Blockchain- Enabling Tomorrow's Rural Agricultural Industries

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Abstract: The world economy is drastically changing, and as of today, emerging economies account for approximately 59% of the total global domestic product (GDP).[1] With seven of the ten largest agricultural producers and exporters being in emerging economies, the agricultural sector constitutes a large portion of these economies. Agriculture accounts for almost one billion in global employment and is the largest employer of women in developing nations. However, ongoing issues, such as lack of transparency and efficiency, plague the industry. Today, nearly 40% of the world's agricultural land has degraded due to either environmental changes or soil problems caused by unsustainable agriculture or mismanagement.[2] Furthermore, demand for non-food biofuel crops, development of former farm lands, rising transportation costs, climate change, consumer demand, and population growth are threatening food security. As most of these economies are going through developmental transitions, they face the additional problems of political instability, corruption, international debt, and lack of infrastructure/agricultural financing options.

Smallholding, which forms the bedrock of agriculture sectors in emerging economies, is considered by the International Fund for Agricultural Development as part of the solution to global food security. According to economists, agriculture was the pillar of the industrial revolution, and in today's perspective, effective and innovative agriculture has the potential to be the pillar of the new digital revolution. Additionally, a report published by the International Food Policy Research Institute suggests that agricultural technologies will have the greatest impact on food production if adopted in combination with each other. The purpose of this study is to identify and dissect current and potential future problems associated with the agricultural industry, and potential solutions to these problems through emerging technologies such as blockchain. The publication will also introduce several companies or projects that utilize blockchain technology and will discern whether their solutions address critical problems or introduce new market opportunities associated with the agricultural industry.

The following map provides a look at the percentage of each nation's population employed in the agricultural sector in 2017:[3]

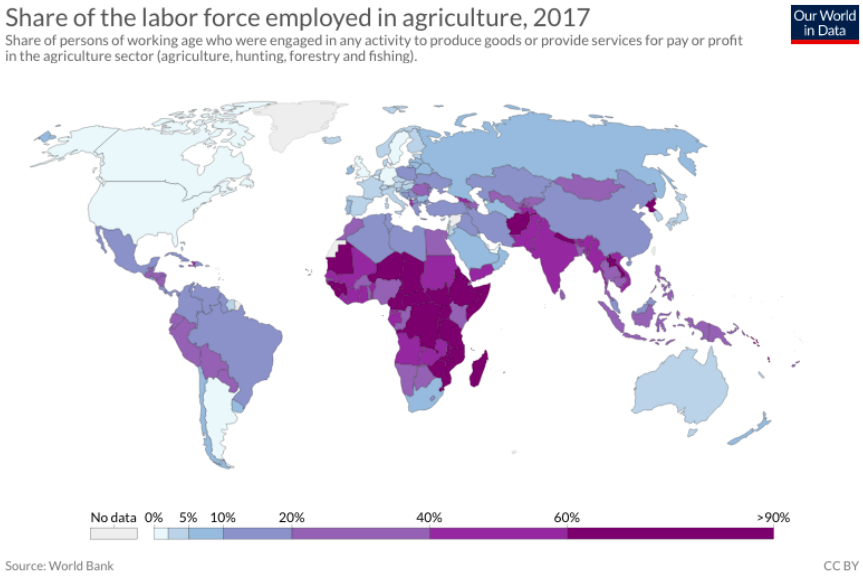

Figure 1: Couldn't find a caption, edit here to supply one.

Problem: The current problems associated with the agricultural industry in emerging economies are multi-faceted; however, key problems can be grouped into the following:

- Agricultural Sustainability (crop yield, environmental damage, mismanagement)
- Agricultural Finance (banking, insurance, agricultural commodities)
- Agriculture Management (value chain, adulteration)
- Agricultural Trends (organic food, consumer demand)
- Agricultural Trade (global trade, transportation, food pricing)
- Agricultural Security (food security, growing population, lack of land)
- Agricultural Livelihood (rural lifestyle vs urban lifestyle)

Examining these issues from the perspective of emerging economies provides a better understanding of the problems at hand.

Agricultural Sustainability: Contemporary agriculture has been characterized by increasing crop yield through the utilization of synthetic fertilizers and pesticides. However, this process has damaged the soil and natural ecosystem, thus hindering the long-term development of crops. Today, as the agricultural industry moves

towards a more sustainable crop production model, it is critical for farmers to possess data, information, and recurring feedback on their assets. In most emerging economies, farmers are ill-equipped with any such resources due to lack of infrastructure, cost of information and updates, and little access to knowledge.

The environment plays another critical role in the agriculture of emerging economies. Drought, natural disasters, and pollution are some of the major problems associated with asset maintenance. Battling the environment requires proper management, as well as knowledge of both pre and post-disaster strategic crop cultivation. Furthermore, environmental issues have led to increased problems in both food security and exports for emerging economies.

Management of the agricultural sector can be underlined as one of the major problems in emerging economies. In many developing nations, the inability to utilize existing resources and provide enough knowledge/tools to farmers leaves them susceptible to sustainability issues and causes them to suffer production and output shortages. Furthermore, some developing nations lack resources such as infrastructure, qualified teams, and equipment to support their farmers altogether.

Agricultural Finance: Most emerging countries are unable to cover the agricultural sector with traditional financial services. Unlike in developed countries, where systems, such as the Farm Credit System (FCS), enable agricultural financial services, similar specialized agricultural banking, insurance, and equipment lending services are relatively new or non-existent here.[4] This lacking is largely due to the risk associated with lending without proper data, models, or gauging methodologies to track farmers' progress. Most agricultural lands in emerging economies are located in rural areas, which lack the mainstream infrastructure to facilitate growth or monitoring mechanisms. Corruption, nepotism, extortion, and transportation add to the complexities of enabling agricultural financial services in emerging economies. Critical risk factors related to lending in the agricultural industry include:

1. Credit risk: Banks financing agricultural operations and capital investments assume the risk associated with the borrower's (i.e. farmers) ability to successfully deliver products to market. Prolonged adverse market conditions can increase borrower defaults and significantly impair collateral value, negatively affecting a bank's ability to withstand a sustained market downturn. The borrower's repayment capacities are also vulnerable to risks, many of which are outside the borrower's control, including adverse weather conditions, commodity price volatility, diseases, land values, production costs, changing government regulations and subsidy programs, changing tax treatment, technological changes, labor market shortages, and changes in consumer preferences.
2. Interest rate risk: Most agricultural operating lines that banks finance are either short-term or variable rate loans, resulting in lower interest rate risk. A bank that provides fixed-rate financing for an extended term (e.g. on farmlands) exposes itself to an interest rate risk where shorter-term liabilities fund the long term loans. For example, to mitigate interest rate risk in real estate, banks may underwrite long-term loans with a three to five-year balloon payment to provide the opportunity for repricing the loans at maturity. Additionally, the bank may have an increased credit risk exposure in a rising rate environment as agricultural borrower's repayment ability is reduced by higher borrowing costs.
3. Liquidity risk: Agricultural lending can result in higher liquidity risk for banks, especially banks with large agricultural credit concentrations. For example, if crop losses or unfavorable market conditions result in loan payment deferrals, the bank's liquidity could be strained. In addition, discontinued farm operations and migration to urban areas can cause declining deposits, creating long-term liquidity pressure.
4. Operational risk: There is extensive documentation, inspection, control, and monitoring associated with agricultural lending. Failure to perform these administrative functions can lead to loan collection problems. In addition, improper controls can unnecessarily expose banks to losses and increased operational risk, particularly if loan collateral is sold out of trust. Failure to properly document a loan supported by a government guarantee can result in the bank's inability to collect on the guarantee if needed. This is most often the result of lender complacence or inappropriate assumptions about a borrower or collateral. Furthermore, lien perfection requirements for agricultural collateral can

vary depending on property type and legal requirements in different areas. If liens are not properly perfected, banks may not be protected by collateral when liquidation, repossession, or foreclosure becomes necessary. Evidence of collateral lien perfection and timely collateral inspections should be documented in the loan file.

5. Price risk: For agricultural loans secured by real estate, price risk can occur upon a bank's foreclosure or physical possession of a property, whereby the loan is transferred into other real estate owned (OREO).[5] During the holding period, OREO must be carried at the lower cost or fair value (less estimated costs to sell). A decline in real estate prices can reduce the number of proceeds realized upon the property's disposal.
6. Compliance risk: Compared with consumer transactions, there are few borrower-focused rules regulating agricultural financing. In developed markets such as the United States, agricultural lending is subject to the Equal Credit Opportunity Act (Regulation B) (12 CFR 1002).[6] Even then it may be subject to zoning, environmental protection, and other government regulations if real estate serves as collateral. Failure to comply with regulatory requirements can expose the lender leadership to liability and jeopardize ultimate repayment, resulting in supervisory actions and/or significant losses.
7. Strategic risk: A sound agricultural lending program should include risk management systems to identify, measure, monitor, and control the bank's risks. The bank should also have staff with requisite knowledge and expertise to manage the bank's unique agricultural risks. Prudent agricultural lending requires specialized expertise. Failure to provide effective oversight of agricultural activities can increase the bank's strategic risk profile while also negatively affecting interrelated risk in areas such as credit and reputation.
8. Reputation risk: Banks with lending activities in certain agricultural enterprises can face reputation risk. For example, a bank may finance operations that generate large amounts of animal waste that could potentially contaminate water sources or cause other ecosystem damage. Public perception and potential litigation may cast the bank as being responsible for environmental cleanup, the costs of which may exceed the amount of the original loan. In addition, a bank can damage its reputation by reducing the availability of its farm credit or foreclosing on farm collateral. Many agricultural lenders do business in small, rural communities where constructively working with borrowers often benefits both parties. Lending decisions that are not publicly perceived as favorable to the community may have a significant effect on the bank's agricultural lending activities. For example, if the bank forecloses on a family farm owned for generations, the community may negatively view the bank's foreclosure action, even if the action was a prudent business decision.

These risks, along with several other factors, make it increasingly difficult for banks to perform operations in the agricultural industry of emerging markets. Governance, rural communities, and smallholdings add to the complexities of banking operations, as do insurance and equipment lending. Thus, a significant amount of risk assessment and management is necessary to execute financial operations in the agricultural industries of developing nations, and without adequate manpower, forecasting, and risk management, it is difficult to deploy such services. Although some emerging economies have introduced a micro-finance scheme that enables them to provide a certain amount of facilities to farmers; the operational costs and size of lending figures cannot be maintained or scaled to tackle the next ten years of global agricultural and food security needs.

Agriculture Management: There are multiple problems pertaining to the successful management and distribution of agricultural products in emerging economies. Value chain, which is defined as the cost of food processing, distribution, and agricultural marketing, is at a significant disadvantage due to poor resource quality, corruption, extortion, pilferage, and lack of adequate storage spaces. These problems hinder product management and encourage product adulteration to increase shelf life and cover target production volumes. Emerging economies are unprepared to tackle problems stemming from the grass-roots level and causing the final costs of agricultural products to rise for consumers without directly attributing to farmers' revenue. With increased monitoring, compliance, infrastructure, and skilled manpower, developing nations can work to potentially reduce approximately 60% of final goods value that is spent on the value chain. This is not

an easy feat to achieve, as most emerging economies have major constraints in place.

Agricultural Trends: As consumers across the world become increasingly aware of the quality of food they eat, the type of high yielding agricultural products produced in emerging economies faces a massive threat. Over the course of time, fertilizers and post-industrialization methodologies have created an adverse effect on the soil along with the knowledge of how to produce food organically. The new health trend caused many farmers to focus on organic production, which resulted in lower yield and global food insecurity due to farmers' inability to satisfy demand. New methods such as genetic modification, agricultural phonics, and organic farming schemes are both costly and require new knowledge insertions.

Agricultural Trade: Global trade wars and changes to import laws along with new tariffs have created new complexities for agricultural exports from emerging economies, while exchange rates and subsidy policies have negatively affected farmers in both the developing and developed world. To make matters worse, new compliance laws related to agricultural products do not allow most emerging economies to tackle these changes with a holistic approach. Infrastructure remains a major problem for the transportation and shipment of agricultural products, and volatility within the food market adds to the list of problems the industry faces in emerging economies. As the global population increases in both size and personalized trends, most farmers are not able to deploy production on demand. Meeting consumer demands for decades to come will require increasing market trend knowledge, faster production capacities, and the ability for producers to reach end consumers.

Instability and corruption within local governments can also have a major impact on agricultural trade in emerging economies. Examples include government officials requiring bribes prior to conducting business, or even the threatening of smallholding owners whose trading is seen as disrespectful. The financial burden of continuous bribes can dissuade potential business from being conducted, thus hindering stimulation of the economy. Furthermore, many people in emerging economies still place great value on traditional beliefs such as holding family above everything. Without means of protecting themselves or relocating, a smallholding owner would most likely refrain from conducting business rather than bring potential harm to their family, thus also hindering economic and personal growth. Finally, most emerging economy smallholding owners lack an education, with many of them being illiterate and lacking trade-knowledge, thus significantly limiting their options by making it difficult to properly handle complex trade deals.

Agricultural Security: Smallholdings agriculture is thought to be the solution to the global food security crisis. A smallholding is a small farm owned by one or several farmers in a developing country. As a country becomes more affluent, smallholdings may cease being self-sufficient for reasons such as rising costs, distribution capabilities, and production requirements. While a large portion of smallholdings exists in emerging economies, food security requires the ability to produce agricultural products in a timely and effective manner, which in turn requires these farmers to be equipped with the knowledge, machinery, etc. In the past decade, the global demand for food has almost doubled due to population growth, which has not only caused a decrease in farms, but also pollution that has affected large areas of previously arable land. Most emerging economies are unable to tackle these problems and will require significant amounts of planning, data, and effective production schemes before any progress is made.

Agricultural Livelihood: Due to changes in the economic outlook of emerging economies, a large number of farmers are moving towards the service sectors. This is primarily because of better economic opportunities and institutionalized education. Most rural populations downplay the role of an agricultural producer in favor of service sector incentives and an urban lifestyle. This move is further threatening the agricultural sector in emerging economies. Unless similar economic opportunities are created where farmers are rightfully credited for their productions, the world will face agricultural manpower shortages in the following decades. Most emerging economies or even developed economies are not prepared to tackle this massive loss of manpower or facilitate employment to over one billion people.[7] Therefore, to address this problem requires substantial planning, new market opportunities in agricultural sectors, and equal opportunities and incentives compared to service sectors.

The following graphs depict the change in rural populations and agricultural labor forces in developing regions: *Agricultural labor force and rural population by continent, 1960-2005 – World Development Report (2008).*[8]

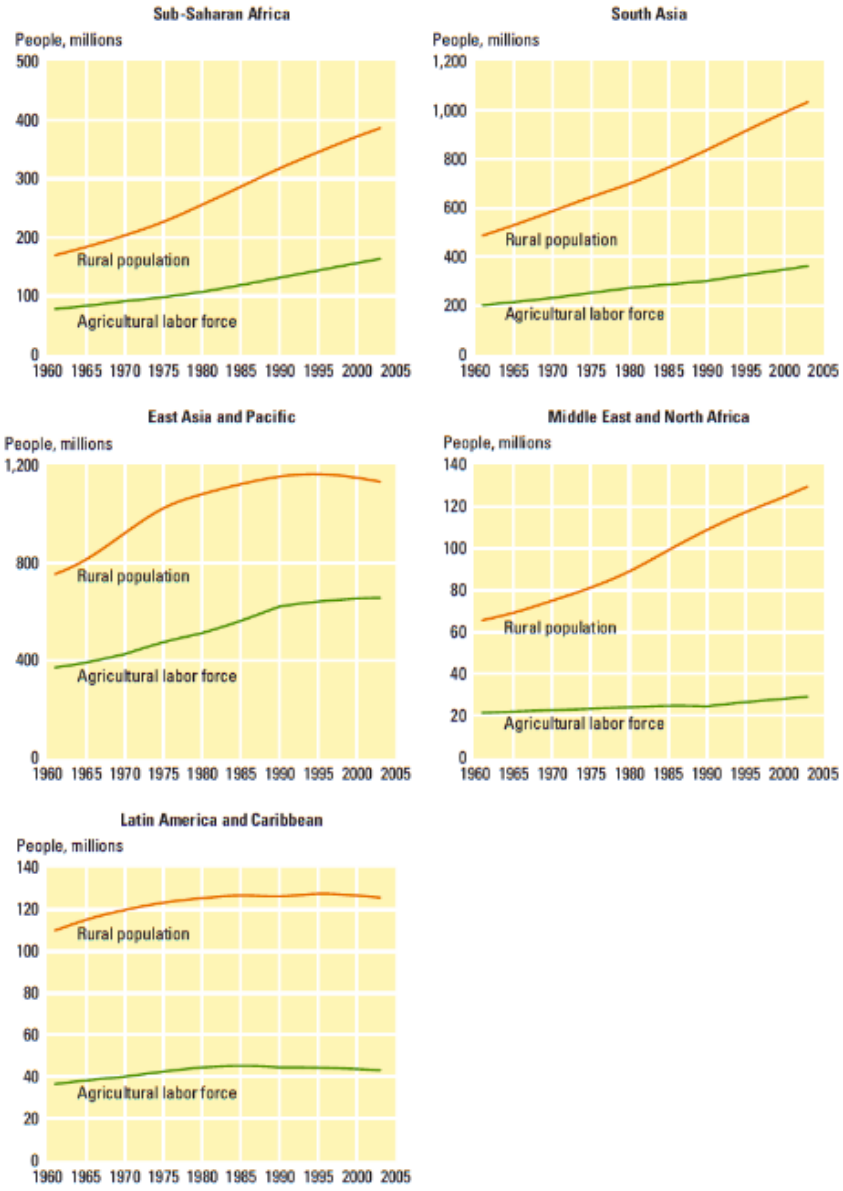

Figure 2: Couldn't find a caption, edit here to supply one.

Technology as a Solution: The plethora of problems stated in the agriculture industry has many folds and will require multi-level solutions. Governance, planning, infrastructure, business models, and technology will act as key catalysts to drive effective changes. In this case, technology can be used as an effective tool kit to address these problems. Technologies such as AI, Big Data, IoT (Internet-Of-Things), Agricultural-Automation, Blockchain, Genetics, Biotechnology, and Geo-Satellite could be utilized as effective tools to facilitate the agricultural industry; however, emerging economies face major challenges in facilitating such

technology, such as cost of deployment and existing infrastructure. Effective utilization of this technology will require the following:

- Infrastructure (power, communication, transportation, facilities)
- Education (knowledge, training institutions)
- Finance
- Research
- Manpower (skilled labor for various operations)
- Planning (governance)
- Support industries

AI, Big Data, and IoT require significantly advanced infrastructure (data retrieval devices, data curation tools, ubiquitous devices, etc.) to address the challenges posed by the agricultural sector of emerging economies. All these technologies require significant amounts of skilled manpower to design, extract, curate and execute operations. Most of this information is also processed in proprietary enterprise systems which make sense of the data. Unfortunately, most emerging economies cannot facilitate such processes, and even in developed countries such as the United States, home of the "Boston IoT Tomato Project", development is still contentious and requires several phases of improvement before producing actionable outcomes that will lead to higher productivity and efficiency.[9]

On the other hand, technologies such as Biotechnology and the Genetic Modification of plant life have yielded far more actionable outcomes. In developed countries such as the United States, scientists at or funded through USDA have opened up new options for farmers responding to market needs and environmental challenges. Many new plant varieties being grown by farmers have been produced using genetic engineering, which involves manipulating the plant's genes through techniques of modern molecular biology often referred to as recombinant DNA technology. However, such processes require considerable amounts of safety and compliance regulations. In the United States, USDA supports the safe and appropriate use of science and technology, including biotechnology, to help meet agricultural challenges and consumer needs of the 21st-century.[10] USDA plays a key role in assuring that biologically altered plants and products derived from those plants are safe to be grown and used in the United States. Once those plants and products enter commerce, USDA supports bringing them and other products to the worldwide market.

As described in this publication, most emerging economies face major governance and infrastructure challenges that leave them unable to create safe and transparent mechanisms. Research is time consuming, costly, and requires considerable amounts of dedicated skilled manpower. While some developing countries have produced successful results through research, such as the high yielding variety of rice (IRRI) produced through BRRI (Bangladesh Rice Research Institute) in Bangladesh, equal amounts of resources and time should be dedicated to meet global demands.[11] Agricultural automation or machinery used in agriculture has been the pivotal tool for industrialization. Most developed countries have utilized these machines to exponentially change the production and efficiency of both plants and livestock. Machines, such as an automated saw for rice fields, improve a farmer's capabilities to produce; however, the saying, "A machine is only as good as its operator," is a daunting reality in emerging economies, as most farmers who lack the knowledge to effectively utilize agricultural machinery resort to more traditional processes of farming. Furthermore, the cost of such types of machinery and their ancillary requirements, such as uninterrupted power supply or fuel, making them difficult to adopt in emerging economies. As mentioned previously, most farms in developing countries are smallholdings, and large farming machinery such as the "In-Row Weeder" or "Harvester" are unnecessary due to their size. This suggests that new tools, both specialized and localized, are necessary to address the agriculture industry in emerging economies. Unfortunately, most of those countries do not house companies able to produce and deploy such products at scale, and without the utilization of agricultural-machinery, it is difficult to attain a prosperous agricultural industry.

Emerging technologies, such as blockchain, are offering solutions and opportunities in the agricultural industry. Blockchain technology requires less on-ground infrastructure and provides affordable access to multiple sets of tools. Additionally, the skilled manpower required for the technology can largely be pooled from

existing resources placed in other parts of the world; thus, the same pool of resources can be shared by multiple parties across various geographic locations. Key challenges in the adoption of blockchain are based on both understanding and creating regulatory and compliance clarity within the agriculture industry. There is no doubt that this technology will have a major impact on the agricultural industry upon implementation.

What is Blockchain and where can it be utilized?

Blockchain is a peer-to-peer decentralized network and distributed ledger system technology that allows a vast array of secured data to be created and shared globally. Furthermore, it allows a globalized storage system through its infrastructure that can be utilized for various operations. Among other functions, blockchain records transactions and changes in data, as well as allows enterprise developments virtually anywhere in the world at minimum cost. Blockchain's skilled resources are remote and therefore do not require a ground unit to be deployed. The technology can be positioned to communicate with existing data, devices, and systems to gather insight and deploy functions. In a nutshell, blockchain technology is capable of conducting operations, storing-exchanging information, transferring real-world value, utilizing decentralized labor force and infrastructure, and being adopted immediately into the current scenario with massive future functional opportunities.

In emerging economies that lack technology infrastructure, specific skill sets, and utilization of current assets, Blockchain can still be operational. For example, a farmer growing rice could need a system that actively monitors droughts and provides him with planning and trading options. He may have difficulty understanding the data and require it in simplified terms of what he can grow, when, where and how he can grow it, and when the best time to harvest and trade it would be. In a traditional system, this would require an enterprise-grade system actively communicating with data provided and other devices or existing data sources. Additionally, key manpower with an understanding of modeling systems in the agricultural industry would need to be utilized, and communication with the farmer or ground unit would need to be conducted to create a system. Existing infrastructure would need to include devices and systems in place to actively monitor certain changes, as well as to communicate with other similar systems to extract certain knowledge or data. Such infrastructure would mean high cost, complexity, and time, all of which emerging economies cannot usually afford.

Blockchain simplifies the entire process by deploying a system that does not require large scale infrastructures such as data centers, data readers, or massive power input to power operations. Instead, existing data collection devices, such as featured phones or even IoT devices, could be leveraged as source inputs. Furthermore, an enterprise-grade system that can curate data and create a model, can be built either on the ground location or in a completely remote location. This is possible because most data available in the decentralized network is easily accessible within the system and does not come at a premium price like traditional systems. At the very least, the decentralized network provides the "utopian dream" of combining the size and quality of data resources similar to Google, IBM, and Microsoft in single global storage space. Most importantly, a decentralized skilled workforce can be pooled, based on its expertise and understanding of multiple geographic locations, to tackle the agricultural industry in emerging economies rather than wait for emerging economies to build a workforce of their own. But this is not the only advantage that blockchain technology provides the industry. Blockchain technology has certain inherent functions that could prove indispensable to the agricultural industries of emerging economies:

- Provenance: This allows an individual to not only track goods, but also to verify the authenticity of a product. Its direct application in the agricultural industry would be providing indispensable information about products from a particular source. This feature will have direct implications on the supply chain and global trade processes of the agricultural industry by addressing the various discrepancies that exist around agricultural products of emerging economies, such as the quality of goods and the adulteration of products before they reach end consumers. It also opens new opportunities to strike better market prices for products where higher qualitative input has taken place, thus allowing global trade to be further localized. For example, during the "Mad Cow Disease" situation in the UK, where beef produced from the entire country received international embargos, there were some uncontam-

inated farms located in the UK that fell victim to the embargo without cause.[12] With blockchain, through clear provenance, one would be able to differentiate those products from the adulterated ones on a more microscopic level, thus preventing the entire industry from suffering for the poor quality of some production.

- Identity: As mentioned earlier, most emerging economies lack the necessary infrastructure to build a robust identity management system. Identity plays a critical role in identifying individuals, activities, and qualitative positioning in global markets. Through blockchain technology, self-sovereign identity can be managed by users choosing who, if anyone, they would like to share their data with. Self-sovereign identity can enable emerging economies to build farmer's credit ratings, farm performance ratings, product ratings, and more. Additionally, as blockchain leverages global networks, these processes can be readily adopted and deployed, thus saving valuable time and cost while developing across the nation.
- Crypto-Currency: Crypto-currency is currently a hotly debated topic and is probably the most defined use case of blockchain technology. It provides a new alternative to financing and trading agricultural products. As discussed previously, the volatility of exchange rate policies and liquidity directly affect the agricultural industry at large. Crypto-currency provides a credible alternative to tackle these problems using a fast and secured mechanism. While key challenges remain in both understanding and regulating compliant use cases of crypto-currency in the agriculture industry, there is a high likelihood that a mutually beneficial relationship will develop between crypto-currencies and emerging economies.
- Autonomous Execution System (Smart Contracts): Smart contracts are one of the founding functions of blockchain platforms such as Ethereum. These systems automate processes of contractual binding between two or multiple parties based on specific task executions. In the agricultural industry, extensive paperwork is required for a farmer to acquire a specific asset from a service provider. This process is lengthy and in many cases unfeasible due to lack of information or structures needed to provide these services. A blockchain enabled smart contract allows both parties to leverage existing data, verify identities, and bind the parties through a contract related to execution, financing, etc. There is no doubt that smart contracts will not only play a critical role in existing scenarios but will also open up new opportunities in the agriculture industry.
- Trust and Transparency: Blockchain enables every transaction/activity across the network to be easily monitored by everyone within the network. This means activities within the value chain, assets, and funds can be securely monitored, and any discrepancies or manipulation will be noticed by everyone within the network. For example, if an agricultural product moving through the value chain shows a discrepancy between its start and end cost, government bodies or even end consumers can investigate the cost changes. Therefore, blockchain has the potential to either lead to direct boycotting of some products (extortion within value chain) or to reduce the end cost of the product, thus drastically reducing the economic opportunities for extortion while at the same time directly facilitating economic empowerment of the farmers. In other words, in broken or corrupt governance systems, transparency and trust can be established without an overhaul of the current system.
- Security: Blockchain technology's most potent tool is its cryptographic immutability. As blockchain is a shared distributed ledger connected through a peer-to-peer network, all transactions and activities can be monitored and secured through a chain. This means that in order to breach the system, the entire system needs to be attacked, which decreases the attacker's capabilities. In other words, the attacker would need to be extremely proficient and lucky to be able to bring down the entire system. Furthermore, even considering such an attack would require both a massive amount of time and resources. Financial incentives to hack a particular contract between a farmer and a financial institution are not high enough to initiate the launch of such an attack. While no system is unhackable, the architecture of the blockchain system makes it the most robust system of its time and primarily creates deterrence. In fact, till today the entire system of blockchain is yet to be completely compromised, and while most traditional system hacks would not be public information, within the blockchain all information is readily available to network peers. Such a secure and resilient system enables the safe movement of assets, value, and data among parties. This is a particularly important tool for emerging

economies, which are constantly vulnerable to cyber-attack strategic interferences, as can be seen in countries such as Turkey, Georgia, and Vietnam.

Use Cases and Projects in Blockchain

Blockchain is being tested and implemented in several projects, many of which use IBM's Hyperledger Fabric, a permissioned ledger that is securely maintained by the interested parties.[13] While using such a system does not provide ultimate transparency, it does provide much more than the current system.

1. Walmart: used blockchain to track mangoes and to test several other food items. Additionally, Walmart is working with IBM and Tsinghua University on a project to track Chinese pork[14]
2. Dreyfus: used a blockchain platform to close a large soybean deal with a Chinese supplier, cutting down transaction time dramatically[15]
3. Coca-Cola: building blockchain platforms to help ensure ethical sugar production[16]
4. Unilever: working with Provenance to track tea in Malawi[17]
5. Carrefour: working on a blockchain system to help trace product origin[18]
6. Dole, Driscoll's, Kroger, Tyson, Nestle, Golden State Foods, McCormick and Company, and McLane Company: working with IBM to build blockchain tracking solutions[19]

Ibisa: IBISA is a Luxembourg based company providing an innovative product for inclusive finance in the agricultural industry using blockchain technology and Earth Observation. In its early stages, IBISA is positioned to tackle emerging markets and create sustainable investment opportunities in those markets. Their product provides the following solutions:

- Risk-Sharing Service: This acts as a mutual alternative to micro-insurance, targeting small farmers worldwide.
- Peer-to-Peer Architecture: This reduces the cost incurred by insurer-centric paradigms.
- Risk Materialization: This leads to effective and attractive compensation for farmers contributing to the scheme through regular micropayments.

IBISA is tackling farmers' requirements in emerging countries in the following manner:

- Protection- Protects crop farmers from weather-related calamities. Thus providing a solution to a permanent need which is more acute with climate changes.
- Affordability- Affordable even for farmers with low revenues. Annual contributions of farmers have to be less than 6% of the sum incurred.
- Loading- Present fair value for money. Current studies have shown that farmers accept loading factors up to 30% above this threshold and thus stop renewing insurance contracts.
- Ease-of-Use- Easy to use and easy to adopt; thus taking into account that a portion of small scale farmers in emerging economies is illiterate.
- Pay-Out- Perform frequent and partial payouts without having to file claims. The current status is the slowness of payout and assessing claims.
- Contribution- Allows farmers to make contributions in a flexible manner. This accounts for the lack of cash at the beginning of the season; a critical barrier in the current scenario.

IBISA has developed an interesting business model that leverages farmers, institutions, and infrastructure solution providers. It is enabling solutions in the following problems existing in emerging economies' agricultural industries:

- Agricultural Sustainability- This is through direct models that tackle weather-centric farming models
- Agricultural Finance: Providing alternative solutions to farmer lending services
- Agricultural Trade: Providing a marketplace for farmers and agriculture-centric institutions
- Agricultural Security: Providing the ability to manage or acquire new farming lands

IBISA leverages blockchain technology in the following categories:

- Decentralized Network and Infrastructure
- Identity
- Trust and Transparency
- Smart Contract
- Security

The key elements of IBISA are as follows:

- The members are farmers, beneficiaries of global mutual risk sharing products.
- The enablers are the link with the farmers' "last mile" that on-boards them as members into IBISA.
- The watchers are the trackers of the index and assessors of the losses, using space assets and other sources of data.
- The profilers are the creators of the risk profiles.
- The developers are the creators of the IBISA infrastructure and its evolution.
- The risk contribution is defined based on the area within which the farmers live.
- Farmers use mobile money to make contributions and receive payouts.
- Farmers pay what they can when they can, and they are responsible for their "merit," which guides how much they are paid in case of loss.
- Loss assessment is done remotely every month, thus eliminating the need to file claims and follow up.
- Partial payments are done whenever a partial loss is detected.

AgriLedger: a project primarily focused on providing regional and international markets and capital access to small farmers, who supply 80% of the food consumed in developing countries. The system primarily runs off of simple smartphone apps and has run pilot co-op projects in Haiti, Papua New Guinea, Myanmar, Kenya, Ethiopia, Ghana, and other countries. All results have been positive so far, with income as much as tripling in some cases.

AgriLedger provides the following services:

- Digital Identity: providing official identification, without which a person can struggle to access financial services, social benefits, healthcare, education, political and legal rights, gender equality, and migration
- Information: Most farmers are operating at just 40% of their potential capacity. With access to information, farmers can now plan and harvest more effectively and gain access to the market.
- Immutable Data: DLT (Digital Ledger Technology) solution provides immutable information, trust, and transparency through the supply chain.
- Traceability: Lack of traceability means tracking and recalling specific contaminated products throughout the supply chain. With the DLT solution, each item can be traced from seed to consumer.
- Financial Service: Without financial access, many agricultural providers lose up to 50% of their potential income. Farmers can prove their identity and income to gain access to financial institutions.
- Record Keeping: Farmers can use their digital ledger for better record keeping and proof of income.

Ripe: a company working to improve the visibility of food supply chains. Ripe is altering the trajectory of the food system through blockchain technology and the IoT by providing the following services:

- Farmers: will be able to leverage IoT and sensors to automate processes and efficiently meet market demand for high quality, sustainable products
- Distributors: will be able to transparently track food products to provide real-time data on food safety and delivery
- Consumers: will receive trusted, certified information on the journey of their food, creating a new standard of food quality

AgriDigital: a commodity management platform targeted toward the grain industry. AgriDigital is an end-to-end solution providing farmers and consumers with simple and easy processes to manage contracts, deliveries, inventory, orders, invoices, and payments all in one place, and in real time, through the following

services:

- Farmers: one platform for contracts, deliveries, and payments. Receive instant delivery and payment notifications
- Storage Operators: from receivable to outturn, all operations on one platform. Communication and dealing with customers
- Traders: easy to use commodity management providing reduction of risk, time, and money

EthicHub: a platform providing crowdfunding and microloans for small format farms, as well as leveraging blockchain to connect investors (lenders) to small unbanked agricultural producers (borrowers) globally. EthicHub provides the following services:

- Investors: are able to choose between highly profitable projects in developing countries. The platform provides access to better reward vs. risk investment opportunities, which are usually found in those countries.
- Small and Unbanked Producers: can benefit from lower interest rates due to greater financing supply and take advantage of stored credit history on the blockchain. More liquidity allows them to improve productivity and have a higher profit from labor, resulting in a better quality of life.

Lokaal: a company that designed a crypto-currency, the LOKA, to support local farms, food-makers, and small businesses by providing microloans and payments. People who are interested in accessing the market can purchase LOKA on Lokaal's site and use it in their curated marketplace, or donate it either through Lokaal support fund or directly to specific farms or food makers listed on their funding pages.[20] Key features of this product are its simplicity and ease of access between end consumers and producers: Farmers: Farms and food vendors get paid instantly for any sale made in their network. Lokaal manages the collections risk with buyers, thus providing cash proceeds based on sales history with flexible repayment options. Conversion to Fiat is very easy, as the exchange rate is recorded during the time of sale to provide stability in exchange rate volatility. End Consumers (Investors/Purchaser): have the option to choose between products they want for their individual purposes (such as retail agricultural products) and can fund projects they believe in, such as organic berry farms, which in turn reduces the retail cost of organic products as they fund the farmers directly. Lastly, they are able to store value and gain in the crypto-currency that is utilized in the platform for lending purposes.

Future of the Industry

The future of the agricultural industry enabled by technology is promising. As explored in this publication, certain technologies can easily be positioned to enable the industry's current scenario, while others hold promise in the long-run. Blockchain technology can present new opportunities in agricultural management, trends, and livelihood, along with areas that IBISA is currently tackling. A clear understanding of the technology by governments will bring about regulatory clarity, which will allow usage of internationally traded agricultural crypto-currencies. Supply chain and production will become more defined and efficient, thus creating new market opportunities. Due to financial and technological improvements through current processes within the agricultural industry, an emerging economy will provide new incentives to onboard technologies such as IoT, AI, Genetics, Biotechnology, and localized agricultural machinery. According to a report published by FAO (Food and Agriculture Organization of the United Nations), the total population of the world will hit 11.2 billion by the year 2100 and current food security needs will double.[21] As emerging economies are positioned to oversee the largest rise in population, it is fair to say that the agricultural industry will carve out a massive chunk of the consumer economy in the future.

Conclusion

Blockchain enabled solutions are a much-needed technology for tackling critical problems existing in the agricultural industries of both emerging and developed economies. Additionally, blockchain provides a

bridge within the agricultural infrastructure space to deploy other technologies into the industry. With the service sector overtaking the agricultural sector in 2009, which bids poorly for the industry that forms the bedrock of food security and thus the survival of humankind, timing is ripe for an overhaul of the industry. While multi-layered challenges exist, including product novelty, government regulations, and key assumptions in technology, the results of certain use cases clearly show that blockchain effectively addresses industry problems better than models enabled by alternative technologies or the current brick and mortar processes. Use cases also show that the utilization of blockchain along with other technologies will address critical problems pertaining to the agricultural industry in the future. Emerging economies are bound to benefit most from the utilization of this technology because there is a symbiotic combination of necessities and disruptions within the existing system and models. Lastly, blockchain is not a duct tape solution to every existing problem in the current agricultural industry, but it is a definite catalytic tool that is ready and well-suited to accelerate the industry for economic growth, increased production, and better management output.

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