payment on a blockchain, including functionality to allow for secure seven days payment terms; and
2. to use blockchain to verify a batch of organic oats by tracing the movement of organic oats from the farmgate, through processing and milling to a retail customer.

The pilot used a three node, private Quorum network. This allowed the use of advanced privacy settings and transaction time.

The grower delivery was received at site using the AgriDigital platform, where information about the quantity and quality of the oats was recorded. This information was pushed through various integrations, generating a digital title token on the blockchain held in the grower's digital wallet. This token was held and flagged for payment in seven days.

A week later, settlement occurred in an atomic (simultaneous) transaction with payment being made to the grower at the same time as the title was transferred from the grower to the buyer. The payment on the blockchain layer was made using a second token, minted by AgriDigital and known as "Agricoi", which was pegged one to one with the Australian dollar. Smart contracts, agreements codified for execution on a digital distributed platform, were used to auto-execute payment on the blockchain layer which was parallel processed using traditional banking methods. Without a broadly accepted digital currency, and as many cryptocurrencies are too volatile for many businesses to hold on a balance sheet, AgriDigital has continued operating using parallel processes.

The Quorum network uses the Raft consensus mechanism, which allowed AgriDigital to process four transactions per second, a settlement rate easily scalable to process all transactions in the Australian grains industry on a blockchain.

In another scenario, a Web application and the AgriDigital platform were used to record essential data on the provenance, storage, transport and batch treatment of the oats. These data points were bundled into various assertions, with each assertion representing an event or claim critically pertaining to the organic oats. The assertions were then hashed and recorded on the blockchain layer. Using a complex analytics model, AgriDigital were able to scan a QR code at the point of sale that produced a report either confirming or denying the organic status of the oats.

A key challenge faced by the bulk commodity supply chains has been providing clear visibility over commodity ownership. Paper-based systems or spreadsheets provide little to no security for growers when payment fails. Being able to match title transfer to payment provides instant benefits to growers and all sellers through reduction of counterparty risk and increased security over the asset up until title transfer.

³⁵ See AgriDigital and CBH Group's "Pilot Report: solving supply chain inefficiencies and risks with blockchain" (available at https://daks2k3a4ib2z.cloudfront.net/593ba04f0052061059d5383e/5a0be176b08b700001502550_AgriDigital%20and%20CBH%20Blockchain%20Pilot%20Report.pdf).

A further challenge has been ensuring the quality of the data posted to the blockchain. Where the blockchain or the blockchain application such as AgriDigital can easily integrate with machines and digital systems, such as weighbridge integration and quality testing instrumentation or processing equipment, this is clearly preferred. Removing human data input and increasing the number of such integrations allows for much more reliable data entry and increases the integrity of the blockchain overall.

AgriDigital and Rabobank

In December 2017, agribusiness bank Rabobank and AgriDigital teamed up to conduct a proof-of-concept that successfully demonstrated a purchase and sale of commodities on a blockchain in a laboratory environment.

The objective was to test whether the AgriDigital platform, supported by blockchain, could facilitate the purchase and sale transaction. This would be in the form of a RaboBank structured inventory product (SIP), with automated settlement of the purchase and forward sales contract.

The proof-of-concept was completed as simulation involving three parties, a grower, a grain trader and Rabobank. Completed as an atomic (simultaneous) transaction, the smart contract layer auto-executed the transfer of title in the commodity from grower to Rabobank in exchange for payment made via the buyer's facility. Rabobank was then automatically repaid by the buyer at the time it was ready to sell the commodity to a third party. All payments were made in real time using a Rabobank-backed digital dollar pegged one to one with the Australian dollar.

Using smart contracts to automate and execute the complexities of an inventory finance product goes a long way to automating timely business processes and reducing the cost and error rate when making loans under an inventory finance product.

A highly novel outcome of this proof-of-concept was the incorporation of a bank-backed digital currency, meaning real-time payment to the farmer was possible in a currency that the farmer recognized and was easily transferred from digital to traditional Australian dollars.

Additionally, using a distributed database to store qualitative and quantitative data on the commodity gives financiers, growers and traders a single truth view of the commodity, valued in real time against existing contracts between the growers and traders.

These pilots have established the ability to eliminate counterparty risk by running commodity transactions on a blockchain, allowing the supply chain to operate with confidence. Farmers are assured they continue to own their commodity right up until the moment they are paid. Solving for this problem of matching delivery to payment is enormous for removing counterparty risk along supply chains.

Using blockchain enables grain buyers to be provided with flexible financing options. Because the ledger creates an immutable record of ownership, financiers are willing to lend at better rates as they have critical information about the commodity they are financing. The use of smart contracts also allows the building of more creative and innovative financing arrangements between non-traditional financiers and buyers.

Blockchain technology allows critical information about the farming, production, transport of agri-commodities to be immutably recorded. Attaching this data to the digital asset, enables it to move securely between participants along the supply chain. With the power to trace commodities and create data rich digital assets, the growing problems of food fraud and security across global agri-supply chains can be addressed with greater success.

The AgriDigital commodity management platform provides a ready network to transition to operating on the blockchain. This has allowed AgriDigital to prove out the technology and uncover the real benefits for users in using blockchain as a key part of the company's technology stack.


Some key challenges faced in building the blockchain application include:

1. Matching the physical to the digital. Although blockchain can be used to create a trustworthy and highly effective digital asset, participants need to be sure this represents what is happening in the physical world. Building a robust digital infrastructure of IoT devices, sensors and on site integrations is critical to providing this physical verification.
2. Gold standards. In many cases certifying systems are largely declaration based, relying on self-regulated compliance to the gold standard with minimal auditing and oversight. In some cases gold standards themselves are the subject of fraud. There needs to be confidence in data inputs and certifying standards to ensure blockchains are not only immutable but also accurate.
3. Connectivity remains a challenge for agriculture, with many participants throughout Australia and globally facing intermittent or largely absent Internet connections.
4. Incentives and cooperation: supply chains are networks of diverse participants with widely varying interests. The right incentives need to be provided by way of efficiency gains, improved liquidity and data security to ensure decision makers buy in across the entire network.

AgriDigital aims to implement its cloud based SaaS product and blockchain protocol as sustainably as possible. Thus it aims to eliminate counterparty risk and inefficiencies and bring greater autonomy and control to farmers and their agribusinesses.

With global caloric demand said to increase by 70 percent by 2050, and China's protein consumption increasing 3-4 percent annually, the agriculture industry is definitely needs to grow. AgriDigital aims to support this growth in a way that reduces fraud and risk over the entire supply chain. The AgriDigital protocol aims to be a low cost product accessible to all participants across the supply chain. The aim is to put control and value back in the hands of farmers, allowing them to monetize their data and receive real time payments and finance.

Some claim that in a few years' time blockchain will be as ubiquitous as the Internet. Others believe that blockchain is all hype, that it is an untested technology with huge risks and little upside. Farmers have always been eager adopters of technologies that make sense and deliver real value. It's clear that blockchain has great potential to solve significant problems in agriculture.



AgriDigital's pilot programme has continued to test its logic and technical solutions over the past 18 months. Each iteration has included advances in the technology stack and more complicated transactions and finance arrangements.

Although the company has been working to test its solutions exclusively in the Australian grains industry, it is arguably applicable to a variety of commodity supply chains. AgriDigital is currently working alongside large rice and cotton businesses to test the solution for other agri-commodities. The challenges faced along these supply chains are similar to the grains industry. The solution has been primarily designed to interface with the AgriDigital commodity management platform so AgriDigital is working to see how users operating through a different application layer can interact with the underlying blockchain protocol.

In 2018, AgriDigital is commercializing the blockchain protocol for the trade and finance of global commodity supply chains.

Commodity supply chains are complex networks of production, processing, distribution and marketing channels with multiple participants who have widely varied interests. Supply chains are typically characterized by competition rather than cooperation, with a lack of trust between buyers and sellers who each store their trade, finance and production data separately.

Despite the global movement towards digital economies, agriculture remains one of the world's least digitized industries. In many ways, agriculture missed out on many of the benefits of the first wave of the Internet and associated technologies because of a lack of connectivity and ready technical skills. Blockchain has been coined the second coming of the Internet, and AgriDigital is working to ensure agri-supply chains do not miss out again.

AgriDigital has been implemented in the Australian market, with the initial global market identified as the North American market. However, making the technology available across developing economies will be critical to achieving the company's goals in providing payment security for farmers globally. These economies have a unique ability to use technology to "leap frog" and AgriDigital aims to increase trust and transparency to these supply chains providing payment security and business opportunities for smallholder farmers, access to finance for buyers, and increased food security.

In order to commercialize the solution, AgriDigital is addressing some widespread business concerns with blockchain technology such as providing transactional data privacy. Although blockchain can be used to increase transparency and provide data security, in many commercial instances users do not want all of the details of a transaction to be made completely public. This is an area of technical development for the technology, and AgriDigital is working to see how these advances can be incorporated into its technology in order to scale its solution.

Farmers' story

AgriDigital's initial blockchain pilot in 2016 executed the world's first settlement of a physical commodity on a blockchain. The pilot captured real-time data of a grain sale between a grain grower and a buyer, and then executed that transaction on a blockchain. The grower was David Whillock of Whillock Pastoral Co Pty Ltd who delivered a load of wheat comprising 23.46 metric tons to Fletcher International Exports (FIE).

For Whillock, the delivery was business as usual, arriving at the site in Dubbo, moving across the weighbridge and testing the quality of the grain at the sample station. However, at the moment of taring off at the weighbridge, the settlement occurred on the blockchain and simultaneously the payment was created: a global first for the agriculture industry.

"The new blockchain technology will benefit farmers such as Whillock Pastoral Company by providing fast and secure payment of grain," commented David Whillock, "knowing that we will be paid on delivery will assist in maintaining regular cash flow, helping us better and more confidently manage our business".

Fletcher International Exports (FIE) was the first customer on board AgriDigital's blockchain enabled commodity management platform. According to Rodger Fletcher, Chairman of FIE, "We never want to see another IT guy in here who doesn't understand the industry and our business. Things are changing fast and we're excited to have AgriDigital as our technology partner for the future."

FIE was founded in 1967, and over the last 50 years has earned a global reputation for innovation and leadership in the agriculture industry. (From the first abattoir in Australia to implement carcass inverting, leading the movement in paying employees electronically, to building an inter-modal freight depot with a direct service to the export container terminal in Sydney on their own trains, FIE has always been at the forefront of the industry. As CFO Kent Dickens explains, "Chairman Roger Fletcher is a true innovator who is always happy to try new ways of doing business, especially when it can help the industry or find new ways to deliver value."

FIE decided to use AgriDigital's commodity management solution for the 2016-2017 harvest after struggling to manage and account for grain ownership on their existing system. At the same time, FIE was planning to roll out a new site plan to manage deliveries during harvest more efficiently, and were looking to implement a commodity management IT system to support the new process and manage ownership issues. According to Corporate Accountant Elizabeth Mitchell, FIE chose AgriDigital because of the team's diverse technical and industry expertise. "When [founders] Bob, Ben, and Emma approached us, we were confident in their agriculture and grains knowledge, and knew that they had the right experience to deliver a solution for us."

FIE continues to use AgriDigital's commodity management solution to handle contracts, deliveries, invoices, cash prices, and payments throughout the grains harvest. FIE also uses AgriDigital as a customer-facing platform to manage their business communications with farmers, including SMS notifications to alert farmers of deliveries. "The intuitive way that

AgriDigital helps us to deliver information to our farmers has been great for us, and for the farmers. SMS notifications remove a lot of pain for us – our farmers don't need to ring up anymore, because they just know what's going on," said Elizabeth Mitchell. According to Kent Dickens, improving the flow of communications, "fostered better relationships with our farmers, and gave them confidence that FIE will be here for them in the future and are prepared to invest in technologies that make the industry better." Jake Young, Office Manager for FIE, was involved in the decision to implement AgriDigital instead of a custom IT solution. Young explains, "ultimately AgriDigital was cheaper, faster, easier to use, and provided more functionality."

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Pexels/Matthias Zomer

Blockchain for livestock traceability



Building blocks: using blockchain for cash-based transfers

In recent years, local economic development and market growth have spurred a shift in the way governments, United Nations agencies and NGOs deliver humanitarian assistance. The World Food Programme (WFP) has recognized that in many contexts, populations can be better served through markets, rather than traditional in-kind food assistance. To enable this shift, WFP's food assistance portfolio has become more diverse.

WFP delivers cash assistance, so that the people in need benefit from greater choice, more balanced diets, and higher purchasing power. Whether it's a sudden onset emergency or a protracted relief and recovery operation, WFP must ensure the most agile, effective supply chain possible to deliver cash, vouchers, food aid, or a combination of all.

Today, WFP is testing blockchain technology as part of its "Building Blocks" pilot, to make cash transfers more efficient, secure and transparent. This could save millions of dollars. In particular, WFP is using blockchain to deliver food assistance more effectively to some 100 000 Syrian refugees in Jordan.³⁶ The aim is to reach all 500 000 refugees living in camps and in host communities in Jordan in 2018. WFP is also exploring the use of blockchain in other areas, such as supply chain operations and the management of personal data. A blockchain collaboration platform, in fact, could benefit the entire humanitarian community.

Blockchain is a way of organizing data through a distributed ledger, that is, a body of information that is shared and synchronized among many people and places. The data updates itself across the system. It is a trusted way to track the ownership of assets without the need for a central authority. This can speed up transactions while lowering the chance of fraud or data mismanagement. The ledger records transactions in a secure manner that cannot be changed by any party. It allows any two parties to transact directly and removes the need for third party intermediaries such as banks or other institutions.


In January 2017, WFP tested a proof-of-concept algorithm to confirm basic assumptions about the capabilities of blockchain in authenticating and registering transactions in Sindh Province, Pakistan. In May 2017, WFP launched a pilot covering 10 000 Syrian refugees in Azraq refugee camp. In January 2018 this was extended to cover 100 000 refugees living in camps.

As a result, WFP has a full, in-house record of every transaction that occurs at a particular retailer. There is greater security and privacy for the Syrian refugee families, as sensitive data do not have to be shared with third parties such as banks or phone companies used for mobile money transfers. This significantly improves accountability and simplifies the reconciliation and payment process.

³⁶ For recent reporting on WFP's use of blockchain see the following:

Fast Company magazine: <https://www.fastcompany.com/40457354/how-blockchain-could-transform-the-way-international-aid-is-distributed>
Reuters: <https://www.reuters.com/article/us-un-refugees-blockchain/u-n-glimpses-into-blockchain-future-with-eye-scan-payments-for-refugees-idUSKBN19C0BB>

See also the WFP website: <http://innovation.wfp.org/project/building-blocks>



The pilot in Jordan has allowed WFP to reduce third-party Financial Service Provider (FSP) fees by 98 percent, which means that approximately USD 150 000 will be saved each month when the system is scaled up to all Syrian refugees in Jordanian camps. Further savings derive from WFP no longer needing to verify data between FSPs, vendors and in-house records. Also, WFP will be quicker to spot discrepancies, deal with complaints and respond to queries.

Finally, the system relies in part on the current use of biometric authentication powered by UNHCR, the UN Refugee Agency. It is integrated with the current identification system, which allows Syrian refugees to purchase food from local shops using a scan of their eye instead of cash, paper vouchers or credit cards. Nothing changes in the experience for the refugees themselves or the retailers. The only change is how the data is processed at the “back-end”.

By harnessing the power of the blockchain for cash-based transfers, WFP has been able to reduce payment costs, better protect beneficiary data and control financial risks.

Through Building Blocks, WFP leads the UN’s largest blockchain pilot. In 18 months, WFP has taken the project from idea stage to large-scale implementation in Jordan.

Realizing the full potential of blockchain technology, and in particular the Building Blocks system, is also in large part dependent on collaboration between humanitarian actors, governments and others serving the needs of vulnerable communities. WFP is offering the use of its blockchain design to others who are interested in building up a broader enabling ecosystem.

The fast and efficient scale-up of frontier technologies, such as blockchain, is somewhat constrained by outdated procedures, rules and regulations designed to eliminate risk. This constraint can be overcome by creating an innovation friendly operating environment and an enabling ecosystem to keep pace with the extreme pace of technological advancement.

Blockchain offers huge potential to improve the flow of information between different organizations and actors in the humanitarian space, and to optimize response efforts. WFP believes that a blockchain collaboration platform facilitates collaboration among the entire humanitarian community.

The successful development of Building Blocks is in part based on the role of WFP’s Innovation Accelerator. Formally launched in 2016, the Accelerator is a creative, collaborative environment that invites the private sector, civil society and WFP entrepreneurs to tackle humanitarian and development challenges together.

Cutting-edge techniques such as a lean startup approach and human-centered design keep the needs of the people WFP serves front and centre, and mean that new technologies are built and tested in an agile manner.

Building Blocks is one of the leading projects to have been identified and supported by the Innovation Accelerator.

As stated earlier, the pilot in Jordan has allowed WFP to reduce third-party Financial Service Provider (FSP) fees by up to 98 percent. Cost-savings allows WFP to invest in further development and scale, and ensure donor money stretches further.

In relation to Building Blocks, WFP now reaches 100 000 Syrian refugees and plans to reach all 500 000 refugees in camps and in host communities in Jordan by June 2018.

In addition, WFP is also exploring the use of blockchain in other areas such as supply chain operations and digital identity management. WFP wants to work with partners and other stakeholders to develop digital ID systems that are modular, secure and interoperable.

Having accurate and up-to-date information on the status and location of cargo, for example, would enable WFP to track the entire journey of goods, optimize various receipt, clearance and distribution stages and eventually better manage complex supply chains.

Blockchain may also provide a solution for improved digital identity management. Already for the current pilot in Jordan, each participating refugee has an identifier on the blockchain. This identifier can be enriched with data such as health records, education data, asset registries, and also support full ID “cards” where people lack birth certificates, passports, social security cards or other forms of legal identity. Blockchain also boosts privacy in that people (as opposed to third-parties such as banks) are in control of their own data.

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AgUnity: blockchain for the greater good

Forty percent of the world's population earn their income from agriculture, however over 50 percent of their crop value is lost between harvest and sale. Simple things that were solved decades ago in the developed world are often insurmountable challenges for farmers in the developing world. This includes crop spoilage, poor planning, corruption, unreliable record keeping and a lack of equipment. Two billion of the world's unbanked are small family farmers, typically living on two or three acres of land and a few dollars a day (a billion of these live on less than USD 1.25 per day).³⁷ These farmers rarely have access to machinery or equipment to assist in the planting, growing and harvesting of their crops, with almost all tasks being undertaken manually. There is also significantly restricted market access, and they rely on local middlepersons who offer disproportionately below market prices for their crops. These farmers also have no access to any financing such as microloans that would allow them to purchase better quality seeds or to rent farming machinery. Finally, these farmers also have no access to information on best farming practices or how to get the most out of their land.

One solution to the above problems promoted widely by FAO, the Gates Foundation and the International Finance Corporation (IFC) is the creation of farming co-operatives run for and by local farmers.³⁸ Co-operatives harness the power of collective bargaining (for example, better prices at the market and cheaper supply purchase costs), create a network between farmers within which they can agree to share equipment and resources at an agreed price/trade, and provide farmers with access to market information that can help farmers select more profitable crops to plant.

However, farming co-operatives face significant challenges, including poor record keeping, a lack of documentation, corruption and graft. It is widely acknowledged that smallholder farmers will contribute the majority of the extra 60 percent of the food required to feed a population of more than nine billion by 2050. It is also widely acknowledged that co-operatives can play a significant role in helping farmers grow more and earn increased incomes.³⁹

Within this context, AgUnity has developed a solution that is providing a pathway to financial inclusion for the world's poorest farmers. The AgUnity App is a simple mobile service that helps small farmers plan, trade and track everyday transactions. This is a way for farmers to cooperate, store value, save money and easily buy products and services.

The application ensures that everyone gets paid by creating a secure record when smallholder farmers hand over their crops to a co-operative, or hire another farmer's equipment. Issues and disputes currently arise when a farming co-operative and a farmer disagree over a previously agreed price for a crop or even the total volume of the crop provided, either because of graft or simply because of a lack of proper documentation. Many smallholder

³⁷ <https://www.ifad.org/documents/10180/666cac24-14b6-43c2-876d-9c2d1f01d5dd>

³⁸ http://www.fao.org/fileadmin/templates/getinvolved/images/WFD2012_leaflet_en_low.pdf; <http://www.nuruinternational.org/blog/agriculture/improving-agricultural-value-chains-through-farmer-cooperatives/>

³⁹ <https://www.rt.com/news/world-food-security-2050-846/>

farmers have very low levels of literacy and cannot read or write, putting them at a significant disadvantage with co-operatives who typically have more educated farmers running the administration. In the farming communities of Nanyuki, Kenya and Bougainville, Papua New Guinea, these kinds of disputes have led to low levels of farmer engagement or the total disbandment of co-operatives altogether.

Following the methodology of Human Centred Design (HCD), the AgUnity App has been developed in partnership with the farmers who are to use it, and is based on the willingness to truly understand the challenges of smallholder farmers.

Getting to know the challenges that smallholder farmers have to face was not easy for the AgUnity App team of developers. Many areas with large groups of poor smallholder farmers, including Nanyuki, have previously been the target of government/NGO support programmes that have not delivered on their promises, and farmers are wary of outsiders (especially foreigners from the West). It was only after several months of interacting with these farmers that the team of developers was able to gain their trust and further insight into how they lived/farmed.

Initial observations of these farmers' key challenges included: a lack of access to machinery; limited storage facilities and associated spoilage issues; issues with delayed or disputed payments; and a lack of documentation of crop transactions to name but a few. The information gathered on the ground informed the team's gap analysis to determine what would be the desired outcomes and how best to address these using a smartphone application.

After multiple iterations, a final version of the App was deployed to farmers to use for their wheat harvest the following season. The final version is designed around simplicity: the use of large, basic geometric shapes and the use of primary colours. It is intended to be used by illiterate farmers or farmers with low levels of literacy who can quickly remember the function and operation of each of key feature.

The results in both pilot projects were better than expected by the developers. Farmers who participated in the AgUnity pilot on average tripled their incomes in one season. Although this represents a significant increase, it still does not represent the full gains farmers can achieve through cooperation, which is fully enabled through an increase in financial ability to spend on inputs.

In the AgUnity pre-pilot study in Kenya, wheat yields were recorded at an average of three to six bags of wheat per acre. To put this in perspective, the commercial wheat farmers nearby produce between 20 to 26 bags of wheat per acre per season. The primary reason for the low production was a lack of farming equipment, with all planting, watering, harvesting and thrashing done by hand. Another major impediment was the inability of local farmers to purchase seeds at the right time for planting because of a lack of available funds, resulting in late seeding and poor crop growth.

In Papua New Guinea the gains were as significant as those in Kenya, however for different reasons. The biggest impact the AgUnity App had on local cacao farmers was to enable them to plan with the co-operative, using a smartphone, when they should pick their green cacao beans so that the co-operative could organize to collect the beans in a timely manner

and thus avoid spoilage. Although the total amount is hard to quantify, based on farmer interviews and several on-farm visits, estimates were that 50 percent of the green cacao picked was spoiling because of a lack of planning and co-ordination between the farmers and the co-operative. This was simply because rather than coordinate the picking and collection of the beans the farmers would pick the cacao beans and pack them in bags to leave by the side of the road for the co-operative to collect them, which meant they could be there for several days. By planning with the co-operative each individual farmer could set a collection time and date with the cooperative and thus almost the entire 50 percent loss was recaptured for the farmers using the AgUnity App.

The next biggest factor contributing to the rise in incomes was that with increased contact and planning with the co-operative, engagement levels rose from 65 percent of the co-operative members to just below 100 percent of all members. This means farmers who preferred to sell their green cacao beans directly through a middleperson instead of through the co-operative were now selling their crops to the co-operative, which was able to ferment and dry these beans thus dramatically increasing their value. The majority of this value is passed on to the farmers but also generates increased revenue for co-operatives with higher net sales of each crop.

The AgUnity App includes the use of blockchain (also known as distributed cryptoleger technology) to record transactions, ensuring security and transparency. As opposed to traditional methods of recording and storing information in a centrally-controlled database, blockchain works by distributing multiple identical versions of the same database to locations all over the world (known individually as a “node”). Whereas previously a hacker might be able to penetrate the firewall of a single database, now hackers are required to attack every single node simultaneously to change records, something that has not happened on any blockchain because of the extreme difficulty of execution. To add a new record (also known as a “block”) to the database (also known as a “chain”), each node first confirms that the details of the new record are correct (that is, has the correct cryptographic identification) and if they all agree, the new record is written into the database. This is of necessity a simplistic explanation of blockchain, but the main advantages are that it is an extremely secure method of recording transactions that doesn’t require a middleperson (such as a bank) to verify each transaction and therefore becomes much cheaper and more efficient to execute.⁴⁰

The major success factor, particularly in Kenya, was the ability to deploy key personnel to be a dedicated on-the-ground resource for farmers. This enabled the direct relationships and trust to be built with the farmers targeted and to gain an intimate insight into how they lived and farmed. Without spending numerous hours talking with individual farmers and spending time with their families, and also demonstrating a willingness to live in their community, it would have been otherwise impossible to convince the farmers that the project was designed to help them.

In Papua New Guinea, the team of developers met and partnered with a local community leader who had established connections with the cacao farmers and co-operatives. Ursula Rakova, who most notably gave a keynote speech at COP21, is Managing Director of Tulele

⁴⁰ <https://www.weforum.org/agenda/2016/06/blockchain-explained-simply/>

Peisa, and has been tasked with helping her people relocate from the climate-ravaged Carteret Islands to mainland Bougainville. Ursula was actively looking to increase the engagement of local cacao farmers and the AgUnity solution enabled her to do this, while also providing farmers with a means of planning to ensure their crops would be collected. Future rollouts of the AgUnity solution will be done in closer alignment with the Papua New Guinea scenario, whereby the developers partner with local community leaders (or in cases of large-scale roll-outs, partnerships with NGOs on existing development projects) who have established relationships with the farmers and co-operatives.

The two most notable constraints faced in the pilot projects, were the wariness of farmers to engage with the developers in Kenya and a lack of telecommunications coverage in both Kenya and Papua New Guinea.

In Kenya, it was possible to overcome the wariness of farmers through persistent engagement and by some of the team of developers choosing to live within the farming community.

The lack of telecommunications coverage was overcome in Kenya through using a Kenyan innovation called the “BRCK”, a device that acts as a signal booster in areas of low reception. In Papua New Guinea, the pilot was challenged by a significant number of farmers being located in areas with little or no reception. To address this, a QR-handshake feature to the App was built that allowed farmers to record transactions offline that were then reconciled the next time the farmer went online.

Farmers need to feel 100 percent sure they won't be cheated if they agree to cooperate to share equipment and buy and sell together. If all farmers feel that they won't be cheated, or at least that they are only as likely to be cheated as any other participating farmer, then the pilot projects suggest they are willing to work together.

Telecommunications coverage remains an issue, however this is rapidly changing in many developing countries, as telecommunications companies seek to expand their user base in all areas. Unfortunately, you cannot always rely on connectivity so there needs to be a satisfactory backup plan if you are working with a mobile product.

If smallholder farmers agree to plan activities together, and harness the power of economies of scale, there is huge potential to increase their incomes and lift them out of poverty.

The farmer-owned co-operative model is not a new one and has been successfully employed by farmers as a means of improving harvests and incomes for centuries. The key challenge faced by farmers in areas where education is limited and corruption and graft is commonplace, is protecting themselves and their families from being cheated. The lack of trust to work with their neighbouring farmers and even the farming co-operatives tasked with helping increase their output and revenue is a profound challenge and one that unless overcome is likely to see these farmers remain stuck in a cycle of subsistence farming and all the trials that come with it. The AgUnity App solves this problem for farmers, is currently provided free of charge to them and requires only a basic smartphone to operate. Once farmers and a co-operative are established on the platform there is little ongoing support required and although challenges will inevitably remain, both groups benefit significantly from the ongoing co-operation.

The use of the AgUnity App was successfully replicated in Papua New Guinea, and currently it is being rolled out in a further four countries by the end of 2018. The App has been designed to be used by any individual and with any crop, however modifications are required when first encountering a new workflow in a new area. As its use continues to expand and more data on how the App is being used in multiple locations are forthcoming, the App can continue to be refined to ensure it can scale to the billions of low-income farmers all over the world.

Beneficiary testimonies

“Since we have been using the AgUnity phone app I feel like my co-operative’s members are able to catch up with time. I am impressed and excited to see how this technology will continue to increase our income. Thank you AgUnity!” – Ursula Rakova

“I use the phone to cooperate with the other farmers, to book equipment or to arrange a time and day to pick up the harvest. This makes my farming much more efficient.” – Alfred Mutethia

Other stakeholders engagement:

1. **NGOs.** These work with potential partners such as International Finance Corporation (IFC), Gates Foundation, Asian Development Bank, African Development Bank, United States Agency for International Development, Australian Agency for International Development, United Nations Children’s Fund, World Food Programme, to give funding to provide smartphones and the AgUnity App to farmers for free, and resources to coordinate farmers into farming co-operatives.
2. **Investors** (e.g. Utopian Ventures, Artesian AgTech Fund), to provide capital to support product development and partnership building for AgUnity.
3. **Suppliers** (e.g. MySundaya (solar lighting), IOTag (cattle tracking devices), Kopernicc (various ethical products) etc., who sell goods and services via the Marketplace on the AgUnity App.
4. **Farming Co-operatives**, to facilitate the collection and sale of crops, and to act as a financing agent on behalf of farmers.
5. **Smallholder Farmers**, who use a smartphone and the AgUnity App to record transactions, plan farming activities, coordinate crop collections, lease out farming equipment, and purchase goods and services.

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Blockchain for digital identity

Annex 1:

Selections from a list of blockchain initiatives for social good

ID	Sector (primary)	Description	URL(s)
1 Bext360	Agriculture/Supply Chain	<p>Coffee is the world's second-most-traded commodity, after petroleum. Some 125 million people make a living growing coffee, according to estimates from the Fairtrade Foundation. Most are smallholders, or small-scale farmers whose families live on less than USD 2 a day. A Denver-based company, Bext360, is using a combination of visual assaying and weighing (also known as a mobile robot), and blockchain for this problem. It allows buyers of coffee to rapidly analyze the quality of a farmer's product in the field and weigh it. The robot uses optical sorting to understand what percent of coffee cherries look perfect or spoiled in a batch. A batch, typically a 30 lb to 40 lb bag, will get higher or lower marks, which are revealed to both buyers and farmers on the spot. They then negotiate a fair price through the bext360 mobile app. The combination of a reliable tracing and blockchain technology allows the company to aspire to bring complete transparency to the coffee supply chain, and other commodities, including cocoa.</p>	<p>www.bext360.com</p>
2 UNHCR / UN	Digital Identity	<p>The United Nations Refugee Agency (UNHCR) has spent the last several years developing a digital ID system for refugees with the aim of meeting three objectives: (1) to rapidly determine what benefits and services a person needs; (2) to provide secure identities; and (3) to improve documentation to help long-time refugees find permanent solutions. UNHCR determined that these objectives could be met using a centralized solution developed by Accenture, which they are now rolling out. More recently, however, Accenture and Microsoft announced a prototype for a digital ID network that uses blockchain technology and runs on top of the UNHCR ID management system.</p>	<p>https://www.reuters.com/article/us-microsoft-accenture-digitalid/accenture-microsoft-team-up-on-blockchain-based-digital-id-network-idUSKBN19A22B</p>

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3 Clean Water Coin + CharityWater	Water & Sanitation	The Clean Water Coin Initiative is the first ever coin designed and developed to be a nonprofit organization. What does that mean? It is a registered nonprofit organization and that has created a crypto charity and coin that lets a community actively participate in helping provide clean water. The nonprofit has teamed up with CharityWater.org to create campaigns and raise funds for clean water projects.	http://www.cleanwatercoin.brg/ www.charitywater.org
4 Provenance	Agriculture/Supply Chain	Provenance uses blockchain technology to track products through the supply chain: materials, ingredients, and impact, to provide consumers with greater transparency about a product's authenticity and origin. Its use of the technology – in the format of a real-time data platform – allows the end user to see each step of the journey the product has taken: where it is, who has it, and for how long? Producers can benefit from this increased authenticity when telling the story of their goods.	provenance.org/whitepaper provenance.org/tuna provenance.org/news
5 Full Profile	Agriculture/Supply Chain	Full Profile is enabling real-time transactions for farmers through “smart contracts” that run on blockchain. Because pre-approved logic can be built into a blockchain—as long as all parties have opted in—payments can be made immediately following the transfer of asset ownership. Full Profile has estimated that supply chain risk, inefficiencies, and insolvency cost the Australian grains industry AUD 1 billion, a significant proportion of which can be recouped through blockchain solutions.	www.fullprofile.com.au
6 Heifer International	Agriculture/Supply Chain	Heifer is using blockchain technology for fundraising and the food supply chain.	https://www.heifer.org/about-heifer/press/press-releases/2017/arkansas-farmers-take-the-mystery-out-of-meat.html

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7 Bill and Melinda Gates Foundation	Financial Inclusion/ Remittances	Financial inclusion.	www.gatesfoundation.org
8 WFP	Financial Inclusion/ Remittances	<p>The UN's World Food Programme (WFP) recently conducted a successful pilot project in Jordan, where it used an Ethereum-based blockchain to manage cash-based transfers to 10 000 Syrian refugees living in the Azraq camp in Jordan. For WFP staff, the project has increased transparency and dramatically reduced costs. Whereas the WFP pays Jordanian banks a fee of 1.5 percent to facilitate cash transfers, the fee to conduct transfers via the blockchain is nearly zero. The organization hopes to expand the pilot to cover all WFP beneficiaries living in camps in Jordan by November 2017 (adding 100 000 people) and all beneficiaries living in communities (an additional 400 000 people) by January 2018. The WFP estimates that once the pilot is fully scaled up, it will pay only USD 150 in monthly financial service fees, compared to USD 150 000 today.</p>	<p>http://innovation.wfp.org/project/building-blocks</p> <p>https://www.fastcompany.com/40457354/how-blockchain-could-transform-the-way-international-aid-is-distributed</p>
9 AID:Tech	Digital Identity	<p>Application areas deployed to date: international aid, welfare distribution, remittances, healthcare delivery.</p> <p>AID:Tech focuses on the delivery of digital entitlements using blockchain and digital identity. It was the first company in the world to successfully deliver international aid to Syrian refugees in Lebanon using blockchain technology.</p> <p>The company's products and services help clients and partners address some of the world's largest social issues as well as targets set out by the UN's Sustainable Development Goals – signed on by over 190 countries. AID:Tech's solutions offer unprecedented levels of insight into performance, transparency and efficiency – generating rich datasets which governments, NGOs and charities can harness to improve how funds, products and assets are distributed and tracked.</p>	<p>https://aid.technology/use-cases/</p> <p>https://www.unglobalcompact.org/sdgs/sdpioneers/2017/joseph-thompson</p> <p>https://www.businesswire.com/news/home/20171002006483/en/Tech-Integrity-Challenge-Announces-Final-Awards</p> <p>http://startupeuropeawards.com/the-irish-winner-in-social-category-is-aidtech/</p> <p>https://newsroom.mastercard.com/press-releases/latest-mastercard-start-path-program-includes-blockchain-digital-identity-and-healthcare-fintechs/</p>

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10 SecureKey and IBM	Digital Identity	<p>SecureKey and IBM are now piloting a digital ID system in Canada using the Linux Foundation's open-source Hyperledger Fabric blockchain. The project connects the Canadian Government (including national and provincial government agencies) with the country's largest banks and telecoms on a permissioned blockchain network. These participating companies and agencies play a dual role of certifying users' attributes and providing digital services. The project is expected to go live in late 2017, at which time Canadian consumers will be able to opt into the network to access a variety of e-government and financial services by sharing verified attributes stored on a mobile phone.</p>	<p>www.securekey.com</p>
11 Chromaway	Land Rights/Land Registries	<p>Founded in 2014, ChromaWay has been on a mission to simplify the land title registry system without having to reinvent the wheel. ChromaWay cooperates closely with the Swedish Office of Geodesy (the science of measuring and mapping the Earth's surface). A consulting company and a telecommunications provider are also on board. The system uses the Bitcoin blockchain in order to keep a record of the many "fingerprints" that are taken during a house purchase, for example. The company is trying to use technology to optimize the classic method of real estate acquisition and its subsequent registration, and to integrate pre-existing facilities. Every participant (buyers, sellers, brokers or land title registries) must be verified through an app, after which they can proceed with just a few clicks. The ChromaWay system is designed to provide support and to save time and money. The ChromaWay project has been the most promising of these projects so far, thanks to its many partnerships and the developers' many years of experience. In March 2017, they will conduct a large-scale test, which will also involve other official parties.</p>	<p>www.chromaway.com</p>

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12 BitLand and BenBen	Land Rights/Land Registries	A local not-for-profit startup, BitLand, in Ghana is using Bitcoin's blockchain to manage land titles and settle land disputes. BitLand is closely working with local institutions whose mandate is to issue land titles and who are willing to try new technologies to solve issues that have been outstanding for decades. BenBen is yet another startup in Ghana working on the same topic.	www.bitland.global.com www.benben.com/gh
13 Blockchain for Change	Digital Identity	NYC is a startup specializing in the implementation of blockchain technologies to advance transparent and accountable social impact projects and organizations. It launched Fummi to help the homeless by providing a digital ID.	https://blockchainforchange.org
14 OneID84	Digital Identity	OneID84 provides multiple-factor authentication and Single Sign-on services, among others.	https://www.ictworks.org/eight-practical-blockchain-use-cases/#.W7bQjXMzAlI
15 Namecoin	Digital Identity	Namecoin developed key technology for potentially protecting and authenticating personal identity, fostering freedom of speech and preventing surveillance.	www.namecoin.org
16 Rupee Blockchain	Financial Inclusion/Remittances	Rupee aims to facilitate money remittances and enable merchants to accept a fast cryptocurrency for goods and services. Its goal is to enable the people of South Asia to cut out traditional middlepersons such as banks.	https://rupeeblockchain.org/

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17 Skuchain	Agriculture/Supply Chain	<p>Skuchain applies the cryptographic principles developed in the Bitcoin network to provide security and visibility for the global supply chain. As goods travel from manufacturers to distributors to consumers, the crucial electronic information about what the item is and where it came from becomes disconnected from the stock keeping unit (SKU) itself. A blockchain offers a universal, secure ledger by which SKUs can attest digitally to their origins and attributes. Skuchain is building a system of next generation identifiers in the form of both barcodes and radio frequency identification devices (RFID) tags to digitally secure the transfer of goods across the entire global economy. Whereas most anti-counterfeiting systems rely on copy resistant labels, holograms etc., Skuchain relies on the uncopyable nature of a blockchain ledger to solve the problem of supply chain integrity. Skuchain's system will provide cryptographic proof of each SKU's origin and supply chain that can be verified all the way to the point of consumption.</p>	www.skuchain.com
18 Ambrosus	Agriculture/Supply Chain	<p>Combining high-tech sensors, blockchain protocol and smart contracts, we are building a universally verifiable, community-driven ecosystem to assure the quality, safety & origins of products.</p>	https://ambrosus.com/index.html
19 UNDP	Financial Inclusion/ Remittances	<p>UNDP is supporting cash transfers and financial tools in Serbia and Moldova, and has plans to expand to other countries soon.</p>	www.undp.org
20 Coinify	Financial Inclusion/ Remittances	<p>Coinify allows you to trade cryptocurrencies, use them as payment methods, or integrate them in existing services.</p>	www.coinfy.com

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21 MONI	Financial Inclusion/ Remittances	<p>Founded by Basemation mastermind Antti Pennanen, this fintech startup offers prepaid MasterCard so travellers can pay without charges, and a money-transfer app that allows interest-free loans between friends. Its profile soared in February 2016, when the Finnish immigration service announced it would use it to make payments to some of Finland's 50 000 refugees. The cards mean that the refugees can receive money — including salaries when they get jobs — and pay bills, without the need to open a bank account. The blockchain technology used by MONI doesn't require a financial intermediary, such as a bank, to process transactions. Instead, transactions are instantaneous between users, and a unique digital record is kept of each one. It's a cheaper payment system that is highly transparent. In addition to paying and receiving money, cardholders can also apply for a loan or credit through their mobile phone, either from friends or financial companies. The card encompasses a "circle of trust" where users choose the friends they would be happy to loan money to, setting a maximum amount, and friends can reciprocate. Loans between friends have no fees and no interest, and the service is free to use.</p>	<p>https://moni.com/ https://moni.com/assets/files/MONI_Finnish_Immigration_Service_press_release_3Dec2015.pdf</p>
22 Circle	Financial Inclusion/ Remittances	<p>Building off its original social payments business model, which allowed users send money (including Bitcoin) like a text, Circle unveiled a new open-source application called Spark in December 2016. Instead of creating a new blockchain platform, Spark adds tools that facilitate regulatory compliance and currency exchange on top of existing blockchain networks (including the Bitcoin and Ethereum blockchains), which it uses as a payments rail. Unlike some of its competitors, Circle charges zero fees for payment services, including remittances, believing that it can generate sufficient profit by offering other services, including credit, to its customers.</p>	<p>www.circle.com</p>

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23 KYC Chain	Financial Inclusion/ Remittances	Start-ups such as KYC Chain and Tradle have developed platforms that allow customers to record KYC verifications in a “digital wallet” stored on a distributed ledger and then share that information with other financial institutions when requested.	https://kyc-chain.com/
24 Regalii	Financial Inclusion/ Remittances	Regalii is an international mobile payments platform that allows immigrants to pay their families’ bills anywhere in the world through SMS.	www.regalii.com
25 WorldRemit	Financial Inclusion/ Remittances	WorldRemit provides an online service that lets people send money to friends and family in other countries, using a computer, smartphone or tablet.	www.worldremit.com
26 Somish	Agriculture/Supply Chain	Somish is using blockchain-based digital tokenized currency for the Bank of Papua New Guinea. The tokens can be exchanged for fertilizer for small farmers. Because the tokens are on a blockchain, they cannot be misused or imitated, ensuring that the government-allocated funds are creating maximum impact where intended.	www.somish.com
27 Cargill Risk Management	Agriculture/Supply Chain	Cargill Risk Management is looking at using blockchain to create immutable land titles to prove ownership and protect farmers from widespread corruption. They are also exploring the digitization of paper contracts into smart contracts to improve efficiency and minimize costs. Smart contracts also offer increased transparency, ensuring contracts cannot be altered without the farmer knowing.	https://www.cargill.com/price-risk/risk-management-home

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28 ICS	Agriculture/Supply Chain	ICS is developing accessible, affordable crop insurance in East Africa. In a world where poor farmers are made to pay high premiums, ICS's blockchain solution cuts out the middlepersons, providing low-premium, affordable crop insurance to rural farmers. It is hoped this technology will reach 10 million farmers in the next five years.	https://www.ics.nl/en/home/
29 AgriLedger	Agriculture/Supply Chain	Small co-operatives are currently by far the best way to improve efficiency in developing countries and help farmers retain a bigger share of their crop value. Co-ops presently rely on paper-based records, verbal promises, and complicated agreements; this frequently causes critical problems because of a lack of transparency, restricted access to price data, lying, graft, and corruption. AgriLedger is a mobile app that records and transacts incorruptible truth using blockchain technology. It is a complete framework of integrated services for delivering an even playing field to farmers and co-ops. This solid framework of trust allows everyone to know they are working, buying, selling, and sharing things according to a cryptographic "book of truth" that is utterly incorruptible.	http://www.agriledger.com/
30 Ripe	Agriculture/Supply Chain	Ripe.io is transforming the fresh produce food supply chain by enabling data transparency and transfer from farm to fork to answer: What is our food? Where has it been? What has happened to it? The company is exposing the journey of our food to create new analytics, automation and business models through blockchain technology and the Internet of things.	www.ripe.io
31 AgriDigital	Agriculture/Supply Chain	AgriDigital software solutions simplify commodity management, revolutionize supply chain finance, and bring traceability to agribusinesses.	http://www.agridigital.io/about

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32 Farmshare	Agriculture/Supply Chain	Farmshare utilizes blockchain currency to buy, sell and trade cryptographic tokens that can be exchanged for weekly deliveries of locally-produced organic food. The project is an evolution of the CSA model that has been around for decades, which takes advantage of the blockchain's potential for creating new forms of community property ownership, collaborative labour relationships, and locally-oriented alternative economies.	www.farmshare.org
33 Filament	Agriculture/Supply Chain	Filament lets you build a connected business without becoming an expert on security, scalability, or network stacks. Blanket a factory in sensors, or control the streetlights of an entire city – Filament's standalone networks span miles and last for years, all without WiFi or cellular connection. The Filament Tap lets you deploy a secure, all-range wireless network in seconds. Taps can talk directly to each other at distances of up to ten miles, and since each Tap has BLE, you can connect them directly to your phone, tablet, or computer. With built-in environmental monitoring, a USB port for your own sensor or device, and a battery life of up to 20 years, it's the perfect grab-and-go connectivity solution.	www.filament.com
34 The Seam	Agriculture/Supply Chain	The cotton industry exhibits inefficiencies throughout the supply chain. US commodities trading and agribusiness software provider The Seam, which has cleared or processed over USD 7 billion through its cloud-based platforms, is forming a blockchain consortium in conjunction with IBM for the billion dollar global cotton industry. The ownership group of The Seam includes renowned cotton leaders Calcot, Cargill, ECOM Agriindustrial Corporation Ltd., EWR, Inc., Louis Dreyfus Company, Olam International, Parkdale Mills, Plains Cotton Cooperative Association and Staple Cotton Cooperative Association.	www.theseam.com

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35	Financial Inclusion/ Remittances	Circles is an electronic cryptocurrency with the aim to create and distribute a globally accessible universal basic income.	www.joincircles.net
36	Financial Inclusion/ Remittances	Remittances.	www.abra.com
37	Financial Inclusion/ Remittances	Remittances.	www.rebit.com
38	Financial Inclusion/ Remittances	Helping the government to distribute public benefits using the blockchain.	
39	Financial Inclusion/ Remittances	Global FinTech and Blockchain network works with startups, industrial leaders, NPOs, and investors to develop and implement solutions for a better world.	https://www.fintech4good.co/
40	Financial Inclusion/ Remittances	Remittances.	www.bitpesa.co
41	Legal/Contracts	Open geospatial data for positive global impact, and improved decision-making.	www.radiant.earth
42	Financial Inclusion/ Remittances	Humaniq is a new generation financial services with its own cryptocurrency, which is aimed at eradicating poverty amongst millions of people living in the emerging economies.	https://humaniq.com/

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43 Factom	Land Rights/Land Registries	In 2015 the government of Honduras signed an agreement with Factom, a US startup, to use blockchains to manage land title registration and help manage fraud and corruption.	www.factom.com
44 Everex	Financial Inclusion/Remittances	Everex enables transferring, borrowing, and trading in any fiat currency, anywhere. No bank account required. With settling times below 30 seconds, transaction costs of a few cents, and global support.	https://www.everex.io/
45 Tokken	Financial Inclusion/Remittances	Provider of an application for mobile payments designed to extend banking services to unbankable businesses. The company's application uses an indelible blockchain ledger to ensure data integrity and a proprietary compliance programme based on structured analytic techniques, enabling users to have a secured banking transaction by linking users' bank accounts and avail themselves of cash back rewards.	www.tokken.com
46 Wala	Financial Inclusion/Remittances	Provider of an online financial management platform designed to help people reach financial prosperity by eliminating the barriers to banking. The company's blockchain-powered financial services platform and mobile application provide access to transactional banking, remittances, loans and insurance for the unbanked and underbanked and offer the tools to save, transact and connect all directly from a phone, enabling the users to get greater access to zero fee financial services and control and manage their financial data.	www.getwala.com
47 Arc-net	Agriculture/Supply Chain	Arc-net connects every step of a product's journey to deliver supply chain transparency and product security. The Arc-net toolset provides an easy to use scalable platform, powering the strategic insights that unlock profit.	www.arc-net.io

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48 Viant	Agriculture/Supply Chain	Viant is a blockchain-based platform for modeling business processes, tracking assets and building the supply chains of the future. Leveraging cryptographic security and smart contracts, Viant provides organizations verifiable insights as assets are managed and propagated through the entire supply chain.	www.viant.io
49 Unocoin	Financial Inclusion/ Remittances	Bitcoin wallet is implemented in India.	https://www.unocoin.com/
50 Genesis Research & Technology Group with MVP Asia Pacific Inc.	Water & Sanitation	US-based Genesis Research & Technology Group has developed, tested and patented a new water purification technology system that can be utilized for multiple applications, including oil and gas, industrial, food and agriculture, humanitarian efforts, and emergency and disaster relief. And in partnership with blockchain development company MVP Asia Pacific Inc., they are creating an Internet of things (IoT) water quality sensor to permanently store tamper-proof water quality records on the Ethereum blockchain.	https://www.genesisrtg.com/
51 Australian Water Partnership & Civic Ledger	Water & Sanitation	The Australian Water Partnership recently accepted Civic Ledger as a member. They completed a proof-of-concept algorithm that intends to increase transparency and capability of water market trading in Australia to help solve the water scarcity problem.	https://waterpartnership.org.au/
52 Programme for the Endorsement of Forestry Certification	Land Rights/Land Registries	Blockchain is being utilized at a rural level where the Programme for the Endorsement of Forestry Certification, which is responsible for more than 300 million hectares of certified forests, has been investigating blockchain as an alternative solution for tracing provenance; an example of SDG 15 – Life on Land in action.	www.pefc.org

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53 Humanity Road	Disaster Management/ Media Monitoring/ Fundraising	An award winning disaster response charity using technology to save lives. Humanity Road now accepts Bitcoin donations.	https://www.humanityroad.org/bitcoin
54 ixo foundation	Global Development	Facilitating global sharing of impact data from INGOs for foundations and aid and donor agencies creating transparency and removing the middleperson and potential for fraud and misuse of funds.	http://ixo.foundation/
55 Moneda PAR	Financial Inclusion	Moneda PAR is a social currency programme that is based on the mutual credit system philosophy and materialized under the form of LETS. Thus, the issuances of PAR are neither made out of thin air nor they are backed by a certain asset such as gold or the legal tender. Every PAR that is issued is backed by the transactions that take place within the community. Tokens are like a voucher for an existing product, service, or future ones. One PAR is worth for one Argentinean Peso. (Winner in the “shakers” category at the LaBitConf 2017 at the blockchain for humanity awards).	www.waba.network , www.monedapar.com , http://waba.network/moneda-par-awarded-in-labitconf-2017/
56 Stellar	Remittances/Payments	Stellar is a distributed, hybrid blockchain that is fully open-source. It is infrastructure that exists to facilitate cross-asset transfers of value, including payments. With just one integration into the Stellar Network, you will join an open, global financial network where all actors – be they people, payment networks, or banks – have equal access & economic participation.	https://www.stellar.org

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57 SeSo Global	Land/Credit Information	SeSo utilizes blockchain technology to solve the problem of the inability of secured lending in emerging economies. We aggregate land and credit data for our clients to easily analyze risk during the lending process. As the lending market increases and land titles are secured by the financial institutions, a digital land registry will be developed through our platform that is facilitating these digital transactions. We are confident our solution has the capabilities to unlock the trapped capital in emerging markets through facilitating investment in land and property.	http://seso.global
58 WiSeKey	Digital ID/Land Rights	"WiSeKey is a leading global cybersecurity company headquartered in Geneva, Switzerland currently deploying large scale digital identity ecosystems with a patented process. WiSeKey's Swiss-based cryptographic Root of Trust (RoT) provides secure authentication and identification in both physical and virtual environments for the Internet of things, blockchain and artificial intelligence." => In partnership with Microsoft and the Rwandan Government in order to set up a system for land rights.	https://www.wisekey.com/about/ ; https://www.wisekey.com/press/wisekey-and-microsoft-collaborate-to-support-rwanda-government-make-secure-transactions-using-blockchain-technology/
59 Civic	Digital ID	"Through our decentralized architecture with the blockchain and biometrics on the mobile device, our platform provides multi-factor authentication without a username, password, third-party authenticator, or physical hardware token."	https://www.civic.com
60 Ethic Hub	Financial inclusion	Ethic Hub is an ethical investment platform that gives access to investors to highly profitable positive-impact projects by connecting them to small unbanked producers through crowd lending. The company aims to break the international borders for money and also humanize the financial sector. Winners of the Blockchain4 Humanity Award in the financial inclusion category!	www.ethichub.com

Source: Original master list compiled by Stanford University (available at <https://docs.google.com/spreadsheets/d/14BPQlqnDUYinkp9eJ7bwYwsg22FJz0AVU9vOSSU94o/edit#gid=1835238919>).
Note: Some of the descriptions have been slightly amended.



Blockchain for food safety and traceability

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