Brussels Rural Development Briefings

A series of meetings on ACP-EU policy Development issues

Opportunities of Blockchain for agriculture

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The information in this document was compiled as background reading material for the 55th Brussels Briefing on "Opportunities of Blockchain for Agriculture"

The Reader and most of the resources are available at:

http://brusselsbriefings.net

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1. Context: Blockchain as an emerging digital technology

Business transactions in agriculture have been transformed by the digitisation of the value chain. The first big impact came with barcodes, which made it possible to track items through a value chain. Mobile data collection devices, more affordable sensors to track conditions, followed by the internet to transform links with consumers brought new applications. Mobile phones now take over many of these roles. Barcodes have been replaced with RFID and QR codes. However, there are still many challenges relating to the traceability of products and transparency in supply chain management, especially the fact that database systems managing transaction records were managed in isolation, they were not open to all the other stakeholders in the chain making transactions difficult to record and verify. While in many cases data had been recorded it was not possible to guarantee that these entries were not misleading either because of manual entry or the possible to change the database after data was entered. Blockchain is an emerging digital technology which has the potential to address these gaps.[1]

A blockchain is a digital transaction ledger, maintained by a network of multiple computing machines that are not relying on a trusted third party. Individual transaction data files (blocks) are managed through specific software platforms that allow the data to be transmitted, processed, stored, and represented in human readable form. Every transaction is disseminated through the network of machines running the blockchain protocol and needs to be validated by all computer nodes. The key feature of a blockchain is its ability to keep a consistent view and agreement among the participants (i.e. consensus).[2]

A ***blockchain*** *is composed of immutable blocks of data, each block containing a list of transactions and a unique reference to its predecessor block. Strong cryptographic techniques are employed to maintain integrity between each block and its predecessor. This allows blockchains to be shared and corroborated by anyone with the appropriate permissions. Blockchain may also be referred to as a distributed ledger, which is also commonly considered to be a specialised form of a distributed database.* ***Distributed ledgers (DLT)*** *are a multi-purpose technology in the digital world that are specifically designed to be shared across a network of multiple sites, geographies or institutions. Records are stored in a ledger that continues to grow. Often, as in the case of the Bitcoin blockchain, the underlying assumption is that the nodes forming the network are not implicitly trusted, i.e. they need mechanisms in place by which all parties in the system can reach a consensus on what the status of the ledger is.*[3]

Blockchains are distributed ledgers, with additional characteristics that make them distinctive:

- Cryptographic functions are used, including hashing algorithms
- Peer to peer synchronisation mechanism
- Consensus: algorithms that determine the sequence and validity of transactions
- Ledger: list of transactions that are bundled together in cryptographically linked blocks
- Validity rules: the network rule set determines what transactions are considered valid and how the ledger gets updated, etc.
- Crypto economics: a combination of cryptography and economics (game theory) that makes sure all actors in a decentralised system are incentivised to remain honest [4]

Information stored on the ledger is protected by a type of cryptography that gives each user two 'keys' – one key is kept private, and the others are made public – which work together like the two-key system used to access a safety deposit box. The private key, like a password or PIN, let the user 'lock' or 'unlock' their information and control when, and by whom, it is accessed. Other trusted 'nodes' on the network can then be given a public key so they can then read the unlocked information and double-check that it actually comes from that user.

Once an entry has been made, the record is time-stamped and given a 'hash' – a unique, mathematically-generated identifier that automatically ties each new record to the entry that came before it. This means that it is impossible for any user to amend, delete or duplicate a single entry in the blockchain without noticeably affecting all of the entries that are part of the chain, making fraud immediately visible to the others on the ledger. This simple innovation guarantees the integrity of the data stored on the blockchain, and allows users to reach a unanimous

consensus that every record is authentic and unchanged.[5]

Types of Blockchain networks

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

Public permissionless systems are those in which anyone can read/write data and make/validate transactions. In public permissioned networks, everyone can view the data but only individuals with permission from its owner can edit transactions. In **permissionless blockchains (private permissioned)**, the public is restricted from accessing the data in addition to the fact that only individuals with the owners' permission can make changes. Permissionless blockchains are gaining traction as a foundation for business-to-consumer (B2C) and consumer-to-consumer (C2C) use cases. Depending on what their needs are, an individual or organization can choose which type is most appropriate to deploy in their food system.[6] A **consortium blockchain** is 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.

Given that no central governance is an important feature of the network, for participants to be incentivized to run and trust the network, transparency is paramount.

Governments can improve efficiency in such areas as contract execution, social services, customer service and Ðexperience, risk management, transparency, and fraud. Blockchain enables a wide variety of transactions, including collecting taxes, delivering welfare benefits, issuing documents, and recording properties.

The company Goldman Sachs estimates that blockchain could facilitate global savings of up to US$6 billion per year in business transactions.[7] The World Economic Forum estimating in a study conducted in collaboration with Bain & Company that the removal of barriers due to Blockchain could result in more than US$ 1 trillion of new trade in the next decade.[8] The reductions in trade costs that the use of blockchain technology could potentially permit open particularly interesting opportunities for micro, small and medium-sized enterprises (MSMEs), which face proportionally higher fixed costs than bigger companies, in particular when they are small producers from developing countries.

Known primarily for its connection to bitcoin and other cryptocurrencies and digital payments, blockchain has far more potential, especially for agriculture.

What is new on blockchain?

While other technology options exist to help manage supply chains, blockchain can bring together different parties that have not directly established trusted relationships with one another through the transparency it provides and its tamper-evident nature. Blockchain stores every transaction or exchange of data that occurs in the network, potentially reducing the need for third parties and/or intermediaries by providing a means by which all parties in the network may share access to the same data, including what is added to the data, by whom, chronologically. Data cannot be removed. By enabling each party to see the same data, in near real time, and assure that 'you see what I see' from a data perspective, blockchain can help eliminate complex and costly data reconciliation required by most systems in the world today.[9]

1.1. Regulation of Blockchain

As any technology, DLT has a certain power of disruption across industries and applications.

Many of current legislative frameworks can apply to blockchain technologies (i.e. in finance, traceability).

Many institutions and authorities, however, apply precautionary monitoring and experimentation, rather than pre-emptive regulation; e.g. in Japan the Financial Services Agency (FSA) announced a "FinTech Proofof-Concept (PoC) Hub" designed to make it possible for financial technology companies, financial institutions, and others to evaluate issues in the areas of compliance, supervisory response risks, and the interpretation of legislation, etc. In the UK, the Financial Conduct Authority (FCA) has set up a regulatory sandbox to provide innovative initiatives with a safe space to develop without worrying about regulatory constraints. Across the world, more than 25 governments are actively running blockchain pilots supported by start-ups.[10]

Experts interviewed, and many European institutions, are of the opinion that DLT and blockchains are an implementation choice and specific legislation and regulations are not needed. Certainly, outside of the remit of financial applications, blockchains, and distributed ledgers more generally, are regarded as a net positive development rather than a threat to the position of major financial players and even official currencies themselves. At this stage, it seems there is need for more innovation, research, development, piloting and proof of concepts, unencumbered by specific additional legislation and regulation. Some experts feel that existing data protection law and guidelines (such as the EU General

Data Protection Regulation, the APEC Cross-border Privacy Rules, and the OECD Privacy Principles) can be applied to distributed ledger developments to create a 'best practice' environment for the design and deployment of the ledger itself, and perhaps more importantly the applications that use the services offered by the distributed ledger.[11]

Accenture, Microsoft and Avanade have built a permissioned blockchain which connects existing record-keeping systems from private and public institutions into one database including personal credentials that have been validated by multiple trusted parties (i.e. birth registration data from UNICEF; national ID numbers or voter documents issued by national registration authorities or electoral commissions; vaccination records from GAVI (global vaccine alliance) and other non-government organisations (NGOs) and refugee registration data from UNHCR. In practice, this means someone arriving at a border crossing could use the information stored on the blockchain to prove origin or access to aid. [12]

1.2. Policy initiatives on Blockchain

Over the last two years, the largest development organizations have begun to examine how using the technology might help them meet their goals. This includes the World Bank, which established a Blockchain Lab in 2017; the United Nations, which reports that 15 UN entities are carrying out blockchain initiatives; the Inter-American Development Bank, which is exploring the use of blockchain as a platform for asset registries; and USAID, which recently a published a primer on the topic. Several humanitarian non-profit organizations (NPOs) are also evaluating blockchain as a potential platform for aid distribution and developing their own proofs-of-concept. This is all happening as the number of start-ups pitching ideas continues to grow and distributed ledger models continue to evolve.[13]

Some groups and networks focused on Blockchain are starting to emerge, such as the Blockchain Research Institute[14] and the Blockchain Interoperability Alliance, an advocacy group that aims to develop globally accepted standards that would promote greater connectivity and interoperability between the disparate blockchain networks.

Various international organizations are also putting in place committees and working groups to look into the technology, including the ICC, ISO, the ITU, UN/CEFACT and the WCO. The IMF launched a High Level Advisory Group on Fintech, composed of senior bank executives, blockchain companies, regulators and academics, to study the economic and regulatory implications of blockchain technology (IMF, 2017), and an ISO committee was created in 2016 to develop standards to stimulate greater interoperability, speedier acceptance and enhanced innovation in the use and application of blockchain technology. More recently, in February 2018, the European Commission announced the launch of an EU Blockchain Observatory and Forum.

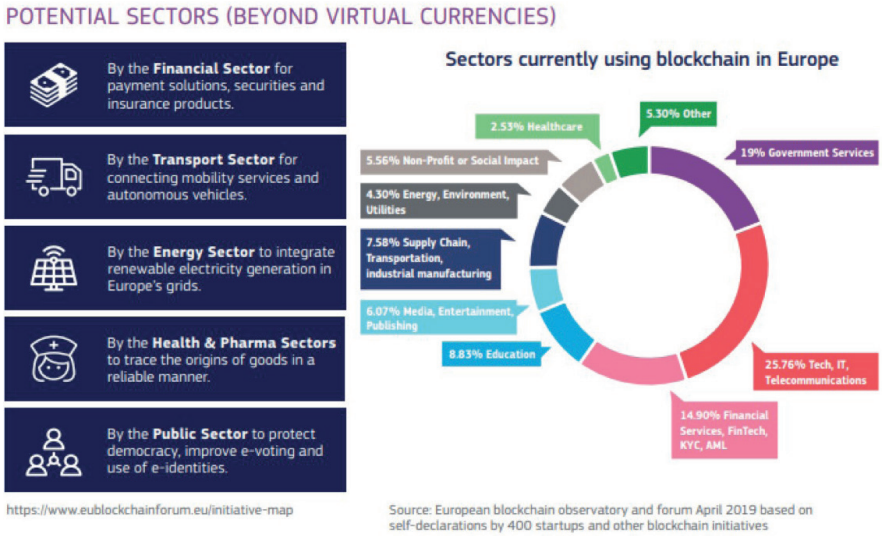
EU initiatives on Blockchain

EU Governments and the European Commission work on blockchain related actions. In May 2017, in the Digital Single Market mid-term review, the Commission recognised blockchain-inspired technologies as having huge potential for our administrations, businesses and the society in general. Also, the Council conclusions of 19 October 2017 highlight blockchain, along with artificial intelligence, as "key emerging trends".

There are regular interactions between the European Commission services and the blockchain constituencies, including organisations that envisage to use such technologies and are running proof of concepts or pilots. In the 1st EU blockchain Conference (11th May 2017), online polls from more than 600 participants asked Europe to take leadership on this topic.

European Blockchain Partnership

Since April 2018, 26 Member States plus Norway and Liechtenstein agreed to sign a Declaration creating the European Blockchain Partnership (EBP) and cooperate in the establishment of a European



Blockchain Services Infrastructure (EBSI) that will support the delivery of cross-border digital public services, with the highest standards of security and privacy.

EU Blockchain Observatory and Forum

On 1 February 2018, The European Commission launched the EU Blockchain Observatory and Forum. The EU Observatory has for objectives to map key initiatives, monitor developments and inspire common actions, inter alia. Since then it has released two thematic reports, the first one in July 2018 Blockchain Innovation in Europe, and the second one in October 2018 Blockchain and the GDPR.

It is a European Parliament pilot project and is being run by the European Commission's Directorate General for Communications Networks, Content and Technology (DG CONNECT). Partners include ConsenSys AG (general contractor), the University of Southampton, the Knowledge Media Institute at the Open University, University College London, and the Lucerne University of Applied Sciences.

International Association for Trusted Blockchain Applications (INATBA)[15]

The EU Commission on 6 March 2019 facilitated the foundation of the International Association for Trusted Blockchain Applications (INATBA) in Belgium as global multistakeholder forum for developers and users of Blockchain / Distributed Ledger Technology (DLT). The 105 founding members are organisations in Europe, North America and Asia. They together will work through INATBA on establishing a dialogue with public authorities and regulators around the world to foster a convergence of the legal frameworks applying to the distributed network economy. INATBA will also promote an open, transparent and inclusive global model of governance and support the development of interoperability specifications and standards in sectors such as financial services, health, energy, agriculture, mobility or public services.

Horizon Prize on Blockchains for Social Good

European Commission/DG Connect is launching the EUR 5 million worth European Innovation Council (EIC), Horizon Prize on "Blockchains for Social Good", open until 2019. This prize provides an excellent incentive to attract developers and interested citizens to this innovative topic.

Financing blockchain and distributed ledger technologies projects

So far EUR 141 million have been allocated by the EU to blockchain related projects, and potentially up to EUR 340 million could be committed before the end of 2020.

Under the Leadership in Enabling and Industrial Technologies (LEIT)research programme, research on Blockchain technologies has been pioneered by a

The observatory features details on nearly 400 blockchain initiatives.

Source: https://www.eublockchainforum.eu/initiative-map

Collective Awareness Programs for Sustainability and Social Awareness (CAPS) project. In addition, projects like D-Cent, DECODE, or MyHealthMyData succesfully use blockchains to address the concerns on centralisation of data.

CTA initiatives on Blockchain

In October 2017, CTA organised a workshop on blockchain opportunities for the agricultural sector. Participants recommended that much more must be done to educate value chain actors, entrepreneurs and policymakers on the understanding and advantages of the technology. The need to promote proofs of concept and use cases was also identified. As a result a new project was established running from April 2018 to February 2020 seeks to gather knowledge about blockchain technology, and to provide a platform to facilitate the sharing of knowledge and to encourage innovation in blockchain's application.

In particular, the project improves understanding and provides evidence for the use of blockchain technology in agriculture across the ACP.

A portal https://www.cta.int/en/projects/blockchain has been setup with blockchain use cases in agriculture being documented, currently including 20 articles covering a range of aspects of blockchain use in agriculture from finance to traceability. Working together with Wageningen University and Research over 50 cases were identified and analysed and a number have been featured on the CTA website in individual articles. Working with GODAN's capacity development working group a webinar and overview were produced to introduce blockchain agriculture applications relevant to use across Africa Caribbean and the Pacific were promoted.

Issue 88 of CTA's magazine ICT Update "Unlocking the potential of blockchain for agriculture" covered a range of perspectives from authors working on implementing and researching blockchain in agriculture and food systems. Working with partners identified in this issue we have exchanged information between networks and are developing new communication opportunities and events. The project will also work with the EU blockchain observatory and forum.

A call for proposals "Blockchain use cases in Agriculture" was launched in 2018, resulting in 59 proposals being received from which four projects were selected to be implemented this year in ACP countries.

Working on cocoa the project "Blockchain Technology for Cocoa Farming of Quality and Excellence: Towards Reward, Trust, Transparency and Traceability from Farmers to Consumers" was selected. This is being implemented in Sierra Leone; Trinidad and Tobago; Papua New Guinea and was submitted by Bioversity International. In Côte d'Ivoire Nitidae was successful with their proposal to track cacao using blockchain. In Uganda CIAT is leading the project "TheMetrix: Using blockchain distributed systems to deploy spatial risk indicators for supply-chain management". The fourth project looking at Blockchain based vegetable traceability is being undertaken in Trinidad and Tobago, lead by Erba96.

BMZ initiatives on Blockchain

German development cooperation works on various blockchain projects. Within the federal government German Federal Ministry for Economic Cooperation and Development (BMZ) advises on the required legal basis and promotes the practical use of blockchain in development cooperation.[16] On behalf of BMZ, KfW Development Bank e.g. has developed a blockchain-based software for the transparent and secure implementation of public investment in developing countries. TruBudget (Trust Budget Expenditure Regime) is designed to ensure that the implementation of funds for investment projects is transparent, secure and traceable. Based on these criteria, donor funds within the meaning of the Paris Declaration can be processes via partner systems. Complex parallel structures and donor harmonization processes involving high transaction costs are therefore eliminated.[17]

Moreover, BMZ is evaluating and harnessing the potential of blockchain technology in agriculture, particularly to promote more efficient, transparent and traceable agricultural supply chains, financial services (agricultural credit and insurance), and secure land rights for farmers. The government-owned Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) is generally contracted by the German government to implement projects pertaining to cooperation measures agreed at government level.

In regard to blockchain technology, one objective is to investigate viable operating models for blockchain applications and convening diverse public and private sector stakeholders to exchange know-how and experience and fostering innovation.

- In 2018, the GIZ Blockchain Lab was established in order to develop governance and operating models for blockchain applications in development cooperation. The Lab focuses on areas such as sustainable supply chains and trade facilitation, insurance, energy, education and environmental auditing.

- In November 2018, BMZ and GIZ Blockchain Lab organised the Chain2Sustain solutions conference.[18] The conference brought together

more than 150 stakeholders from the private and public sector, development agencies, science, and tech start-ups to identify viable blockchain solutions in the area of sustainable supply chains. The four most promising use cases are currently being pursued and implementation should follow soon.

- In January 2019, the BMZ convened 160 participants from the European Commission, food industry and civil society at the Global Forum for Food and Agriculture (GFFA) in Berlin at a panel discussion on the topic "Blockchain – The digital agricultural revolution?".[19]

Another objective is to pilot promising blockchain use cases in agriculture, with the aim of eventually scaling and transferring successful proofs of concept.

- In the context of reforming and modernizing administration, GIZ was commissioned by BMZ to work with the Georgian Government to reform the legal system. Blockchain is playing an important role here as a means for the national public registry in Georgia to make land register entries available digitally. Integrating the entries into the data record chain verifies their authenticity. Blockchain technology thus prevents manipulation and corruption – and helps to build the trust of the population and investors in the judiciary. Around one million processes have already been registered.[20]

- The GIZ, on behalf of BMZ, is currently undertaking a proof-of-concept of a weather index-based insurance to mitigate climate change risks for cotton farmers in India. Similar blockchain-based climate index insurance approaches are currently in their early piloting phase in a number of other countries, in cooperation with the InsuResilience Global Partnership, supported by BMZ.[21]

- GIZ is currently elaborating project approaches for BMZ in selected African countries using blockchain to support traceability and transparency in agricultural supply chains. The intention is increase value addition in producing countries and linking producer organisations to international markets, while securing smallholders' land titles and halting deforestation.

BMZ has also contributed to the general blockchain strategy of the Federal Government of Germany. The strategy covers more than thirty blockchain application areas, including food supply chains and agriculture and will be published by August 2019.

2. Blockchain technology in support of agriculture

Blockchain technology offers many benefits, as it can provide a secure, distributed way to perform transactions among different untrusted parties. This is a key element in agriculture and food supply chains, where numerous actors are involved from the raw production to the supermarket shelf. The potential transparency provided by blockchains could facilitate the development of trading systems that are based on reputation, improving the behaviour of participating parties and increases their reliability, responsibility.

It can increase overall transparency and facilitate real time on the field payments,[22] handling and storing administrative records, perform digital authentication and signature systems and smart contracts. It can track the movement of inventory from one warehouse to another; change in ownership in a title or property deed, intellectual property rights and patent systems.[23] Blockchain application can improve logistics[24] and distribution of locally produced goods, strengthen traceability and certification providing information from farm to table to the consume who can track products as they pass through a supply chain from the manufacturer and distributor, to the final buyer.[25] Whether it is applied to managing warehouses, silos, and supply chains more intelligently, or utilized in the field as a tool to transmit real-time data about crops and livestock, there are few aspects of an agricultural operation that wouldn't benefit in one form or another from blockchain technology.

From finance, including trade finance, to customs and certification processes, transportation and logistics, insurance, distribution, intellectual property (IP) and government procurement, possible applications of Blockchain encompass a diverse set of areas related to WTO work.[26]

The observatory features details on nearly 400 blockchain initiatives.

Source: CTA. ICT Update. Issue 88. September 2018.

Establishing a connection and good communication with farmers in developing countries is challenging and requires lots of paperwork and handwork to get data into the system. Reducing these costs is very important as well as facilitating access to smart technologies to farmers.[27] Inclusion and fairness are important when reducing poverty. Technology and blockchain systems can make a difference.

The global blockchain in agriculture and food supply chain market was valued at USD 41.2 million in 2017 and is projected to reach USD 429.7 million by 2023, at a CAGR of 47.8% according to MarketsandMarkets.[28]

The market for blockchain in agriculture and food supply chain is dominated by key players such as IBM (US), Microsoft (US), SAP-SE (Germany), Ambrosus (Switzerland), Arc-net (Ireland), OriginTrail (Slovenia), Ripe.io (US), VeChain (China), Provenance (UK), ChainVine (UK), AgriDigital (Australia), and BlockGrain (Australia).

Some applications of blockchain in agriculture

The main benefits of decentralizing supply chain management using distributed ledger technology and blockchains: traceability and transparency; real-time tracking; faster transactions; smart contract technology eliminates fraud and error and provides more secure environment for data; reduced carbon footprint by minimising returns of goods which contribute to global carbon emissions. Improved logistics contributes to more efficient shipping and storage, and therefore greener and cheaper transport systems by cutting middlemen. It also reduces food waste. Consumers are empowered as they know more about the supply chain behind what they eat.

Investments in blockchain for agriculture are in their early stages but they have the potential to impact the lives of large numbers of people. **Although nearly 90% of Agriculture initiatives are headquartered in Europe, Australia, or the United States, and 50% of implementations are in these same regions, another 30% of the implementations are in sub-Saharan Africa.**[29]

2.1. Blockchain for food security and humanitarian assistance

Distributing and tracking funds to ensure they have maximum impact in humanitarian crisis context remains a challenge for the development community.

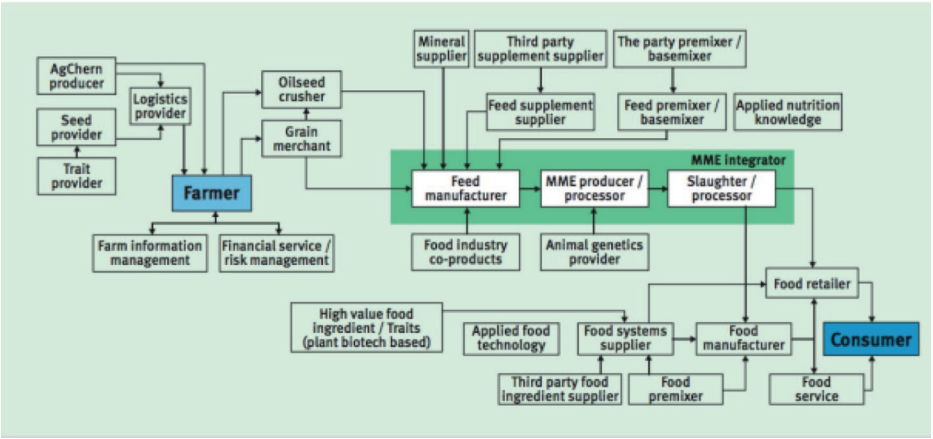
Disberse[30] is a fund management platform that aims to make the delivery of development and humanitarian aid more transparent, efficient and effective. Using a permissioned blockchain, they help donors, governments and NGOs transfer and trace their funds through the whole value chain, ensuring that resources reach the people they are intended to serve and have the desired impact.

The World Food Programme (WFP) uses the Blockchain technology to address the risks and inefficiencies in the cash transfer programme. In January 2017, they launched a small pilot in Sindh province, Pakistan, to test the ability of blockchain technology to authenticate, record, and reconcile cash and food assistance transactions. Based on positive results, the project moved into full-development and the **'Building Blocks'** platform, which utilises a private blockchain, was rolled out in with food vouchers to Syrian refugees. The platform removes WFP's reliance on an intermediary bank to verify transactions and distribute funds and create secure profiles for each refugee. This allows the management of identity data by the individual using iris scans. The blockchain provides WFP with a permanent, real-time record of every transaction, verifiable instantly on the blockchain, allowing WFP to make payment to merchants as frequently as desired. Building Blocks has also eliminated the need to advance funds to a bank, reducing finical risk.[31] WFP now plans to test blockchain for the tracking of food delivery in East Africa(ref coindesk https://www.coindesk.com/un-food-program-to-expand-blockchain-testing-to-african-supply-chain). Specifically, the new project will monitor the movement of food from Djibouti's port, where the WFP receives shipments, to Ethiopia, where much of its food operations are located.

2.2. Blockchain technology for Food Traceability

The Complexity of Food Chain

While the investments in improving the sustainability of the food industry has been increasing, one of the challenges remains the traceability, accountability and transparency of supply chains. The blockchain technology can address this by connecting digitally the dots. It can help food companies mitigate food fraud by quickly identifying and linking outbreaks back to their specific source. Improved data traceability provided by the IBM platform reduced the time it took to trace a mango from the store back to its source from seven days to 2.2 seconds (Walmart).[32] By increasing the transparency in the market. visibility and reliability of transactions and the real-time traceability, businesses can



Source: European Commission FP7, University of Bonn

The observatory features details on nearly 400 blockchain initiatives.

gain in efficiency, cost savings and achieving product premiums. Reliable data can also optimise business and investment decisions. Improved trust in product provenance contributes to brand enhancement.

Consumers can know where their food comes from, how it was produced and by who. Product provenance is particularly important, and it can increase consumers' trust and loyalty. Traceability programmes could become a standard in the food industry.

There are numerous examples of companies, start-ups and initiatives aiming to improve food supply chain integrity through the blockchain technology.[33]

Walmart and Kroger were the first companies to embrace blockchain and include the technology into their supply chains, working initially on Chinese pork and Mexican mangoes.

This initiative documented the producer of each specified food product so that Wal-Mart can easily address any case of contamination. The test put mechanisms in place to identify and rectify the improper care of food throughout the journey from farm to store.

The highest profile food traceability initiative is the **IBM Food Trust** which connects growers, processors, distributors and retailers through a permissioned, permanent and shared record food system data and has grown into a global consortium with companies such Dole, Driscoll's, Kroger, Nestle, Tyson, and Unilever.

Transaction processing and storing blockchain data to trace products can be expensive. **OriginTrail** in Slovenia, found a way to store only "fingerprints" of data on the blockchain, which reduces the cost to only cents per item. It has also created the Trace Alliance, a consortium of companies who are using blockchain for supply chain traceability (Deloitte, HalalTrail, Oregon Tilth, Phy2Trace).

Cargill is one of the USA largest suppliers of fresh turkeys. In 2017, it launched a pilot programme to trace 60 000 turkeys from the shop to the farm. In 2018, the programme sourced more than 200 000 traceable turkeys from more than 70 farms and 3 500 retail stores and other markets across the country. They are also sold on Amazon.com.

The program allows consumers to visit the Honeysuckle White website, enter a package code and trace their turkey back to a specific farm, view photos from the farm, and learn more about the farm's history and the farmers who raised the animals. The program allows the consumer to receive a text with this information, as well.

This farm-to-table connection is building consumers' confidence about where their food comes from, while giving farmers an opportunity to share their story.

Partnering with the U.S. State Department, Bitfury Group, Emercoin, and Blockchain Trust Accelerator, **Coca-Cola** is creating secure registries for workers to prevent labour rights violations and forced labour, through a decentralized blockchain-based registry to ensure that employers respect the terms of work contracts.[34] Coca-Cola agreed to conduct 28 country-level studies on child labor, forced labor, and land rights for its sugar supply chains by 2020.

Carrefour launched in 2018 the use of blockchain in its Quality Line (Auvergne chicken, Cauralina cored tomatoes, Loué farmhouse eggs, PDO Rocamadour cheese, Gillot milk, Norwegian salmon and Noël fattened chicken) aiming to have applied this technology to 100 Quality Line food products by 2022. In the chicken example, a consumer can see how each animal was reared, the farmer's name, what they fed the chicken, treatments used (for example, antibiotic-free), any quality labels and the slaughter location.[35]

Walmart has been working with **IBM Food Trust** since 2016 to digitize the food supply chain process. It has announced that it will require by September 2019 all suppliers of leafy green vegetable to upload their data to the blockchain.[36] 2018 had seen a large outbreak of E. coli in romaine lettuce which affected more than 200 people across 36 states.[37] It took seven days to trace the source of food (contact the supplier, get paper records and use those records to contact the company that imported or shipped the product to Walmart's distribution centre). With the blockchain, it's been reduced to 2.2 seconds. That substantially reduces the likelihood that infected food will reach the consumer.[38] Using IBM's blockchain solution based on Hyperledger Fabric, Walmart has successfully completed two blockchain pilots: pork in China and mangoes in the Americas.[39] It is using blockchain to track products over 25 product lines, from dairy products to processed foods and meat. As of August 2018, Walmart had tracked over 4 million food packages over a period of approximately one year.[40]

COFCO International Ltd is partnering with four global agribusinesses (ADM, Bunge, Cargill, and LDC) to standardise data and digitise global agricultural shipping transactions. Together, the companies are looking to increase transparency and efficiency for customers through digital technologies, such as blockchain and artificial intelligence.[41]

COFCO International is the overseas agriculture business platform for COFCO Corporation, one of China's

state-owned food processing holding companies. The company is focused on being a leader in the global grains, oilseeds and sugar supply chains, with assets across the Americas, Europe and Asia-Pacific. In 2017, COFCO International handled over 100 million tons of related commodities with revenues of $34 billion.

The initiative will initially focused on developing technologies to automate grain and oilseed post-trade execution processes, significantly reducing costs and resources needed to move documents around the globe. The aim of the **ABCD blockchain initiative** is to digitize manual, paper-based processes tied to contracts, invoices and payments in order to improve security, reliability, efficiency and transparency.

The 'ABCD' of global agricultural trade – ADM, Bunge, Cargill and Louis Dreyfus – cooperate to improve trade practices using new technologies such as blockchain and artificial intelligence.

Downstream beer in Ireland is the first to use blockchain technology, revealing everything one wants to know about beer, i.e. its ingredients and brewing methods. Consumers can use their smart phones to scan the QR code on the front of the bottle and they are then taken to a website where they can find relevant information, from bottling to the raw ingredients.

Chinese online insurance company **ZhongAn** has developed a new GPS tracker for poultry called **GoGo Chicken**. The device fits around the animal's leg while sensors monitor information like the chicken's environment, what it eats, and how much exercise it gets. The aim of the company is to build trust by documenting the origins of the food.[42] The company plans to use facial recognition to monitor life journey of chickens in organic farming using blockchain.[43]

Spain is the world's largest olive oil producer. Two of the biggest problems in the commodity supply chain are price volatility and quality control. Olivacoin ensures the traceability of the olive oil and uses smart contracts for payment.

Blockchain Beer was introduced in Canada by Alberta-based companies. Hamill Farms, Canada Malting Co. (a GrainCorp company), Red Shed Malting and Last Best Brewing & Distilling have teamed up with TE-FOOD to deliver a new beer officially launching on 1st February 2019which uses blockchain technology to trace the beer grain ingredients from field to can. It also gives consumers greater visibility on where their food comes from, how it's been processed and what it has been in contact with providing timelapse videos about cultivation and harvesting by Kakaxi cameras, inspection result document by SGS, process descriptions and photos about malting, roasting and brewing bring the Bock Chain beer closer to the visitor.[44]

In January 2018, the **World Wildlife Foundation (WWF)** announced the Blockchain Supply Chain Traceability Project, to eliminate illegal tuna fishing, tracking fish from vessel to the supermarket, in the fresh and frozen tuna sectors of the Western and Central Pacific region to strengthen supply chain management.[45] A simple scan of tuna packaging using a smartphone app will tell the story of a tuna fish – where and when the fish was caught, by which vessel and fishing method. Consumers will have certainty that they're buying legally-caught, sustainable tuna with no slave labour or oppressive conditions involved. WWF-New Zealand, WWF-Australia, and WWF-Fiji have teamed up with global blockchain venture studio ConsenSys, information and communications technology (ICT) implementer TraSeable, and tuna fishing and processing company Sea Quest Fiji Ltd. to deliver the project in Fiji.

Auchan is an international retail group headquartered in France. It is present in 17 countries worldwide with 58.5 billion USD yearly consolidated revenue, and 351 000 employees. Recently, Auchan announced a strategic partnership with the e-commerce Chinese firm **Alibaba** to combine their online and offline expertise to explore new retail opportunities in China's food retail sector. It is moving now to blockchain based food traceability.

The retail chain's Vietnam branch started to use TE-FOOD back in 2016. The group is focusing now on France, Italy, Spain, Portugal, and Senegal.

For the moment, in France, the chain is operational on organic carrot, potato and chicken. It is preparing to arrive in Italy on the tomato and chicken sectors, in Spain for Iberian pork and exotic fruits grown locally, then in Portugal and Senegal on chicken.

Consumers of the retail chain can scan QR codes on the products and view the food history with any mobile app which is capable to read QR codes. The authenticity of all data will be verified on the FoodChain (TE-FOOD's blockchain for global traceability information).

In March 2017, **Alibaba** announced a partnership with **Pricewaterhouse Coopers** to help solve China's food safety issues. Alibaba is testing uses of Blockchain to track food products through the supply chain.[46]

To address fraudulent imports of honey, **Casino** with the start-up Tikal introduced in 2017 a first blockchain on quality honey Casino. He is extending traceability to Poultry Terre & Saveurs and chicken eggs raised in the open air.

Starbucks has also begun to explore how the technology could be used to record each transaction that takes place in their coffee value chains, capturing detailed information on the farmers, weight, grade, and other specifications of the beans that are analysed by coffee buyers.[47]

In 2017, **Fairfood** was among the first in the world to put the supply chain of a product on the Blockchain, namely the journey of a coconut, with the help of Provenance.

Supermarket chain **Coop** will sell **nutmeg** from Verstegen Spices & Sauces starting in May 2019. In partnership with Fairfood, a transparent nutmeg chain and every step between farmer and plate is recorded: where the nutmeg comes from and whether the farmers get paid the agreed upon price. The purpose of blockchain is to improve the position of the farmer and to stimulate the entrepreneurship approach of the farmer. Consumers can view the nutmeg's journey in the final app via a QR code.[48]

TE-FOOD, a German start-up is the world's largest publicly accessible, farm-to-table fresh food traceability solution. Started in 2016, it serves 6000+ business customers, and handles 400,000 business transactions each day.[49] At the core of TE-FOOD are easy identification tools, business-to-business apps, optimised for low-end phones, a consumer mobile app to check products and standard interfaces for third party integrations. They also plan to innovate with animal facial recognition and food safety transportation devices, for example, measuring temperature. By introducing a token into their operations, TE-FOOD can scale more rapidly, while increasing efficiency and transparency.

TE-FOOD signed a contract with **Cofidec**, a 31 years old Vietnamese food manufacturer about the implementation of TE-FOOD's blockchain based traceability system from farm to export. Cofidec's products are processed high quality frozen seafood, vegetable, and fruit products. With over 18 million USD yearly revenue, most of its products are exported to Japan, the USA, South Korea, and other foreign markets. The project will cover activities in full depth from seedbed preparation on the fields until the export of packaged food products.[50]

TE-FOOD South Africa was established under a Franchise Licence Agreement with TE-FOOD International and the Laurel Africa brand. The main objective of TE-FOOD is to assist Governments and stakeholders in the supply chain to improve the standards of the local authorities regulations, to introduce TE-FOODs traceability technology, and to give the consumer information on the product they buy, the farm, the abattoir,the processor, wholesaler and retailer. It certifies that a code of Good Practice is implemented across the supply chain.[51]

FAO and TE-FOOD cooperate to provide a better understanding of blockchain technology and its implications for the statisticans in the livestock sector. They will develop a pilot case based on the pig statistics sector in Vietnam. They will analyse the cost effectiveness of the blockchain technology in comparison with other administrative data technologies used in the livestock sector and proposals for scaling up these approaches in other countries.

TE-FOOD's technology will be utilised on two pilot projects in June 2018 with **HALAL TRAIL™**, a UK based company, to track chickens and lambs from farm to table, through the halal food chain. The halal method in the food industry refers to the permissible or lawful way of preparing food and drinks according to Islamic law. This significant market seeks trusted, halal certified sources. According to industry estimations, the global halal food market will reach USD 2.55 trillion by 2024. Food traceability combined with blockchain technology is the solution which can give Muslims peace of mind that their food was prepared according to Islamic law.[52]

The first cross-border transaction between banks using blockchain technology took place on a shipment of 88 bales of cotton from the US to China, involving Commonwealth Bank of Australia, Wells Fargo and Skuchain.

The Seam (a commodities software company based in Memphis, Tennessee.) partly owned by Cargill, Olam and Louis Dreyfus, three commodity trading giants, launched **"cotton blockchain"** which involves the biggest cotton exporters in the world tracking cotton from the field to the fabric. The Seam envisages collaboration with banks such as BNP Paribas and HSBC. If the pilots go well, Pryor says, the support is already there to roll it out on a fully operational basis.

Three pilots are set to be launched, having successfully moved through the proof of concept stage: one for smart contracts, one for physical shipment of cotton, and one to enable retailers to track and trace the finished product.[53]

For consumers and manufacturers to know if the cotton they are buying is organic, Bext360, an agricultural blockchain startup, is partnering with fashion giants, nonprofits and other tech companies for a pilot test to see if blockchain can be utilized to ensure the integrity and authenticity of the organic cotton supply chain. The initiative, called the **Organic Cotton Traceability Pilot**, is a partnership between the C&A Foundation, the Organic Cotton Accelerator and Fashion For Good. It's operating with

support from fashion companies C&A, Zalando, PVH Corp and the Kering Group. The initiative is currently being used to trace organic cotton from farms to the gin where it is processed for textile use. The second phase of the pilot will be ensuring cotton can be traced from gin to consumer and scaling up so it can be used for organic cotton farmers, textile producers and fashion companies alike.[54]

Carrefour and Nestlé just launched a Blockchain platform for **Mousline purée**. Consumers can use their smartphone or other device to scan a QR code on the *Mousline* packaging which takes them to the journey of the product from the Nestlé factory in the north of France to Carrefour stores. They can see the quality of potatoes, production date, quality control parameters, storage times and the location of warehouses. In addition to the blockchain data, consumers will also find information on the farmers who supply the potatoes for *Mousline* and how the puree is made.[55]

Connecting Food is a French start-up with service focuses on the notion of "real-time certification". As things now stand, brands which rely on suppliers can only verify whether specifications are followed by audits and occasional monitoring. The start-up offers a service to compare client specifications with what suppliers actually provide at every stage of production and in real time, so as to prevent an intermediary product that is unsuitable from being finished. The solution is based on a combination of technology implemented with support from IBM and CEA Tech LIST: blockchain, but also connected objects, cloud, cryptography and artificial intelligence. The economic model is based on a service approach ("Software-as-a-Service" or SaaS) with a subscription paid by the client whose specifications need to be followed. The company also supports the work of farmers by offering financial compensation for their participation in the Connecting Food scheme.[56]

Accenture has announced a prototype blockchain-based supply chain app designed to **reward business practices that conserve natural resources**.

Working with **Mastercard**, blockchain start-up **Everledger** and humanitarian aid organization Mercy Corps to encourage the introduction of the "circular supply chain", aimed at recycling goods. The app will allow consumers to easily track the provenance of the goods they are buying and see if a producer has a certification for sustainable practices. Consumers could also use the app to send tips as a reward for responsible producers (in a form of a blockchain-based token or a fiat transfer powered by Mastercard payment rails). Accenture is aiming to enrol small farms across the world and allow them to register their certificates of ecologically conscious practices on a blockchain as a part of their digital identity, allowing consumers to see who produced the goods they are buying and how the business is managed. The company is also working with farmers' associations in Africa and South America that might want to participate in the system. The associations will be responsible for maintaining cloud-based nodes on behalf of their farmers.[57]

The **Trace Alliance** is a non-profit association which connects businesses, the public sector, academics and technology companies in the field of blockchain research and the creation of practical solutions primarily for supply chains. The collaborative effort of the alliance aims to resolve a variety of challenges and come up with solutions for a wide range of use cases through achieving increased supply chain integrity, data governance, transparency and trust.

Belfast-based **arc-net** has incorporated **DNA information into their blockchain platform**. They begin by taking a tissue sample of an animal early in the supply chain and uploading part of the genetic code with other information being stored. When importers and others further along the supply chain receive the meat, they can then test a sample and confirm that the DNA matches that which they were expecting.

Provenance, a UK-based blockchain company with an overt social and environmental impact focus, provides transparency for both food and clothing companies, allowing customers where the products comes form but also confirm that the people who helped make the product were fairly compensated and that it was made in a manner that is environmentally responsible.

It conducted a pilot in early 2016 using blockchain, along with mobile and smart tags, to track tuna from catch to consumer. Their pilot enabled Indonesian fishermen to convert physical tuna into codified assets linked to a digital identity that can be verified on an open registry. As a result, suppliers along the value chain as well as consumers can freely access a suite of proofs that certify a product's quality standards.[58]

Provenance is working with Coop, the largest UK consumer cooperative, to track the journey of fresh products from source to supermarket in real time to increase consumers' trust in food retail. At each point of the journey, data on the product, supplier, location, as well as on the environmental and social impact of each business, are collected and added to the blockchain, creating a digital history of the product that is accessible to all, from the farm to the consumers.[59]

Everledger applied similar provenance tracking technology to wine bottles to

counter fraudulent sales which attracts great attention in emerging markets.

BeefLedger, an Australian beef traceability initiative focused on exports to the Chinese market; the Chai Vault, a UK-based wine initiative focused on verifying the provenance and authenticity of wines; OwlTing enables consumers concerned about food safety to buy directly from farmers; TE-FOOD, focused on providing farm-to-table traceability in emerging markets; and US company Zest Labs, uses sensors to collect data that enables companies to reduce food waste.

In the Caribbean, developed as an open-source project, **BreadTrail**[60] comprises a mobile app compatible with Android and iOS, and a backend system that uses the blockchain to provide immutable and transparent farm-to-fork traceability for everyone in the supply chain from farmer to consumer, especially bananas.

Choco4Peace[61] is using hyperledger blockchain technology to support smallholders in the cocoa sector in Colombia through a combination of decentralised phone applications supporting an inclusive economic network, which aggregates smaller-scale cocoa producers with chocolate makers, socially oriented investors and sustainable development service providers.

BlocRice is a blockchain project implemented by Oxfam to empower organic rice growers in Cambodia. Oxfam is working with small-scale rice farmers in Preah Vihear province, Central North of Cambodia. These farmers produce on average 2.5 to 3 tons of organic rice per year on 1 to 2 hectares. The project looks at whether farmers having more information about the supply chain are more empowered and whether they are better served by digital verification of their contracts.

The project is introducing cashless payments to several farmers and will use a digital contract between primary producers organized in an Agricultural Cooperative, a Cambodian rice exporter and a manufacturer in The Netherlands. The project is designing an application providing full value chain transparency and traceability to the cooperative, exporter, importer and end consumers. Therefore, the consumer will see that farmers have been paid correctly for their rice. This is expected to provide small rice farmers with more influence and more control in securing their own livelihoods. Three aspects of the project use blockchain:

- The project introduces blockchain technology to the organic rice value chain by registering all chain actors with unique identification codes on blockchain.
- It also introduces a smart contract between farmers, their agricultural cooperative, exporting companies and manufacturing company.
- There will also be a consumer communication component from the Cambodian countryside to the retailer.

Blockchain in ACP countries

In Africa, Blockchain has the power to transform the way businesses share information, track assets and deliver their services. There is a real appetite for public and private organisations alike to seize the blockchain opportunity. However, standards or regulations need to be in place for the technology, and new skills are required in the workforce to support its rise.[62]

Technology is particularly relevant in the African context because it presents the potential to overcome trade finance and cross border payment issues.

With Kenya, Nigeria, Uganda and South Africa among the countries taking the lead in blockchain experimentation, the financial sector looks set to be the continent's earliest big adopter. However, development and trials are also underway to apply blockchain technology to virtually every industry sector from health and social development to retail and agriculture. Helping drive blockchain growth in Africa are factors such as declining costs and rising capabilities in computing, storage, and bandwidth, which allow multiple nodes in a blockchain network to connect and act together seamlessly.[63]

EZ Farm help small-scale farmers to better manage their water resources. The researchers use big data and IoT technologies to help small scale farmers better manage water resources and agricultural aggregators identify the best prospects for investment.[64]

Violanda De Man at **ICS** is developing accessible, affordable crop insurance in East Africa to rural farmers and aim at reaching with this technology 10 million farmers in the next five years.

Farmshine is attempting to rebuild the value chain infrastructure in East Africa connecting actors in the value chain on a fully transparent blockchain platform, providing them with a digital identity and fully traceable record of transactions.[65]

FairChain and **KrypC** made **Moyee Coffee** from Ethiopia the first European coffee company to benefit from blockchain. Moyee's FairChain coffee is roasted locally in Ethiopia generating added-value in country. The KrypC blockchain platform gives all stakeholders – farmers, roasters, and consumers – access to data across the entirety of the supply chain.

At the point of collection, the KrypC platform instantaneously creates cryptotokens, which represents the value of the commodity. As the commodity flows through the entire supply chain, new tokens are automatically created which increase in value as the beans move through the supply chain. This process makes the entire chain transparent and added-value shared.

Currently patent-pending, this technology promises drastic reductions in the transaction costs of global commodities. KrypC's tokens can be used for **inventory valuation** and to **streamline the certification processes** by reducing paperwork and physical inspectors, which can cost up to **€0.80 per a pound of coffee**.[66]

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.

The IDB Lab, the innovation laboratory of the Inter-American Development Bank (IDB) Group, with technology and consulting companies, launched the **LAC-Chain**, a new alliance to promote the use of blockchain in Latin America and the Caribbean.[67] This alliance is formed by the Alastria Consortium, ConsenSys, Everis, NTT Data, the Enterprise Ethereum Alliance, and RSK, and will soon also include the Ethereum Foundation, Hyperledger, the MIT Media Lab, IBM and Accenture. LAC-Chain was conceived with the aim of developing an inclusive, efficient and safe blockchain ecosystem for all. LAC-Chain's objective is to share knowledge of the different initiatives that are emerging in countries for the development of national ecosystems in the region, providing technological advice, market stimuli, and analysis of impact data as catalysts for the democratization of the use of this technology.[68]

Wageningen CDI and **Wageningen Food Based Research** are working since 2018 on the traceability of Mango and avocado transport systems in Haiti to improve farmers' incomes. Having trialled QR codes on shipments they have started to identify some of the logistical gains of better traceability and reduction of food losses. They are now putting the produce of 100 avocado and 100 mango farmers on the blockchain. This work has been requested by the Haiti ministry of trade and Industry and is supported by the World Bank. (Rene Oostewechel, Yves-Laurent Régis, Jan Brouwers with Jan Vogels, Anton Smeenk and Xin-Ying Ren Wageningen University and Research "Haiti technical cold chain dry run: Applying distributed ledger technology to connect Haitian mango and avocado producers to foreign markets").[69]

AgUnity, an Australian agri-tech start-up established in 2016 is working in Papua New Guinea and the Solomon islands with the help of blockchain technology. By providing farmers with smartphones AgUnity ensures equal access to the blockchain traceability system. The AgUnity App is a blockchain-based smartphone app which lets farmers schedule various farming activities – such as sharing farming equipment and recording transactions when buying and selling with cooperatives and other third parties, as well as managing their incomes using the in-built digital wallet. AgUnity is also in the process of facilitating access to micro-loan services from their online 'Marketplace' within the app.

2.3. Smart contracts and crop insurance

The impact of unpredictable weather is significant for farmers who are encouraged to have a crop insurance. However, processing and verifying claims is a long process and it is not an incentive for farmers adoption. Removal of risk through insurance can increase smallholder investment and income.

For the insurance, it is key to verify that claims are not fraudulent or report beyond the actual damage to limit the losses in their companies.

With the introduction of Blockchain technologies and Smart Contracts, the crop insurance industry has new opportunities for improvement. Smart Contracts will create major improvements in the claims processing system. The Internet of Things (IoT) devices can be used on major equipment possessions

The use of smart contracts for processing insurance claims can improve turnaround time, reduce costs, and provide seamless claim processing experience.[70]

To feed data back to the smart contracts in the event of disaster for verification purposes. [71]

SmartCrop is an Android-based mobile platform leveraging smart contracts and intelligent weather prediction to help farmers hedge against crop volatility. Through the use of weather APIs, SmartCrop provides farmers with the option to initiate crop insurance pay-outs before natural disasters strike. The solution is a win-win for all stakeholders in the value chain.

SmartCrop's mobile solution enables users to purchase insurance policies for their valuable crops and monit or weather conditions for proactive insurance pay-outs.

SmartCrop uses a Smart Contract architecture to power the claims process. Smart contracts are computable legal contracts that automatically execute when a set of pre-programmed conditions set forth in the contract are satisfied. They can be stored in the blockchain ledger and are secured using cryptographic key pairs to make them tamper resistant. Smart contracts will trigger automatic payments upon the occurrence of certain weather trigger events. If SmartCrop detects that there is a 90% chance that a natural disaster will occur within a certain timeframe, a Smart Contract condition is triggered to give the user the option of an early pay-out under the insured amount. The insurance claims process is dramatically streamlined by reducing the staff needed to verify and distribute the claims. As a result, insurance companies save on back office expenses. Also, insurees will receive immediate payment of the policy value through the blockchain infrastructure, enabling them to quickly use the capital to plan for the upcoming natural disaster.[72]

African farmers pay a high price because of climate-related disasters. More than 20,000 farms in Ghana, Kenya and Uganda have access to simple and affordable crop insurance via their smartphones. The policies or "smart contracts" currently under development are based on blockchain, removing paperwork and facilitating pay-outs. The system uses high-resolution satellite images to detect rainfall and plant growth data.

Payments can be made using mobile money transfer services such as M-Pesa.

US-based **WorldCover** which developed the system, has been working with Lloyd's of London insurance market and Nephila Capital, an investment management company specialising in weather reÐinsurance, to create a viable product.

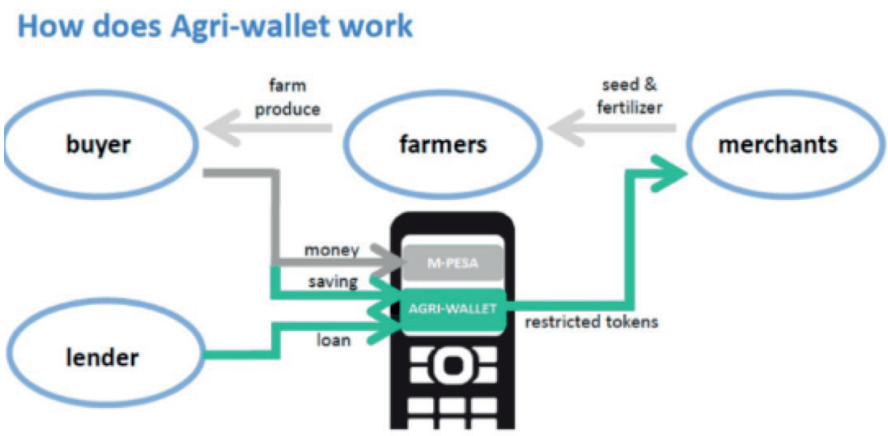
The fact that the policies are based on third-party data, such as rainfall measured by satellite and ground sensors, means they are objective, thereby avoiding disputes and fraudulent claims. Eventually, the Etherisc group plans to extend the system to include crop disease affected by the weather, such as brown plant hopper, which is linked to dry conditions.[73]

In 2017, **Ingeni partnered with World Bank / International Finance Corporation, BASF, and Credit Dnipro** (a major Ukrainian bank) to develop a farmer registration and loans platform that provided additional financing to farmers in emerging markets. The goal of this partnership was to increase financial aid for farmers in Ukraine for inputs such as seeds, pesticides and fertilizers. ingeni is bringing the experience they acquired through the World Bank partnership, to register African farmers and businesses with the blockchain.[74]

Agri-wallet is a digital wallet, a mobile financial tool, for the agricultural sector providing a business account for farmers, which they can use to save, buy, and earn. Farmers can open an Agri-wallet account for free. When farmers earn revenue through sales, they can choose to be paid in money through M-Pesa (a Kenyan mobile payment system) or (partly) in tokens for their wallet. Tokens are then earmarked for purchasing input supplies from merchants that have been vetted by Dodore, comparable to a voucher system. These tokens can be used to purchase inputs for the next cropping season. Furthermore, because credit takes the form of tokens rather than currency, lenders are more willing to provide farmers with loans.

As part of an 'ecosystem' with earmarked credit, Agri-wallet helps farmers to save and in turn enables them to access short term loans through Rabobank – without the conventional stack of paperwork. This kind of credit ecosystem is comparable to a voucher system, combined with a savings element. Currently 35% of the farmers who use the wallet, save.[75]

Dodore has enlisted a number of partners to help finance the Agri-wallet venture, including Netherlands Development Organisation (SNV), the Mastercard fund, Rabobank Foundation, International Fertilizer Development Centre, BoP Inc., Mennonite Economic Development Associates (MEDA) Agriterra, and Technoserve.



A proof of concept developed by IBM to ship flowers from Mombasa, Kenya, to Royal Flora in the Netherlands illustrates the advantages of the technology. Exporting flowers from the port of Mombasa requires signatures from three different agencies and six documents that describe the origin, chemical treatment, and quality of the goods, and customs duties. The Kenyan farmer, using his mobile, submits a packing list that becomes visible to all participants in the permissioned ledger. This action initiates a smart contract that enforces an export approval workflow among the three agencies that must approve the export. As each agency gives its consent, the status of export is updated in real time, and for all to see. Simultaneously, information about the inspection of the flowers, the sealing of the refrigerated container, the collection by the trucker and the approval from customs is communicated to the port of Mombasa, allowing it to prepare for the shipping of the container. At all times throughout the process, all actions relating to the documents and the goods are captured and shared on the permissioned ledger and are visible to all authorized participants in real time: which documents were submitted, when and by whom; where the flowers are and who is in possession of them; and the next steps.[76]

2.4. Blockchain and Land Governance

Blockchain-based land registries attempt to address two critical pieces of information infrastructure needed for land governance: (1) storage and verification of titles and ownership, and (2) more efficient processes and transactions.

In many countries, land ownership is an issue and land titling is a challenging process. Physical assets registered on the Distributed Ledger Technology (DLT), such as land titles, can be used as collateral. DLTs are a secure, fast, and immutable method to register land titles, providing greater legal clarity to land tenure systems, avoiding corruption and fraud, and unlock capital.

Switzerland-based cybersecurity company WISeKey partner with Microsoft to help the Rwandan government develop blockchain-based initiatives. The first phase of the initiative includes digitizing Rwanda's Land Registry to aid authenticity – proving ownership of land and property in developing countries is a well-documented problem .

IBM is working with **Ghana's** government to develop blockchain capabilities for land administration.[78]

The use of smart contracts could foster efficiencies in official processes related to registering land, like purchase, sale, subdivision, or inheritance. It could make it more difficult to register one plot of land to multiple owners or overleverage financing from different sources on the same plot, and it could prevent illicit sale of already-owned land to new parties.

In **Georgia**, GIZ has been commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ), to work with the Georgian Government to reform the legal system. Blockchain is playing an important role as a means for the national public registry to make land register entries available digitally. Integrating the entries into the data record chain verifies their authenticity. Around one million processes have already been registered.[79]

The bigger problem being untrusted information, challenges in using blockchain for land registries is that it requires digitizing, geo-referencing, and harmonizing maps in remote parts of the world which is a huge and costly work.

Land rights and blockchain

For centuries, unequal land rights have facilitated income inequality. Without adequate collateral such as land, it is particularly difficult for smallholder farmers to obtain loans at local banks. In Kenya, land ownership is traditionally recognised by a village elder. This person has typically been around for a long time and keeps track of who owns what in a notebook or in their mind. Whenever a dispute occurs, individuals seek out this person. Naturally, this is a vulnerable process and unforeseeable circumstances, such as death, illness or war, threaten this information. Formally obtaining landowner status can be a tiresome, frustrating and even dangerous process. Some government officials or real estate agencies are known for producing fake title deeds. Corruption is rampant, which affects both local businesses and foreign investments.

Since 2014, a pioneering organisation called Land LayBy has been developing land acquisition solutions. After a successful pilot scheme in Kenya, Land LayBy has scaled up their services to Australia, Ghana, London and New York. The solution according to Land LayBy is to make landownership more transparent in Sub-Saharan Africa and other developing nations by recording land ownership. Our technology highlights where the large landowners are, which also helps to raise questions about the inequality of landownership. Blockchain was a logical choice for us, assisting us to achieve our vision of making land more transparent and affordable." The application adheres to local land commission procedures and details the transaction history of the land.

Land LayBy uses an Ethereum based shared ledger to keep records of land transactions. These records can never be altered, corrupted, forged or erroneously replicated. They take

legally verified land, with traceable histories, and place this information on the application. Users can then access the platform and add extra information about the land. Land LayBy will verify this information and announce the land as 'LLL certified' (Land LayBy Listed). A person looking to buy land can log-in to interact with the current owner. For example, they can ask to purchase the land or rent it to grow crops on." Details about a user can be shared but specific permission settings can be changed by the account holder. Land Layby has a tech partnership with Winjit in India. They understand the challenges related to developing nations.[80]

2.5. Blockchain and Financial Services

The complexity of trade finance with many manual checkpoints, multiple disintegrated platforms, regulation leads to both payment and shipment delays and higher costs.

The banking industry have started to test the blockchain technology a few years ago with cryptocurrencies and other assets represented in a form of tokens that can be exchanged on blockchain directly without involvement of a third party that would normally charge for services.

Today we see major banks developing decentralized ledger technology (DLT) strategies and building a pipeline of blockchain projects. Blockchain secures and speeds up transactions, and is already affecting the way banks, credit card companies and investment funds operate.

Several banks joined the we.trade[81] project, a trade finance platform empowered by blockchain. Consortia are also being formed to develop standardized solutions suitable for multiple industry players. The more participants there are on a decentralized network, the more benefits can be harnessed from blockchain.

There are many other applications in trade finance and supply chain management that are in the process of testing their proof of concept, with the intention to pilot and scale thereafter. One example is a group of Dutch and French banks (ING, ABN Amro and Société Générale), partnered with Louis Dreyfus Co. (one of the biggest agri-food traders), to ship a cargo of soybeans from the US to China using a DLT. It is said to be one of the first fully fledged agricultural commodity transactions using the technology, which reduced the time spent on document and data processing to a fifth through digitising documents for the deal (including sales contracts, letter of credit, government inspections and certifications).[82]

Another initiative, including a group of international banks (Barclays, Standard Chartered and BNP Paribas), large corporations (Unilever, Sainsbury's and Sappi) and fintech start-ups, has launched a project to use DLTs to track physical supply chains and unlock access to financing for sustainable sourcing. The first pilot plans to test the technology to track tea and tea packaging materials from farmers in Malawi to the corporations. This pilot is one of the first initiatives to combine supply chain tracking with trade financing.

America's largest financial services companies have already made sure they'll get their piece of the blockchain intellectual property pie: Bank of America, Mastercard and Fidelity aggressively patented blockchain in 2017.[84]

In December 2016, the company AgriDigital[85] executed the world's first settlement of the sale of 23.46 tons of grain on a blockchain (ICT4Ag, 2017). Since then, over 1,300 users and more than 1.6 million tons of 4 grain has been transacted over the cloud-based system, involving $360 million in grower payments. The success of AgriDigital served as an inspiration for the potential use of this technology in the agricultural supply chain.

Farmers assume risk when selling their crops to buyers in agricultural supply chains as their payment is done days or weeks after. By integrating blockchain into their platform, AgriDigital is able to create a programmable asset — a token — to represent a physical commodity (such as a ton of wheat or a head of cattle). When that token is moved between different participants, such as from a farmer to a purchaser, each transaction is immutably tracked on the platform, with a full ecosystem of data (finance data, traceability data, and transactional data) attached to that token and payments occurring in real time via smart contracts. When a farmer delivers his or her goods to a buyer, an "atomic swap" occurs: the digital token representing those goods is transferred from the farmer to the buyer at the exact same time that the money is transferred from the buyer to the farmer.[86]

BBVA and **the European Investment Bank Group** (EIB) have signed a synthetic securitization of €1 billion. The agreement is a very innovative financing operation, as it is the **first synthetic securitization to be supported by blockchain technology in the European Union** and the third synthetic corporate loan securitisation signed by the EIB Group and BBVA. Moreover, BBVA and EIB Group will provide €360 million to finance investments projects of SMEs and midcaps.

The DLT platform developed by BBVA was used by the three parties to negotiate this agreement, from the origination to the agreement signing,

and also ensuring traceability and immutability, making that way the documentation process safer and more transparent. All the negotiation was recorded on the private blockchain Hyperledger, while a hash or unique identifier of the signed agreement were recorded on the public blockchain Ethereum (testnet).[87]

Twiga Foods, a business-to-business logistics platform, connects small-scale farmers to shopkeepers in East Africa. In 2017, Twiga Foods partnered with IBM to build a blockchain-enabled lending platform to provide microloans to small retailers, enabling them to purchase food from Twiga's suppliers. By eliminating layers of middlemen, Twiga creates more efficient supply chains, benefiting farmers and vendors. The Twiga system, which has brokered 200 million bananas, uses conventional technology and mobile connectivity.

In July 2018 IFC committed a $3 million investment in Twiga Foods.[88]

Microfinancing and Bitcoin Payments

Atlas is a start-up launching a mobile peer-to-peer application to give to communities in the developing world access to savings and credit through a decentralised solution built on blockchain technology. The app aims to create a network of people from local communities, which in turn will create and cultivate trust while boosting financial inclusion. In addition, access to capital through savings accounts and loans are offered through the Atlas platform. The blockchain shows proof of origin for the money and all transactions, ensuring users know exactly where their money is and the latest transactions on their account.[89]

Other organizations are focusing specifically on the financial component, specifically in leveraging blockchain technology to increase smallholder farmers' access to finance.

Coin22 is an Amsterdam-based technology company that has developed a blockchain-based **Agriwallet**, currently being implemented in agricultural supply chains that ultimately end up in Kenya (with a reach that spans Europe and North America). The interface is simple, operating through SMS messages and based on the already widely-used MPesa mobile money platform. Four thousand farmers are currently using the AgriWallet, and Coin22 is working toward scaling up to 100,000 farmers across Kenya, Uganda and Rwanda. Because the platform is blockchain-based, it can easily be scaled across different countries, without needing to adapt the platform in each country based on varied financial regulations or restrictions.

ICS, the parent company of the East Africa-based agricultural social enterprise Agrics, is exploring a blockchain-based savings product, utilizing Coin22's Agriwallet, that will enable farmers in Kenya to purchase "drought coins." Depending on weather conditions and satellite data, the virtual coins can be cashed in at the end of the season and transferred to farmers' mobile wallets.

MicroMoney is using a combination of Blockchain and AI. Their neural network uses 10,000 data points from a person's mobile phone to generate a credit rating. They can then be issued with micro-loans – progressively larger as they prove their creditworthiness.

Users' credit rating is stored on the Blockchain, updated to reflect their repayments, a score which can be used with other business'. The hope is that the unbanked can use MicroMoney to enter the global financial system without jumping through the traditional hoops.

If WePower is tapping into a new stream of investment, MicroMoney is opening a previously untapped market.[90] https://ambrosus.com

Ambrosus (AMB), Swiss company founded in 2017, combines high-tech sensors, blockchain technology, and smart contracts to track transactions in the food and medicine industry. Ambrosus, is working with the United Nations on their 10YFP Sustainable Food Systems programme. Their solution provides P2P marketplace where blockchain verification and sensor systems allow consumers to learn about their food source from verified reports. This enables consumers to make choices based on the quality of the food product, and with escrow mechanisms and reputation points in place, other parties are kept accountable with incentives to improve their service.

Ambrosus recently joined the United Nations Sponsored 'One Planet Network' to establish unique partnerships with Blendhub and Flatev. Blendhub is the world's first decentralized network for food production of powdered foods, while Flatev is a consumer-oriented company focused on snacks and baked goods.

2.6. Transport & Agro-logistics

Trade relies largely in the shipping industry where size continues to grow in complexity and cost. More than $4 trillion in goods are shipped each year, and more than 80 percent of the goods consumers use daily, are carried by the ocean shipping industry. The maximum cost of the required trade documentation to process and administer many of these goods is estimated to reach one-fifth of the actual physical transportation costs. According to The World Economic Forum, by reducing supply chain barriers within the international supply chain, global trade could increase by

nearly 15 percent, boosting economies and creating jobs.[92]

Blockchain technology can help alleviate many of the frictions in global trade logistics including procurement, transportation management, track and trace, customs collaboration, and trade finance. With over 50,000 merchant ships involved in the global shipping industry and multiple customs authorities regulating the passage of freight, a major area of focus for efficiency gains is ocean freight. Blockchain technology has huge potential to optimize the cost as well as time associated with trade documentation and administrative processing for ocean freight shipments. One example that highlights the complexities behind ocean freight today is the estimate that a simple shipment of refrigerated goods from East Africa to Europe can go through nearly 30 people and organizations, with more than 200 different interactions and communications among these parties.[93]

IBM calculated that moving a container of avocados from Mombasa to Rotterdam costs approximately US$ 2,000, of which US$ 300 were associated with paperwork. According to IBM, digitalization of the process could save up to 15 per cent of the cost of international maritime transport and going entirely digital could save shipping carriers about US$ 38 billion per year.[94]

Examples of use of blockchain in transport

Blockchain offers opportunities to address such constraints. **Maersk**, one of the largest shipping companies in the world, partnered with **IBM** applying blockchain to improve trade and digitise supply chains.[95] The aim of the new company **TradeLens**[96] is to offer a jointly developed global trade digitization platform built on open standards and designed for use by the entire global shipping ecosystem which can simultaneously access information about a shipment. It will address the need to provide more transparency and simplicity in the movement of goods across borders and trading zones. By the close of 2018, the Tradelens platform enlisted 40 active ports and terminals worldwide and handled over 20 million cargo containers. It is impressive considering that the platform just began commercial activity in August 2018.[97]

By Maersk's own estimates, blockchain will reduce shipping costs by one fifth, and boost international trade by 15%.[98] Blockchain technology can save millions of dollars for global transport and logistics companies and revolutionize the transport, logistics and freight industry soon.

Transporters must deal with a lot of administration - large amounts of paperwork to be filled in, signed and sent to a number of different locations around the world - which requires the organisational capacity to deal with all these processes. Blockchain has the potential to ease this process by making it an automated system to prove the integrity of documentation throughout the transport. It can record and track assets as they move through the chain. This will decrease the administrative burden for SMEs in logistics.[99]

A distributed ledger technology, blockchain establishes a shared, immutable record of all the transactions that take place within a network and then enables permissioned parties' access to trusted data in real time. By applying the technology to digitize global trade processes, a new form of command and consent can be introduced into the flow of information, empowering multiple trading partners to collaborate and establishing a single shared view of a transaction without compromising details, privacy or confidentiality.

Israel-based ocean carrier company **ZIM** has conducted a pilot to digitize the actual bill of lading, one of the most important documents in ocean shipping, and it acts as a receipt and a contract for the goods being shipped. The information stored on a bill of lading is critical as it contains all necessary details such as the shipment description, quantity and destination, as well as how the goods must be handled and billed. During the trial of a blockchain-based system developed by Wave, ZIM and pilot participants issued, transferred, and received original electronic documents successfully through the decentralized network.[100] The containers, shipped from China to Canada, were delivered to the importers (i.e., consignees) without a problem. Although still in pilot phase, industry adoption of a digital bill of lading would be significant. It could greatly support supply chains in reducing costs, enabling error-free documentation and fast transfer of original documents.[101]

In the first quarter of 2019, ZIM plans to focus on the Asia-South Africa and North America-Mediterranean trades. These trades were chosen due to their diverse activities and involved players.

Founded in August 2017, the **Blockchain In Transport Alliance (BiTA)**, has quickly grown into the largest commercial blockchain alliance in the world, with nearly 500 members in over 25 countries that collectively generate over $1 trillion in revenue annually. BiTA is a member-driven organization; members are primarily from the freight, transportation, logistics and affiliated industries. Alliance members share a common mission of driving the adoption of emerging technology forward. We accomplish this by developing industry standards; educating members and

others on blockchain applications/ solutions and distributed ledger technology (DLT); and encouraging the use and adoption of new solutions. Thousands of companies have applied for membership.[102]

BiTA has offices in Chattanooga, TN, USA (Global/USA/Canada); Sydney, Australia (Asia-Pacific), and London, United Kingdom (Europe).

Commonwealth Bank of Australia trades Almonds on the Blockchain. In June 2018, an Australian bank moved 17 tons of almonds from Australia to Germany using the Ethereum blockchain network. The transaction involved "five domestic and international supply chain leaders" and combined various software and hardware elements to track the whereabouts, contractual status (including payments, documents, and operations), and physical attributes (such as temperature and humidity) of the shipment every step of the way.[103]

There are some problems in the transport, shipping and logistics (TSL) industry that could be solved with blockchain-based platforms:

- Transportation payment and dispute resolution in reducing payment delays and disputes.

- Administrative costs reduced (cost of document processing and administration reaches 20%2 of the costs of transportation according to Maersk and IBM).

- Freight monitoring and quality control, i.e. cold chain monitoring

- Transparency and trust Cargo: thefts alone are estimated to $30 billion annually worldwide. Blockchain implementation leads to a significant reduction of dishonest behaviour and its identification along the supply chain.

- Trust and fraud detection: With a single shipment oftentimes involving over 20 parties with roughly 200 interactions between them, there are numerous opportunities for dishonest behaviour. These include: — paperwork manipulation, — shipment counterfeiting, — fabricating data about cargo condition, — goods theft, — requesting fines under a false pretext. With blockchain, companies can detect and combat fraud by tracking and validating every step of the supply chain process, benefiting both the buyer and manufacturer.

- Provenance tracking Trustworthy and detailed product lineage process can quickly help with: — identifying parties impacted by recalls, — locating faulty batches, — providing proof that a product was sustainably grown or manufactured. Great examples include both Walmart and the Australian meat industry using blockchain to record and track information about beef or IBM helping with tracking of ethically sourced coffee.

- Enhanced data visibility and transparency Telematics, IoT, RFID, NFC tags and similar technologies are already improving the TLS industry, but the collected data is siloed across the organizations in the delivery chain. Utilizing blockchain technology provides: — access to the same data by all parties, — real-time information acquisition, — permanent data storage, — tamper-proof information, — tracking modifications to stored data. By reducing the analogue gaps, DLT can help with gaining an insight into where the shipment currently is, predict arrival times and help drive cost reduction.[104]

Boxinsider[105] is an initiative for setting up a track-and-trace application that allows companies to more easily check where their containers are and when they'll arrive at their destination, saving up to two hours in checking where the containers are.

Deliver also uses blockchain technology to give an insight into all necessary papers and data for the parties involved.

The port of Antwerp applies Blockchain to cargo documentation. A pilot project will involve Belgian fruit forwarding company **Belfruco**, Belgian importer **Enzafruit**, **PortApp** — a blockchain application developer, **1-Stop — a port logistics solution provider**, and New Zealand fruit and vegetable grower, exporter and importer **T&G Global**. The companies' aim will be to ship fruit from New Zealand to European markets by using the blockchain-enabled, digital phytosanitary certificates. If successful, the technology should transfer certificates to the Belgian authorities for inspection and approval before releasing the cargo of fruit for import in Belgium.

To release the cargo of fruit from the SEA-invest terminal, a facility operated by SEA-invest group — the owner of Belfruco, a digital certificate will be validated as it passes from T&G Global, Enzafruit, Belfruco and the Belgian authorities.

The transfer of a certificate takes place after product inspections are carried out prior to export.[106]

Waltonchain (WTC), a project which targets the trade and transport niche with a specific focus on using RFID chips and hardware to help track a wide range of products like clothing and electronic components.

Waltonchain has chosen the clothing industry as the first test for its platform, as part of Phase 1.0 of their release. The clothing industry already makes use of RFID tags, which gives the team an enormous amount of data to work with.

The project has already teamed up with **industry partners in China**, and the development will act as a proving ground for Waltonchain's combination of distributed ledgers and RFIDs, allowing them to refine it before they move onto other industries.

CargoCoin, plainly describing its intent as "blockchaining logistics," is one of the newer entrants in the space. It has a general agenda for the supply chain industry, specifically wanting to replace its paper-processing systems with smart contracts and escrow payments to ensure efficiency and security in the shipment of goods.

CargoCoin's plan for blockchain logistics extends to all layers of transport and trade, including inland transportation, air cargo, pipeline transport and the inter and outer city shared lines.

3. Challenges facing the blockchain technology

Although there are clear benefits and opportunities in the use of blockchain technology to enhance the efficiency of several processes and cut costs, it is not a panacea. There are a number of challenges for the companies in digitizing their supply chains. Challenges to be addressed include:

Level of collaboration between partners

Coordination process and digital transformation across multiple, disbursed, and often disconnected supply chain actors is challenging. Global supply chains are more and more complex and involve many actors—producers, brokers, transporters, processors, wholesalers, retailers, and consumers—who may not trust each other and be reluctant to share data, hence limiting the level of collaboration. Value and incentive for each actor are important to have a successful collaboration. In addition, the technical solution often requires different companies to work together to deliver a solution.

Level of connectivity and level of digital maturity of various actors

Blockchain technologies require internet connections and digital literacy for widespread adoption; this remains a challenge in some emerging markets, as well as in rural areas of developed countries, where many farmers and producers are located.

Close to 80 per cent of Europeans use the internet, compared to less than 20 per cent of Africans, and the digital gap between Organisation for Economic Co-operation and Development (OECD) countries and least-developed countries (LDCs) has been growing sharply since the beginning of the millennium, with a slight improvement since 2013 (ITU).

More worrisome is the growing bandwidth gap. Having more powerful telecommunications installations and a stronger bandwidth speed will support blockchain development.

Data reconciliation processes are costly

As businesses expand into multiple facilities and countries, it can be difficult to keep track of inventory and manage the numerous data and regulatory requirements. Efforts are needed in the tracking and reconciliation of data for a single transaction from numerous data in different regulatory environments. In many cases, these reconciliation processes are still manual and

Regulatory frameworks are needed

Blockchain and smart contracts could help administer border procedures and national single windows in a more efficient way and improve the accuracy of trade data. The real challenge will be settling interoperability issues and standardization but also political will to create a regulatory framework that is conducive to paperless trade.

Energy consumption limits scalability

Many observers point to the limited scalability of blockchains due to the predetermined size of blocks and energy consumption issues. While scalability is a serious issue for public blockchains, it is less so for consortium permissioned ones, which do not face the same limitations.

Security issues

Although blockchains are highly resilient compared to traditional databases due to their decentralized and distributed nature and the use of cryptographic techniques, they are not completely immune from traditional security challenges, and advances in technologies.

Conducive regulatory framework

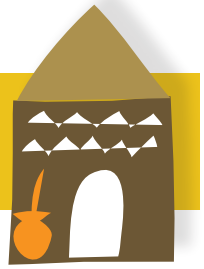
Need for a regulatory framework that recognizes the legal validity of blockchain transactions, clarifies applicable law and liabilities, and regulates the way data can be accessed and used. The most critical issue relates to the legal status of blockchain transactions. Legislation that recognizes the validity of e-signatures, e-documents and e-transactions, in particular blockchain transactions, is crucial.

Data privacy

Another potentially challenging legal issue is the question of data privacy and data localization,

restrictions on cross-border data transfers and data privacy, with a growing number of countries adopting measures that impose requirements or restrictions on data flows.

Two key provisions of the GDPR seem a priori incompatible with Blockchain, namely the “right to rectification” and the “right to be forgotten” – i.e. the right to rectify or obtain the erasure of personal data (Articles 16 and 17 of the GDPR). The immutable nature of blockchains makes it very difficult to update, erase, change or correct data. Some in the community argue that a possible solution is to keep personal



data off the chain, with only its evidence (cryptographic hash*) exposed to the chain, thereby maintaining the integrity of the transaction while making it possible to erase the transaction itself. The deletion of the data stored externally would mean that the hash stored on the blockchain would point to a location which has been deleted. Others note, however, that hashed data qualifies as personal data under EU law.[107]

Cost of maintaining a blockchain-based system

However, careful consideration needs to be given to the costs of transiting to and maintaining a blockchain-based system. Establishing a blockchain platform is a complex endeavour that requires complicated integration processes. In fact, a large part of the cost reductions to be derived from a blockchain may not be linked to the technology itself, but rather to the integration and streamlining work that is necessary to move to a blockchain system.

The scalability challenge

Limited scalability of blockchains due to the predetermined size of blocks and energy consumption issues. This is particularly true for public blockchains, but less so for consortium and private blockchains, which do not face the same limitations.[108]

A McKinsey & Company report claims that the technology on the rise had limited use cases.

For 2019, the post suggests that niche applications, modernization value and reputational value are the areas for blockchain to look in to for restoring its value.

The scalability of blockchain is another area of concern. Moreover, the security issues associated with it adds up to downvoting the technology.
A quantum computer made by Google was mentioned as another problem for blockchain. As the computer is said to work with extremely high speed, it is expected to have the potential of hacking codes used by cryptocurrencies.[109]

Deloitte's 2018 survey of more than 1,000 blockchain-savvy executives globally gives some insights into the perception and use of the technology.

Nearly 39 percent of the broad global sample said they believe blockchain is "overhyped" (44% in the USA). Deloitte believes that this is because blockchain's development is in early stage rather than a current failure of the technology.[110]

Supporters are composed by the adopters of the cryptocurrency (59%) who believe in the disruption Blockchain can bring to various industries. Skeptics view blockchain as the overhyped engine behind a volatile and unregulated financial market. However, there are still few cases which operate at a significant scale and the debate is more about its potential.

However, survey indicates that one-third of respondents have already brought a blockchain implementation to production; another 41 percent plan to bring blockchain to production in the next year. Another positive trend is the organisation of consortiums and collaborative networks with shared costs and advantages at scale which are attractive for finance and technology.

While the financial technology (fintech) sector was leading in blockchain development, today more organizations in more sectors—such as technology, media, telecommunications, life sciences and health care, and government—are expanding their blockchain initiatives

Simultaneously, 53 percent of respondents say that blockchain technology has become a critical priority for their organizations in 2019.

4. The way forward

While blockchain solutions in production are still relatively limited globally, it's clear that there's greater interest in—and a better understanding of—blockchain and its benefits. Multiple proofs of concepts are completed already or are in progress, and some solutions are already in or close to production release. Companies and other organizations are putting more effort into development of the technology every day, and governments have started to take adoption seriously. In addition to the progressive adoption of blockchain by enterprises, efforts to standardize blockchain platforms are happening.

However, there are still some challenges and limitations to a wide adoption of blockchain : (i) a lack of common understanding among policy makers, technical experts and value chain actors on the use of blockchain technology; (ii) insufficient investment in research and innovation, as well as in education and training by the government; (iii) mass adoption requires interoperability and a certain level of standardization; (iv) blockchain platform has to partially or fully replace existing legacy systems which requires time and resources; (v) regulatory and legal frameworks are needed to guide the use of blockchain technology in food supply chains (i.e. avoiding effects of speculation and significant price fluctuations) and possible security risks, even if blockchain offers advanced security (ensuring trusted data in entered in the system).

With 444 million unique mobile subscribers in sub-Saharan Africa, according to the GSMA 2017 report, the possibility that farmers could harness blockchain technology does not seem too far off. However, for farmers' transactions to be uploaded to the ledger, they still need access to the internet and only 38% of mobile users in sub-Saharan Africa were connected to mobile broadband in 2017. Despite current limitations in terms of digital infrastructure, progress is heading in the right direction and by 2025 the GSMA expects 87% of mobile users in the region to be connected to mobile internet. There is evidently still a long way to go in terms of building the human and infrastructural capacities to harness the full potential of blockchain technology in the food system, but the industry has already begun to embrace the possibilities and invest in developing agricultural solutions using the technology.[111]

Acronyms

API
Application Programming Interface

BC
Blockchain

BCT
Blockchain Technology

CoP
Community of Practice

DAG
Directed Acyclic Graph

DLT
Distributed Ledger Technology

ETN
Electroneum

FAO
Food and Agriculture Organization

F&BKP
Food & Business Knowledge Platform

GIS
Geographic Information Systems

IoT
Internet of Things

KYC
Know Your Customer

LMICs
Low- and Middle-Income Countries

MSME
Micro, small and medium enterprises

PoS
Proof of Stake

PoW
Proof of Work

RFID
Radio Frequency Identification

SDGs
Sustainable Development Goals

WCDI
Wageningen Centre for Development Innovation

WTO
World Trade Organization

Glossary

Address
Cryptocurrency addresses are used to send or receive transactions on the network. An address usually presents itself as a string of alphanumeric characters.

Bitcoin
Bitcoin is the first decentralised, open source cryptocurrency that runs on a global peer to peer network, without the need for middlemen and a centralised issuer.

Block
A block is the data structure used in blockchains to group transactions. In addition to transactions, blocks include other elements such as the hash of the previous block and a timestamp.

Blockchain
A blockchain is a linear form of a distributed ledger composed of immutable blocks of data, each block containing a list of transactions and a unique reference to its predecessor block. Strong cryptographic techniques are employed to maintain integrity between each block and its predecessor. This allows blockchains to be shared and corroborated by anyone with the appropriate permissions. Blockchain may also be referred to as a distributed ledger, which is also commonly considered to be a specialised form of a distributed database.

Key blockchain characteristics are:

i. **Cryptography:** a wide variety of cryptographic functions are used, including hashing algorithms.
ii. **Peer to peer:** consist of a peer to peer discovery and synchronisation mechanism
iii. **Consensus:** algorithms that determine the sequence and validity of transactions
iv. **Ledger:** list of transactions that are bundled together in cryptographically linked blocks
v. **Validity rules:** the network rule set determines what transactions are considered valid and how the ledger gets updated, etc.
vi. **Crypto economics:** a combination of cryptography and economics (game theory) that makes sure all actors in a decentralised system are incentivised to remain honest

Block Explorer
Block explorer is an online tool to view all transactions, past and current, on the blockchain. They provide useful information such as network hash rate and transaction growth.

Block Height
The number of blocks connected on the blockchain.

Block Reward
A form of incentive for the miner who successfully calculated the hash in a block during mining. Verification of transactions on the blockchain generates new coins in the process, and the miner is rewarded a portion of those.

Central Ledger
A ledger maintained by a central agency.

Consensus
Consensus is achieved when all participants of the network agree on the validity of the transactions, ensuring that the ledgers are exact copies of each other.

Cryptocurrency
Also known as tokens, cryptocurrencies are representations of digital assets that use cryptography to control key processes including creation of additional units and transfer of assets. Decentralised control is achieved through distributed ledger technology. In this way, cryptocurrencies operate independently of central authorities, such as banks.

Cryptography
A method for securing communication using code. The main example of cryptography in cryptocurrency is the symmetric-key cryptography used in the Bitcoin network. Bitcoin addresses generated for the wallet have matching private keys that allow for the spending of the cryptocurrency. The corresponding public key coupled with the private key allows funds to be unlocked. This is one example of cryptography in action.

Dapp
A decentralised application (Dapp) is an application that is open source, operates autonomously, has its data stored on a blockchain, incentivised in the form of cryptographic tokens and operates on a protocol that shows proof of value.

DAO
Decentralised Autonomous Organizations can be thought of as corporations that run without any human intervention and surrender all forms of control to an incorruptible set of business rules.

Digital Commodity
A digital commodity is a scarce, electronically transferrable, intangible, with a market value.

Digital Identity
A digital identity is an online or networked identity adopted or claimed in cyberspace by an individual, organization, or electronic device.

Digital Signature
A digital code generated by public key encryption that is attached to an electronically transmitted document to verify its contents and the sender's identity.

Ethereum
Ethereum is a blockchain-based decentralised platform for apps that run smart contracts, and is aimed at solving issues associated with censorship, fraud and third party interference.

Distributed ledgers
Distributed ledgers are a multi-purpose technology in the digital world that are specifically designed to be shared across a network of multiple sites, geographies or institutions. Records are stored in a ledger that continues to grow.

Distributed Network
A type of network where processing power and data are spread over the nodes rather than having a centralised data centre.

EVM
The Ethereum Virtual Machine (EVM) is a Turing complete virtual machine that allows anyone to execute arbitrary EVM Byte Code. Every Ethereum node runs on the EVM to maintain consensus across the blockchain.

Hash
A hash is the result of a function that transforms data into a unique, fixed-length digest that cannot be reversed to produce the input. It can be viewed as the digital version of a fingerprint, for any type of data.

Internet of things (IoT)
A network of 'smart' devices (typically involving sensors) that can communicate over the internet, collecting and sharing data.

Mining
Mining is the act of validating blockchain transactions. The necessity of validation warrants an incentive for the miners, usually in the form of coins. In this cryptocurrency boom, mining can be a lucrative business when done properly. By choosing the most efficient and suitable hardware and mining target, mining can produce a stable form of passive income.

Node
A node is a computer running specific software which allows that computer to process and communicate pieces of information to other nodes. In blockchains, each node stores a copy of the ledger and information is relayed from peer node to peer node until transmitted to all nodes in the network.

Oracles
Oracle are trusted providers of external data. By design, a smart contract is not aware of any outside data or events. It resides inside a blockchain and knows only about the data stored on that blockchain. Oracles facilitate an interface between the distributed ledger and the outside world. They can range from IoT sensors, weather stations or trusted information providers supplying relevant data.

Peer to Peer
Peer to Peer (P2P) refers to the decentralized interactions between two parties or more in a highly-interconnected network. Participants of a P2P network deal directly with each other through a single mediation point.

Permissioned blockchain
A closed platform, built to allow an organisation or network of organisations to exchange information and record transactions. Participating organisations manage permissioned blockchains; only preapproved entities can access and interact with them.

Permissionless blockchain
Decentralised and distributed platforms that have no central governance. No single entity or government can bring the network down and participants must be incentivised (through tokens) to run and trust the network – transparency is paramount.

Public Address
A public address is the cryptographic hash of a public key. They act as email addresses that can be published anywhere, unlike private keys.

Private Key
A private key is a string of data that allows you to access the tokens in a specific wallet. They act as passwords that are kept hidden from anyone but the owner of the address.

Proof of Stake
A consensus distribution algorithm that rewards earnings based on the number of coins you own or hold. The more you invest in the coin, the more you gain by mining with this protocol.

Protocol
A set of rules that dictate how data is exchanged and transmitted. This pertains to cryptocurrency in blockchain when referring to the formal rules that outline how these actions are performed across a specific network.

QR code Quick Response code
A QR code (quick response code) is a type of 2D bar code that is used to provide easy access to information through a smartphone. In this process, known as mobile tagging, the smartphone's owner points the phone at a QR code and opens a barcode reader app which works in conjunction with the phone's camera.

Signature
Signing a message or a transaction consists in encrypting data using a pair of asymmetric keys. Asymmetric cryptography allows someone to interchangeably use one key for encrypting and the other key for decrypting. Data is encrypted using the private key and can be decrypted by third-party actors using the public key to verify the message was sent by the holder of the private key.

Smart Contracts
Smart contracts encode business rules in a programmable language onto the blockchain and are enforced by the participants of the network.

Token
Tokens are a type of digital asset that can be tracked or transferred on a blockchain. Tokens are often used as a digital representation of assets like commodities, stocks and even physical products. Tokens are also used to incentivise actors in maintaining and securing blockchain networks.

Tokenless Ledger
A tokenless ledger refers to a distributed ledger that doesn't require a native currency to operate.

Transaction
Transaction are the most granular piece of information that can be shared among a blockchain network. They are generated by users and include information such as the value of the transfer, address of the receiver and data payload. Before sending a transaction to the network, a user signs its contents by using a cryptographic private key. By controlling the validity of signatures, nodes can figure out who is the sender of a transaction and ensure that the transaction content has not been manipulated while being transmitted over the network.

Transaction Block
A collection of transactions gathered into a block that can then be hashed and added to the blockchain.

Transaction Fee
All cryptocurrency transactions involve a small transaction fee. These transaction fees add up to account for the block reward that a miner receives when he successfully processes a block.

Turing Complete
Turing complete refers to the ability of a machine to perform calculations that any other programmable computer is capable of. An example of this is the Ethereum Virtual Machine (EVM).

Validator nodes
Validator nodes are specific nodes in a network that are responsible for constituting blocks and broadcasting these blocks with the network. To create a valid new block they have to follow the exact rules specified by the consensus algorithm.

Wallet
A file that houses private keys. It usually contains a software client which allows access to view and create transactions on a specific blockchain that the wallet is designed for.

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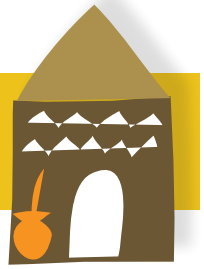

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Endnotes

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The joint venture will now enable IBM and Maersk to commercialize and scale their solutions to a broader group of global corporations, many of whom have already expressed interest in the capabilities and are exploring ways to use the new platform, including: General Motors and Procter and Gamble to streamline the complex supply chains they operate; and freight forwarder and logistic company, Agility Logistics, to provide improved customer services including customs clearance brokerage.

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