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Impact tokenization and innovative financial models for responsible agrifood supply chains

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Acronyms and abbreviations

AI	Artificial intelligence
AIS	Automatic identification system
ANN	Artificial neural network
API	Application programming interface
ARAF	Acumen Resilient Agriculture Fund
BaaS	Blockchain as a service
CDS	Catch documentation scheme
CoC	Chain of custody
CTE	Critical tracking event
DAO	Decentralized autonomous organization
dApp	Decentralized application
DIB	Development impact bond
DLT	Distributed ledger technologies
DNA	Deoxyribonucleic acid
EEZ	Exclusive economic zone
EIB	Environmental impact bond
ERP	Enterprise resource planning
ESG	Environmental, social, and governance
ESMC	Ecosystem Services Market Consortium
EU	European Union
FAD	Fish aggregating device
FAO	Food and Agriculture Organization
GPS	Global positioning system
HACCP	Hazard analysis and critical control points
ICT	Information and communications technologies
IMP	Impact management project
IMS	Information management system
IoT	Internet of things
IP	Intellectual property
IUU	Illegal, unreported, and unregulated (fishing)
KDE	Key data element
M&E	Monitoring and evaluation
MCS	Monitoring, control and surveillance
MRI	Mission-related investments
MSC	Marine Stewardship Council
NFC	Near-field communication
NGO	Non-governmental organization
OECD	Organisation for Economic Co-operation and Development
PFS	Pay for success

PNAO	Parties to the Nauru Agreement Office
PRI	Program-related investments
PoS	Proof of stake
PoW	Proof of work
QR	Quick response (code)
RCT	Randomized controlled trial
RFID	Radio-frequency identification
RFMO	Regional Fisheries Management Organization
SDG	Sustainable Development Goal
SEC	Securities and Exchange Commission
SIB	Social impact bond
SIG	Social impact guarantee
TRU	Traceable resource unit
UHF	Ultra high frequency
UN	United Nations
VMS	Vessel Monitoring System
WEF	World Economic Forum
WFP	World Food Programme
WTO	World Trade Organization
WWF	World Wide Fund for Nature

Executive summary

This report aims to provide a comprehensive summary and analysis on how impact tokenization and innovative financial models can promote responsible agrifood supply chains. The report is intended to inform both policymakers and practitioners on best practices for creating a regulatory environment that is conducive to impact tokenization and private sector investment in sustainable supply chains. It builds upon the framework set forth in the OECD-FAO Guidance for Responsible Agricultural Supply Chains and contributes to SP4 output 40401 on providing analysis to promote transparent markets, and enhanced trade and market opportunities, by conducting research on innovative financing vehicles for responsible agrifood supply chains.

Recent advances in the development of impact tokenization techniques, distributed ledger technology, and innovative financial models have created new opportunities to improve transparency, verification, and incentive alignment across multiple stakeholders in agrifood supply chains. This report outlines those opportunities and describes how practitioners and policymakers can implement enhanced methods for efficiently defining and verifying impact in agrifood supply chains. The report concludes with an analysis of the most promising financial models for promoting responsible supply chains.

The key research questions for this report, along with a summary of the report findings informed by research and interviews with 24 experts and practitioners, include the following:

1. **What are the key data points and verification techniques that can be used to measure farmer engagement and social, financial, and environmental impact?**

Impact measurement in low infrastructure settings can be more efficiently implemented and scaled by focusing on meaningful output measures (e.g. providing fair wages, implementing regenerative farming practices). With the focus on outputs comes a higher need for detailed and robust collection of data points – ideally through overhumanized data (i.e. coming from consensus among multiple participants) or underhumanized data (i.e. coming directly from non-human sources) that support the achievement of each output. These may include time stamped and geotagged photos, receipts from third party sources, usage data from mobile devices, or data from remote sensors. Verification processes can then use this data to conduct validation (e.g. checking data points cross-sectionally and longitudinally, and against external sources) and third party confirmation (e.g. via random sampling) to ultimately increase the confidence score for each impact output. Once data is verified, impact can be tokenized onto a blockchain to maximize transparency, increase auditability, and provide funders with unique attribution and ownership of the impact they have funded.

2. **How can these data points support due diligence and impact tracking and verification efforts, while at the same time incentivizing funders to invest in impact causes?**

A series of detailed and reliable data points supporting the completion of each impact output builds evidence, allows verifiers to triangulate true impact occurrence, and ensures immutability of the impact record through tokenization on a blockchain. Funders can use these data points to support the vetting and due diligence of the implementers to whom they are providing funding, which can also reduce business risk and increase funder confidence. Measurable and meaningful impact outputs, supported by detailed data and collected real-time (or near-real time), can also allow implementers to identify new ways to enhance their business operations, maximize their social and environmental impact, and engage in active performance management to improve their positive impact over time. This level of independent impact tracking and verification – especially when the impact is minted and tokenized onto a blockchain to enhance permanence and auditability – creates new opportunities for funders to confidently engage in innovative performance-based funding models that rally the implementers they fund around a standardized set of measurable results.

3. **What are some of the concrete models that can be applied by the private sector and policymakers?**

Innovative financial models identified included: performance-based philanthropic giving or grantmaking, hybrid philanthropy-investing models (e.g. principal-only return models), crop or price insurance, loan guarantees, forbearance (i.e. forgiveness) loans, interest-bearing impact loans, fixed income bonds, and interest-bearing Pay for Success models. Each of these models provides an incentive for funders to participate in the funding process, and each model presents its own set of advantages and disadvantages in real-world application as outlined in the analysis section.

4. **What are the most promising and scalable impact investment models to create more responsible supply chains? Which financing vehicles can incentivize the private sector to promote and fund responsible supply chains?**

One key distinction discovered in the research was the difference between performance-based financial models (where the level of financial returns is dependent on the achievement of measurable targets) and financial models that aim to make a positive impact, but do not tie financial returns to the achievement of concrete impact targets. Given the growing demand for objective, quantified impact measurement as a part of any impact investment product, performance-based financial models present a significant opportunity for evolution in the field. The most promising performance-based impact investment models identified in this report included performance-based donations, principal-only Pay for Success models, interest-bearing impact loans, and interest-bearing Pay for Success models. All four of these models have potential to incentivize the private sector to promote and fund responsible agrifood supply chains.

5. What are the risks and the limitations of these newly emerging models?

The models were evaluated based on four core criteria: financial return, accessibility, replicability, and regulatory feasibility. In general, there was a tradeoff between the models' financial return and their replicability and regulatory feasibility, as the models with financial return were generally subject to more complex structuring and financial regulatory requirements. The uncertainty surrounding potential regulatory barriers in bringing these models to market presents the largest barrier to scale, followed by the complexity with structuring the models' financial design. However, all of the models presented have precedent around how to achieve regulatory approval and financially structure the products, which paves the way for piloting. In addition, all of the models scored highly for accessibility, which suggests significant potential for democratization of impact investing in the retail sector.

6. Who are the existing organizations working in this emerging ecosystem and how can their experience be leveraged?

One of the key resources in this emerging ecosystem is the group of intermediary organizations that have experience designing, structuring, and successfully launching these innovative, performance-based financial models. These include (but are not limited to) Social Finance, Palladium, Instiglio, Third Sector Capital Partners, Quantified Ventures, and NPX. In addition, there are a growing number of implementers (i.e. service providers), impact investment fund managers, and payers (i.e. government, philanthropy) that have experience participating in similar financial pilots, and that could extend their current projects to test new models. Finally, independent verifiers – particularly those with experience in digital verification – can provide insight into efficient and creative methodologies for defining and verifying impact beyond traditional (and more costly) monitoring and evaluation designs.

7. How can governments, policymakers, and other stakeholders maximize the impact of these newly emerging models?

The analysis found that the interest-bearing Pay for Success model – and particularly the Impact Security – received the top score across the evaluative criteria as the most promising performance-based financial model. Although many Pay for Success projects have been tested previously, there are significant complexities around the tailoring of each project to specific investors' interests, as well as a limitation in the type of investors who can participate. As such, the first recommendation for governments, policymakers, and other stakeholders is to support the development of a Pay for Success investment platform that is accessible to institutional and retail investors alike. This platform could help to standardize, simplify, and automate the development and structuring process while at the same time expanding the market of potential impact investors. In addition to supporting a Pay for Success investment platform, the analysis found that performance-based interest-bearing loans are another promising and innovative financial model, particularly in promoting responsible agrifood supply chains. The second recommendation in this report is to advance the research and piloting of such a loan product and help to catalyze the impact investment industry to test this model.

Chapter 1.
Introduction

There are more than 500 million family farms around the world who produce approximately 80 percent of the world's food (FAO, 2014b). Despite their critical importance, they represent half of the world's undernourished people and many of these families live in absolute poverty (FAO, 2020). Many of them are unbanked, underbanked, and without credit history, which prevents access to critical loans and other financial services that can help lift them out of poverty. Additionally, a significant number of family farmers live nearby natural ecosystem resources, such as coastal areas, natural habitats for endangered spaces, or rainforests.

The 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs) provide an ambitious framework for a better and sustainable future for all. However, public financing is insufficient to generate the required change needed to achieve the SDG transformative agenda. At the same time, the private sector is discovering that the sustainability of its agrifood products is an increasingly meaningful sales promoter. The OECD-FAO Guidance for Responsible Supply Chains provides the private sector with a framework to incorporate responsible business practices into their supply chains. Building upon this Guidance, there is an opportunity to provide increased transparency in supply chains on companies' sustainability performance and test innovative funding mechanisms that can attract greater investments to promote sustainable and responsible agrifood supply chains.[1]

There is a lack of consumer-oriented product information in agricultural industries, such as technical processes, shelf-life, quality, origin, and sources of certification. Therefore, quality labels, such as GLOBALG.A.P, help certify product quality, sustainable supply chains, and safety to the end consumers. Organizations are forced to follow government legislation on food and product quality and safety to ensure trust of end consumers.[2] However, consumers usually cannot evaluate the quality of products before using or consuming them. Nowadays, consumers generally can only rely on brands and labels' reputation; hence, product traceability and transparency from field to shelf and food information credibility are crucial in the food and agricultural industry (Meixner and Haas, 2016).

Leveraging exponential technology, in particular distributed ledger technologies (DLT) and blockchain (Tripoli and Schmidhuber, 2018) that allows for data tokenization, storage of verified impact data, and securitization has created an opportunity to rethink and articulate new categories of business

[1] *Throughout this paper, the authors may use the term "impact investor" or "investor" to refer to any participant providing capital resources with the expectation of a measurable impact return (i.e. a non-financial incentive), regardless of potential for financial return.*

[2] *GLOBALG.A.P. is a trademark and a set of standards for good agricultural practices (G.A.P.).*

and financing models that can improve family farmers' ability to achieve economic prosperity while promoting more responsible supply chains. Additionally, these technologies provide meaningful due diligence tools to prove companies' responsible business practices and overall impact, ultimately creating a stronger value proposition for these companies' shareholders, consumers, and employees. Individual consumer and retail investors can also be further incentivized to participate in the global impact marketplace with increased transparency, prospect of financial returns, and stronger feelings of connection with the impact taking place on the ground.

At the same time, digital transformation of modern agrifood supply chains creates new challenges for a safe, secure, and efficient data exchange between the various supply chain stakeholders. This digital transformation requires establishing end-to-end supply chain visibility and transparency of product movements and provenance within the supply network from product origin to final consumer (Abeyratne and Monfrared, 2016). Despite the challenges, digital supply chains – powered by technology-based data collection (e.g. via machines, sensors, mobile devices) and minted on the blockchain – can offer stakeholders a competitive advantage with faster information integration, reducing product and service costs while at the same time building the data infrastructure needed to monetize the social and environmental impact of their work. DLT can help resolve challenges related to traceability, transparency, and security in supply chains by ensuring protection from non-authorized revisions, tampering, or deletions, thereby allowing individual funders to measure and own the unique impact they have funded (Conoscenti *et al.*, 2016). The combination of technology-based impact measurement and blockchain-supported data tracking sets the stage for a new form of impact investing, driven by, and based on, the achievement of concrete impact targets.

Purpose of the report

This research paper examines how new forms of impact measurement, verification, and tokenization can be leveraged to test innovative financial models that ultimately incentivize more responsible agrifood supply chains, following the guidelines outlined in the OECD-FAO Guidance report. This paper includes insights around practical due diligence frameworks, enterprise policies, and concrete business models, including quality standards and access to capital for smallholder and family farmers.

The report outlines how key data points for impact funders and private investors (e.g. commodity and farmer characteristics, certification, quality standards, and quantifiable outputs such as farmer yield over time) can be collected, verified, and secured along each step of the supply chain. It also assesses how current blockchain applications can be leveraged to improve sustainability in supply chains, and further analyzes and proposes tailored impact investing models that use tokenized data to issue impact returns, financial returns, or both to investors. In meeting these goals, the paper builds on existing research, describing how emerging verification and tokenization techniques can be used to channel private investment capital towards responsible supply chain practices, equitable family farmer payments and well-being, and sustainable environmental approaches.

This paper is intended to inform policymakers, regulators, nongovernmental organizations, policy institutes, impact funders, impact investors, and practitioners in recommending and creating a regulatory environment that is conducive to impact tokenization and private sector investment in sustainable supply chains. It sheds light on the most promising models and ideal ecosystems for those models to be tested and scaled in achieving the greatest impact.

Key research questions

1. What are the key data points and verification techniques that can be used to measure farmer's engagement and social, financial, and environmental impact?

2. How can these data points support due diligence and impact tracking and verification efforts, while at the same time incentivizing funders to invest in impact causes?

3. What are some of the concrete models that can be applied by the private sector and policymakers?

4. What are the most promising and scalable impact investment models to create more responsible supply chains? Which financing vehicles can incentivize the private sector to promote and fund responsible supply chains?

5. What are the risks and the limitations of these newly emerging models?

6. Who are the existing organizations working in this emerging ecosystem and how can their experience be leveraged?

7. How can governments, policymakers, and other stakeholders maximize the impact of these newly emerging models?

Chapter 2.
Literature review summary

Blockchain technology has created a new opportunity to address the growing challenges related to commodity supply chains and the resulting high levels of poverty among family and smallholder farmers. As demonstrated by Tripoli and Schmidhuber (2018), blockchain technologies can help farming families as well as facilitate the emergence of new business models and practices. One example is AgriDigital, which helps ensure farmers get paid for the commodities they produce in real-time when they deliver them, utilizing blockchain technology to create a smart contract system (FAO and ITU, 2019). Other solutions can help farmers get paid fair wages (e.g. Binkabi allows farmers to directly access a commodity marketplace and bypass the traditional intermediaries in supply chains), or help farmers build their digital economic identities on the blockchain, which can give them new access to financial services such as banking and lending (e.g. BanQu) (Noel, 2018). Many of these blockchain solutions are collecting data that serve as a rich source of information to make the supply chain more equitable for family farmers and to begin measuring and monetizing their social and environmental impact. This shift towards collecting decentralized, ground-level data opens the door for innovative funding models that can not only directly remunerate the farmers for their work, but also bring together private investors, willing to pay for and incentivize measurable improvements in wages, standards of living, and environmental practices.

Current financial and impact investing models in the area of agricultural commodities and supply chains (as well as other impact areas) generally focus on microloans, insurance for crop failures, and environmental outcomes, with the occasional initiative related to performance based financing and blended finance (Yin and Meyer, 2016). However, there is a growing need to identify sustainable market-driven solutions that address the broader challenge of family farmers facing poverty at the bottom of the supply chain.

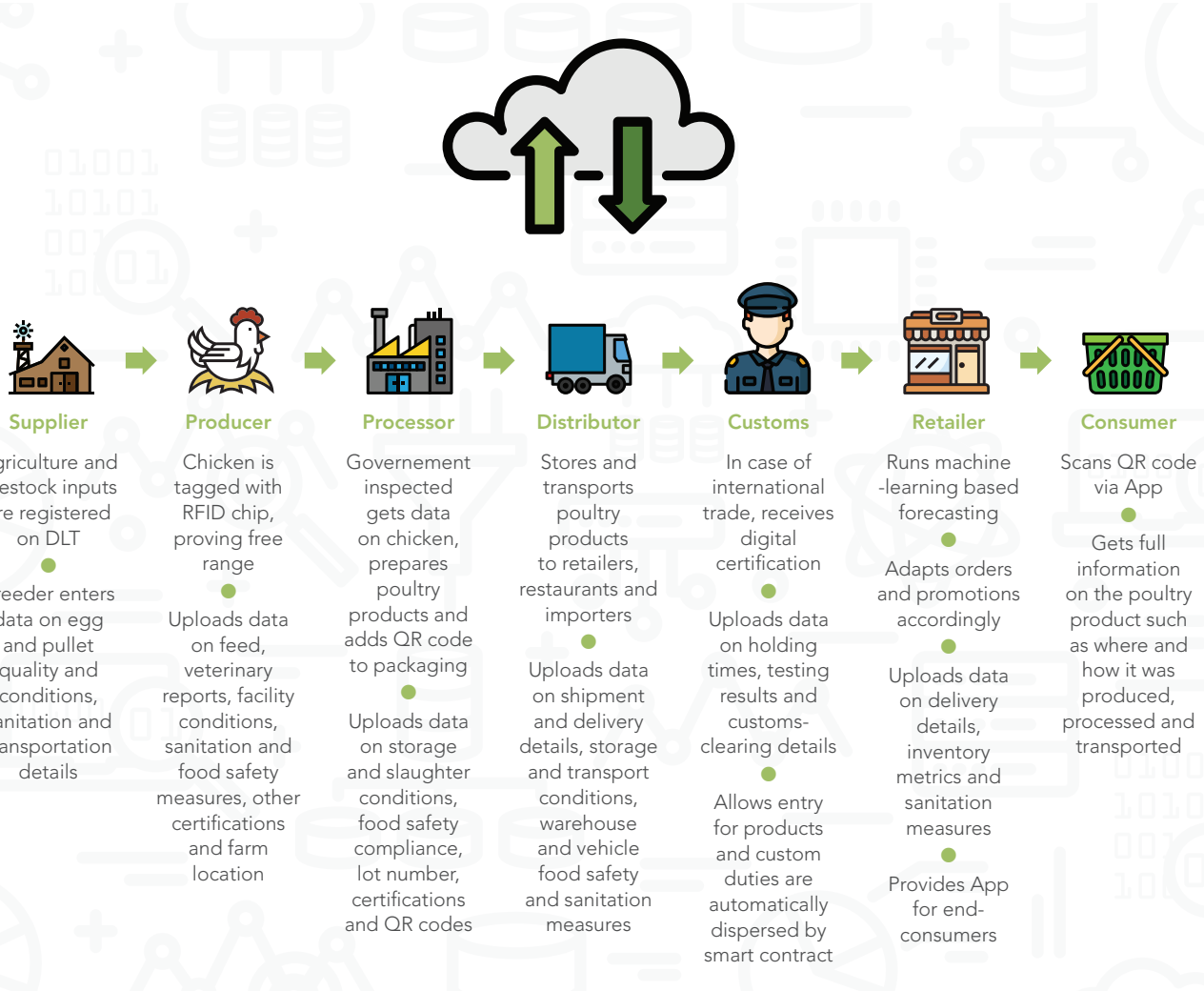
Impact investment models that have been tested and implemented in other sectors and industries have a tremendous potential that can be tailored to help family and smallholder farmers and other workers in the agrifood supply chain. These range from simple rewards-based smart contracts or loans to more complex Pay for Success (PFS) models, all of which could be structured around and made contingent on the achievement of measurable impact targets.[3] Additionally, the data collateral generated by these models could be successfully built into event-triggered insurance products and other innovative iterations of traditional farming infrastructure. This study expands on these models and builds upon existing research and use cases to design a set of options for potential piloting and future applications.

[3] *The terminology of Pay for Success (PFS) and impact bonds are often used interchangeably. Impact bonds were first used to describe financial models where government outcome payers paid back private investors from project based cost savings. However, the industry has since broadened the terminology to Pay for Success to describe a broader set of financial models and instruments that tie payments to and incentivize achievement of desired impact targets. As such, this paper uses the term Pay for Success (PFS) to describe impact bonds and other performance-based models that tie payment to impact achievement, are funded upfront by private capital, and involve an outcomes payer that pays for the impact if impact targets are achieved.*

Blockchain technology

The agrifood supply chain is a complex system responsible for the circulation of food and agricultural products in the market (Leng *et al.*, 2018). In today's digital age, food and economic security can benefit from blockchain technology's transparency, relatively low transaction costs, and instantaneous applications (Antonucci *et al.*, 2019). Blockchain technology can create a link between capital markets and family farmers, making a positive difference in their daily lives. The assignment of blockchain unique digital identifiers to food products can make specific products traceable through supply chains, along with their growth conditions, batch numbers, and expiration dates (Antonucci *et al.*, 2019). The immutable food transactions register can potentially avoid fraud while enabling source identification of foodborne illness and, considering the digital nature of these technologies, can be used to help promote on-farm data sharing (Ahmed and ten Broek, 2017). In addition, recent studies have explored the role of the Internet of Things (IoT) within the agrifood supply chain as an enabler of real time quality management and control systems to achieve an increased security (Figorilli *et al.*, 2018), as displayed in Figure 1.

Figure 1: Agricultural supply chain on distributed ledger technology



Source: (Tripoli, M. and Schmidhuber, J. 2018).

Generally, agri-food trade involves several stakeholders (e.g. suppliers, farmers, processors, traders, wholesalers, retailers, and consumers) demanding high-quality and safe products including as much information as possible (Verbeke, 2005). However, this can also produce information asymmetry problems. As reported by Mao *et al*. (2018), asymmetric information ensues when parties involved in an economic transaction are not equally informed and prevents the first-best allocation of resources, causing a market failure. Blockchain technology can help to resolve this issue through the even distribution of information to all stakeholders involved.

All stakeholders involved in the food supply chain, but particularly retail businesses, need to demonstrate to customers the superior quality or reduced price of their products, and increasingly businesses need to also demonstrate how their supply chains are sustainable (Smith, 2008). In such a context, blockchain could simplify this task by providing a one-to-many data integration and process orchestration regarding transparency, efficiency, security, and safety among participants (Galvez, 2018). This means that the blockchain provides one source of information which is available to every blockchain solution participant. Generally, the industry can enormously benefit from the growth of blockchain technology and relative service applications, including making transactions, storing data more securely, and having singular events available where impact investment is possible; regardless of size or experience, all blockchain developers must include from design and from development activities a high level of relative refinement to security threats (English *et al*., 2018). This should enhance the overall security and validity of the information being stored on the blockchain.

Another key point inherent in the food supply chain is food authentication, a process by which the compliance of foods with their label descriptions (e.g. geographic origin, production method, processing technology, composition) can be verified (Antonucci *et al*., 2019). As reported by Gerbig *et al*. (2017), food fraud not only causes economic losses but could represent a serious threat to human health. All factors should be in accordance with the standards, guidelines (Danezis *et al*., 2016) and labeling regulations (Esteki *et al*., 2017). As reported by Galvez *et al*. (2018), the rapid and analytical techniques for detecting adulteration, verifying quality, and guaranteeing geographic origin most commonly use spectroscopic and separation techniques (e.g. gas chromatography, high-performance liquid chromatography, electrophoresis), mass spectrometry, stable isotope measurements, and DNA and polymerase chain reaction methods.

Normally, as reported by Galvez *et al*. (2018), the delivery contract relies on IoT and wireless sensors networks. The inclusion of global positioning system (GPS) coordinates of each location regarding the delivery flow could allow the tracing back of products in the case of an accident (Antonucci *et al*., 2019), or add a level of confidence in triangulating the true occurrence of an event along the supply chain. In this context, Wu *et al*., (2017) provided suppliers and customers with validated, near real-time visibility during the physical distribution phase of the supply chain, attracting the attention of the transport of the goods from the supplier to the customer.

In the precision agriculture context, information and communications technology (e.g. remote control of farm conditions, remote monitoring of farm equipment through smartphone applications) can be further implemented within a blockchain infrastructure to enable new farming systems and e-agriculture schemes (Lin *et al*., 2017). In addition, the blockchain introduction, implemented with agricultural and environmental monitoring data, stored in a distributed cloud, permits engineers to secure and trust sustainable agricultural development with transparent data collection making them immutable and decentralized for future management (Antonucci *et al*., 2019).

Besides the many technical and regulatory challenges (Saberi *et al.*, 2018), some of the limits of blockchain technology relate to the high energy bill these systems pay to supply extended hardware computing power and the network transfer infrastructure needs. As reported by Smetana *et al.* (2018), a potential solution for the progression and application of cyber physical systems within material flow analysis is represented by artificial intelligence (e.g. artificial neural network [ANN]).

Innovative financial models

Bridging the 2.5 trillion USD per year funding gap to achieve the SDGs by 2030 will require more than public and philanthropic funding sources alone. For comparison, official development assistance, a key source of funding for the SDGs, is only about 152 billion USD annually (OECD, 2019). Private investments present a significant and rapidly growing source of impact capital, with the current size of the impact investment market estimated at over 700 billion USD (Hand *et al.*, 2020) and many investors shifting more of their investments into funds that directly or indirectly generate positive social and environmental impacts. Despite 8 in 10 individual investors indicating interest in sustainable investing (Morgan Stanley, 2019), access to impact investing and other innovative financial opportunities remains limited among large segments of audiences due to the complexity of current impact measurement approaches (including data collection, verification, and lack of measurement infrastructure) and regulatory restrictions (e.g. registration or accreditation requirements and limits on crowdfunding among individual retail investors) (Valoral Advisors, 2018). Recent evolutions and uses of emerging technology, including blockchain, AI, and IOT, are now eliminating some of these infrastructure barriers that have prevented financial innovation in the past.

The rapid growth in the number of food and agricultural investment funds (Figure 2) suggests a strong private sector interest in agriculture related impact investments. And with "large corporations invest[ing] approximately 2.4 billion USD annually in initiatives and ventures designed to achieve financial returns as well as positive economic, social, or environmental impact" (CECP, 2016), attractive and innovative models to appeal to the private sector should be explored.

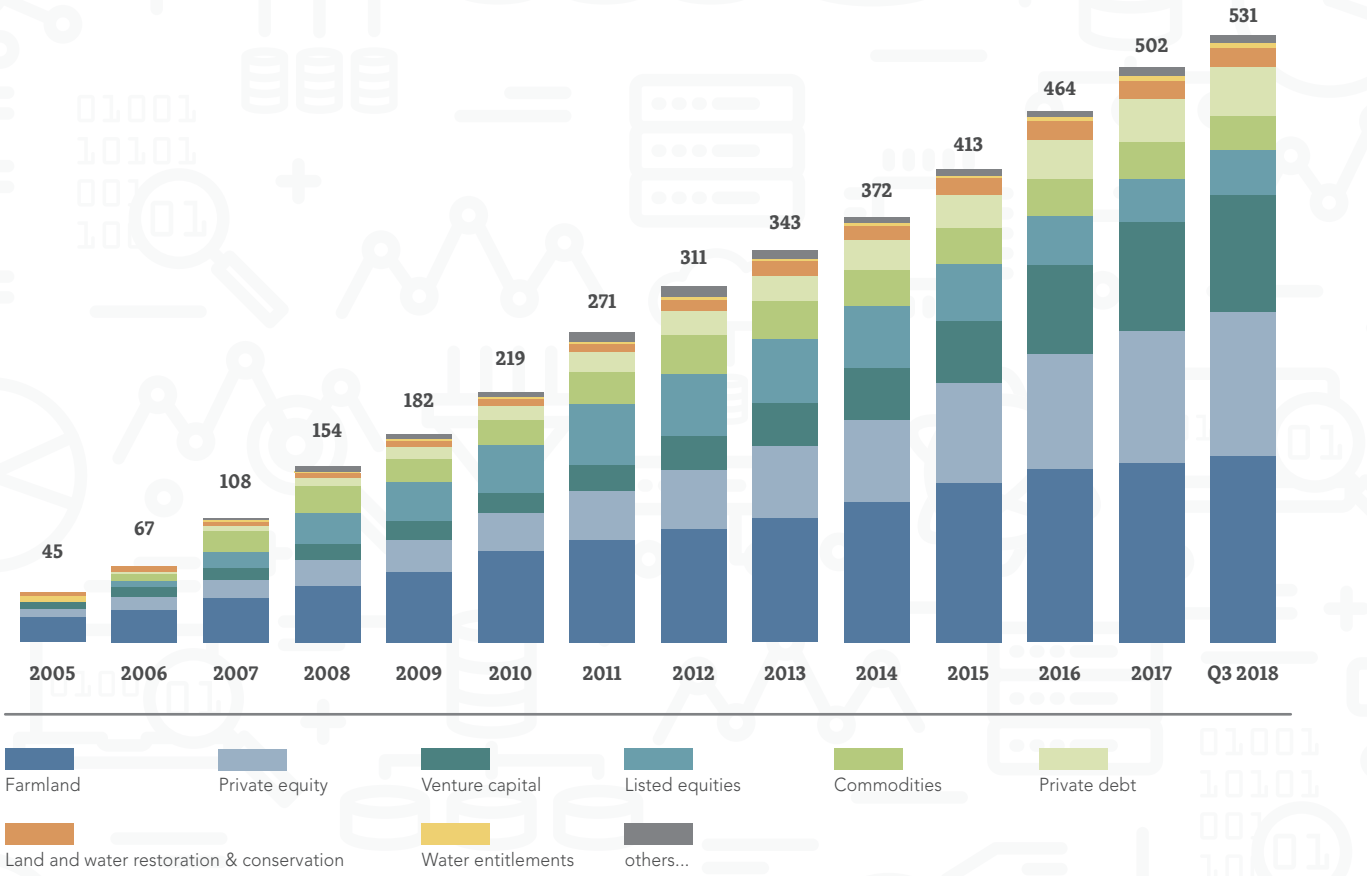
Innovative financial models that may have a high potential to improve, accelerate, and enhance agrifood supply chains exist across a spectrum of more philanthropically-driven to more financially-driven investments (Figure 3) (Valoral Advisors, 2018). There are numerous models that fall within this spectrum, including (but not limited to):

1. Reward-based token models (e.g. payer commits to pay for the cost of the program and the investors get back principal in the form of tokens that they can then only use to reinvest in impact projects again);

2. Principal-only return models (e.g. Kiva microloans (Kiva, 2020), principal-only Pay for Success models); models where returns are not conditional on impact achievement (e.g. traditional microloans, equity investments in impact-focused businesses) (Benhamou *et al.*, 2020);

3. Models where financial returns are contingent on the achievement of measurable impact targets (e.g. Pay for Success models, impact bonds, contingent loans, and blended finance loan guarantees).

Figure 2: Number of food and agriculture investment funds by asset strategy

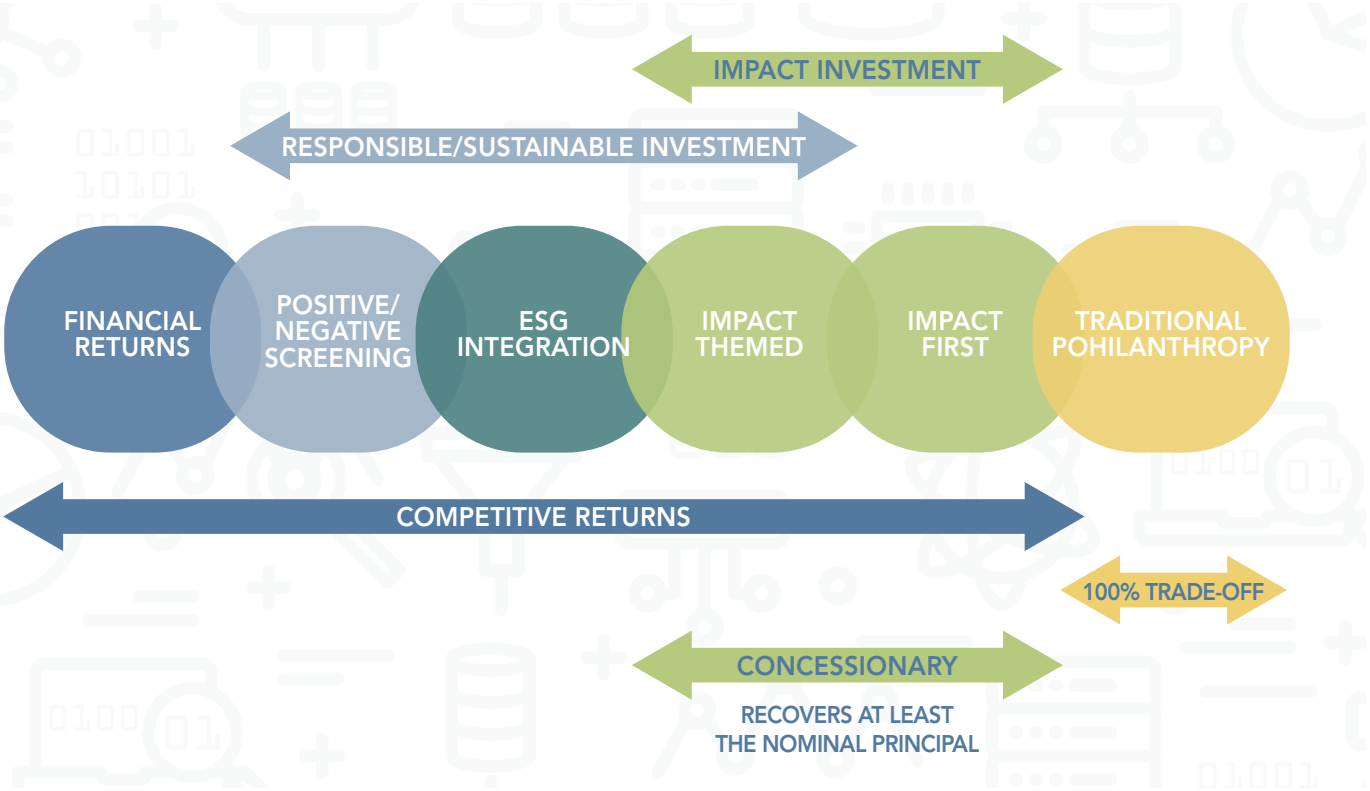


Source: (Valoral Advisors, 2018).

It is important to note that although Figure 3 characterizes impact investments as "concessionary" (i.e. sacrificing financial return for impact return), a majority of funds that prioritized investments in companies that met environmental, social, and governance (ESG) standards (i.e. adhering to certain sustainability standards) actually delivered higher returns than equivalent conventional funds over the past 10 years, according to a study by Morningstar (Riding, 2020). In addition, many of the aforementioned performance-based financial models have the potential to meet or exceed traditional market rate financial returns.

Access to impact investing varies widely depending on jurisdiction and the wealth or income of an investor. For example, U.S. non-accredited investors cannot invest in certain impact investment models, including microloans structured as fixed term bonds through organizations like Lendahand (Lendahand, 2020) and Energise Africa (Energise Africa, 2020), which are available to individual retail investors in European countries. Considering the strong demand for sustainable products (Kronthal-Sacco and Whelan, 2019), evidence indicating that consumer interest in sustainability does influence investment preferences (University of Cambridge, 2019), and increasing appeal of impact investing internationally among millennials (Mascotto, 2019), continued expansion of opportunities for consumers to engage in innovative financial models should be explored, both for the benefit of prospective investors and to provide additional capital to impactful initiatives.

Figure 3: Spectrum of innovative financial models



Source: Valoral Advisors, 2018.

Agrifood supply chain

There is widespread interest in impact investing in food and agriculture. According to Mudaliar *et al.* (2019), 58 percent of respondents reported allocating to food and agriculture, with more investors participating in food and agriculture investing opportunities than any of the other sectors listed in the survey (e.g. energy, microfinance, housing, healthcare). While more investors engaged with food and agriculture than other sectors, their overall exposure remained relatively low with only 10 percent of assets, showcasing the need for innovative and more accessible investing opportunities.

Climate change has significantly influenced the sector's response to helping family farmers, with a growing focus on climate change adaptation and resilience to help these farmers prepare for the impacts of climate change. The Acumen Resilient Agriculture Fund (ARAF) is one example of a fund that has directly shifted its strategy from grants towards a long-term capital approach (Green Climate Fund, 2020). The continued change in climate and its downstream effects on the agricultural supply chain have broadened the discussion on impact in the sector, with a focus on solutions that acknowledge social and environmental considerations as directly intertwined.

At the same time, with the global population expected to rise to 9.7 billion by 2050 (UN, 2020), there is an expected increase of between 70 percent and 100 percent in demand for food (FAO *et al.*, 2011). With demand rising, agriculture production must increase to avoid continued upward pressure on prices. Integrating technologies into farming and agriculture supply chains is a

valuable tool that can help to achieve the needed growth in production and ensure that this is done while promoting sustainable practices. Technology in agricultural supply chains can boost crop yields, save time and financial resources, and benefit the environment (Busch, 2012). IoT solutions have had a significant impact on precision agriculture (Khattab, 2016), drones can be used to significantly decrease planting costs and monitor crops (Mazur, 2016), and other technologies have successfully demonstrated improvements in both the sustainability and efficiency of farming practices.

Blockchain brings enhanced transparency into the agriculture supply chain, providing investors with a real-time view into the performance of impact and sustainability initiatives on the ground. According to Deloitte, blockchain use in supply chains can generate data that increases "... traceability of material supply chains, lower[s] losses from counterfeit and gray market, improve[s] visibility and compliance over outsourced contract manufacturing, and potentially enhance[s] an organization's position as a leader in responsible manufacturing" (Lapper and Fitzgerald, 2019). Innovative models for financing participants in the agricultural supply chain, in combination with the use of data tracking and exponential technologies (e.g. IoT, blockchain, AI), can allow for the development and implementation of sustainable and scalable solutions that increase production to meet growing demand for food, while rewarding family farmers and better ensuring sustainable practices are being deployed.

The application and benefits of blockchain technology extends to multiple different agricultural supply chains. A 2020 FAO study on the applications of blockchain technology in seafood supply chains, for example, concluded that "blockchain, with its inherent characteristics of immutability, security, and decentralization together with its smart-contract feature, has the potential to improve efficiencies and accountability in seafood value chains" (Blaha and Katafono, 2020). This study analyzed various seafood commodities that have been tracked on the blockchain, finding that actors on the supply chain worked to create links between the physical fish and their corresponding digital units, which allowed them to securely track and exchange commodities. Many blockchain projects in seafood supply chains provide QR code labels on end products to communicate all of the product history and locations to the consumers.

Innovative financial models have also started to emerge that aim to create positive incentives to promote sustainable agricultural supply chains. The Ecosystem Services Market Consortium (ESMC) is currently building a marketplace, supported by a consortium of members from across the entire agricultural supply chain and value chain (e.g. Cargill, Danone, General Mills, McDonalds), to incentivize farmers and ranchers to improve soil health systems that benefit society (ESMC, 2020). Similarly, Nori is a smaller technology platform that has built a carbon removal marketplace, where farmers can be rewarded by private donors for using sustainable farming practices that remove carbon from the atmosphere and store it in the soil; carbon removals are quantified and verified by an independent third party before being tokenized via blockchain technology (Nori, 2020). Proof of Impact is a technology company that helps impact investors and other funders measure, track, and verify the impact of companies and nonprofits. Proof of Impact tokenizes each verified impact output and supporting data onto a blockchain, which impact funders can then use to structure innovative financial models (Proof of Impact, 2020). Solutions like these can empower and reward farmers and other stakeholders for participating in sustainable agriculture by integrating scalable and cost-effective data collection, storage, and verification technologies that are deployed within the existing operations.

Chapter 3.
Expert interviews summary

The authors completed 24 interviews with subject matter experts to supplement the online research summarized above.[4] To the extent possible, interviewees had expertise in, or exposure to more than one of the three focus areas of the report (i.e. blockchain technology, innovative financial models, and agricultural supply chain). Table 1 summarizes the key themes and sub-themes gleaned from the completed interviews thus far.

Overall, the interviews provided a holistic view on the findings from the literature review by highlighting specific use cases, methodologies, and models in the field (e.g. Ayadee's supply chain verification, Ecosystem Services Market Consortium's impact marketplace, Kiva's interest-free loan model) and providing a ground-level perspective on the mechanics of real-world implementation. In particular, interviewees cited the rapidly evolving landscape of agricultural technology and technology-based data collection and verification, suggesting that multimodal data collection techniques combining data from multiple sources are an emerging gold standard for tracking, certification, and verification. In addition, interviewees cited the added level of data quality confidence that blockchain adds to the impact verification process and confirmed the potential for blockchain technology to provide funders with proof of ownership for the impact they have funded.

The interviews revealed a number of key considerations when designing and implementing blockchain-based solutions for sustainable agricultural supply chains. Most notably, a strong governance model needs to be established where ownership, accountability, and decision rights are clear. This will guide the behaviour of the stakeholders in the blockchain consortium to establish best practices for agricultural supply chains as suggested by the OECD-FAO Guidance. The incentive alignment structure and overall data quality supported by verification will also help to promote responsible behaviour by all stakeholders.

In discussions around innovative financial models, the interviews shed light on the critical need for objective impact measurement and verification as the first key step to unlock the impact investment market to larger groups of stakeholders. Considering the applicability of different innovative financial models for testing, the interviewees revealed the importance of considering the appropriate target audiences (e.g. institutional investors, corporations, retail funders) and target countries (with varying levels of financial regulatory barriers), as these may significantly impact the possibilities for scale.

In addition, the interviews provided valuable perspective on the benefits and costs of specific innovative financial models in the agricultural supply chain space. Models discussed included (but were not limited to) impact bonds, traditional loans or crowdfunded microloans (e.g. Lendahand), forbearance (i.e. forgiveness) loans where only a portion of the loan needs to be repaid if impact

[4] *See Appendix A for the interviewee names and key takeaways from each interview.*

targets are achieved, loans with variable interest rates contingent on achievement of impact targets (i.e. lower interest rates if impact targets are achieved), and crop insurance programs.

One key distinction discovered during the interviews was the difference between performance-based impact investing models (where the level of financial returns is dependent on the achievement of measurable targets) and impact investments that aim to make a positive impact, but do not tie financial returns to the achievement of concrete impact targets. The latter form of impact investments commonly take the form of equity investments in social enterprises or investments that meet broad ESG criteria while screening out investments that do not meet the criteria. Given the growing demand for objective, quantified impact measurement as a part of any impact investment product, performance-based financial models present a significant opportunity for evolution in the field.

Table 1: Key themes and sub-themes from interviews

KEY THEME	SUB-THEMES
Performance-based financial models – where payments are dependent on measurable impact targets – provide significant opportunity to generate both impact and financial return for investors and can attract a larger pool of impact-first investors.	• Loans with terms that are contingent on the achievement of measurable impact targets (e.g. lower interest rate if certain working conditions are met) are a promising model with high demand and potential for scale in the agricultural supply chain. • The rewards-based token donation model, where investors can get their principal and/or returns back (only if impact targets are achieved) in the form of online tokens that they then can re-invest (but cannot withdraw), could mobilize the market of more philanthropically minded investors and funders. • Crop disaster or price insurance programs are becoming a larger impact investing trend and gaining interest in the field as a viable model to provide financial returns to investors while positively impacting farmers. • Government regulations can be a major barrier to crowdfunded impact investments (i.e. funded by retail investors), but there is an emerging opportunity for crowdfunded impact investment with financial returns in certain countries (and pathways to navigate regulatory barriers in others). These impact investment models traditionally do not tie the level of financial returns to the achievement of measurable, verified impact targets. • Corporations typically engage in performance-based impact investing through their non-profit arms (i.e. foundations, endowments). Program-Related Investments or Mission-Related Investments are two avenues for this form of corporate investment.

KEY THEME	SUB-THEMES
Advancements in technology have allowed for real-time, scalable impact measurement and verification in agricultural supply chains, which can unlock innovative performance-based financial models.	• Technology-based data collection and verification can help to achieve two goals for businesses: ensuring compliance in meeting regulatory responsibilities for a sustainable supply chain, and determining whether impact targets have been achieved to open the door for performance-based financing. • Creating a fully transparent data reporting system – rooted in objective technology-based data collection and stored on the blockchain – can provide a new incentive for investors to invest in impact. • Methods for collecting and verifying data via technology vary widely across different agricultural supply chains and different countries, but certain impact measures (e.g. farmer yield as opposed to total income), standards (e.g. regenerative farming practices), and data collection techniques (e.g. mixed method collection from multiple internal and external sources) are starting to emerge as promising practices. • A combination of technology-based and human-based verification techniques can provide a high level of confidence that impact has been achieved, while minimizing the burden and inefficiency of traditional auditing and certification techniques. • There is an opportunity for real-time output (as a meaningful proxy for an outcome) verification, which can be more efficient and reliable than quarterly or annual evaluations that rely solely on administrative, human-collected data.

KEY THEME	SUB-THEMES
Ideal blockchain-based agricultural supply chain solutions are those that fit into existing financial frameworks, complement current free market incentive structures, and are managed with strong governance practices.	• Blockchain-enabled agricultural supply chains must have strong governance practices in place to maintain the integrity of the blockchain solution and allow for clear and transparent impact ownership. • Smart contracts make the tailored insurance product more efficient, cheaper, and more transparent compared to current solutions. • Combining crowdfunding with blockchain technology opens the door for new types of business models through tokenization (e.g. data can be leveraged and used for analytics). • Usage of new digital technologies such as blockchain and IoT allow for traceability of agricultural products from farm-to-fork which increases overall food safety for end consumers. • Strong leadership is ideal for the coordinating role in a blockchain consortium when formed for sustainable agricultural supply chains. • Blockchain technology can serve as the technical foundation for incentives schemes which allow steering of independent agents in a defined system. • Benefits of transaction cost reduction should be split among all participants to provide an incentive for all participating stakeholders. Reduction of remittances costs can provide enough savings to create incentives to join a blockchain-based and tokenized solution. • Stakeholders should establish an incentive alignment system that serves the needs of everyone in the consortium. This can trigger enough stakeholders to participate and form a strong interest for new business models. • A private/permissioned blockchain solution is ideal to ensure that only pre-selected actors are within the consortium, which also increases data validity. Provision of neutral servers for the overall blockchain pilot project is another vital detail for successful implementation. • Usage of price forecasting for agricultural commodities (such as arabica coffee) based on econometric modeling could enable farmers to adapt their crop planting behavior based on price prediction parameters.

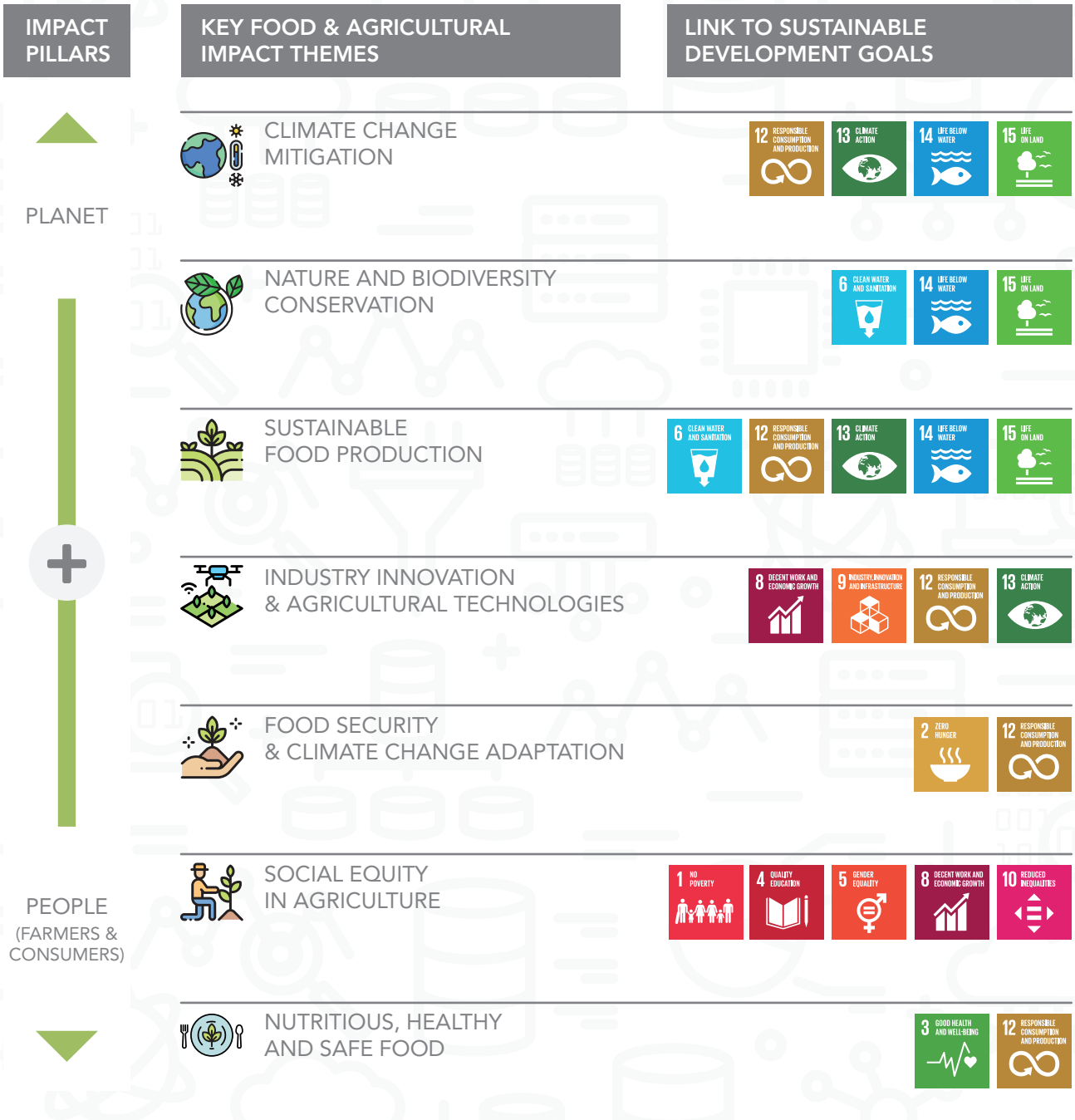
Chapter 4.
Defining and verifying impact in the agrifood supply chain

In the context of sustainable agrifood supply chains, the UN FAO defines impact as ending poverty and hunger by addressing sustainability and economic concerns faced by agricultural supply chains (FAO, 2018). From a private sector perspective, impact can be defined as incorporating sustainability into corporate strategy to promote growth and increase profits, as well as contributing financially to impact through corporate social responsibility efforts (Ipsos, 2018).

Impact can take different forms at each stage of the agrifood supply chain. Broadly speaking, the agrifood supply chain consists of planting and harvesting, production, processing, packaging, distribution, and retail (FAO, 2007). At the beginning of the supply chain, for example, ensuring farmers and laborers are able to use sustainable practices with ease, or that workers are paid and treated fairly, contributes to positive social impact (FAO, 2018). When agricultural products are ready to be produced and processed, ensuring that the processor is trustworthy and abides by good hygienic and environmental standards can increase laborers working standards and decrease the supply chain's carbon footprint. When the products are ready to be packaged and distributed, ensuring that optimal transportation routes and methods are utilized can further reduce environmental footprints while decreasing costs to all parties. Finally, at the retail stage, ensuring consumers have relevant information on the product's sustainability along the supply chain can enhance decision making of impact-minded consumers. At each of the steps along the supply chain, impact can be quantified and investments can be tied to the achievement of those metrics.

More broadly, the UN SDGs generally focus on two overarching "impact pillars": people and planet. As illustrated in Figure 4, the SDGs related to sustainable agriculture relate to seven core themes, and creating sustainable agricultural supply chains can have far-reaching effects on many of the SDGs.

Figure 4: Key food and agriculture themes linked to the SDGs



Source: Valoral Advisors, 2018.

There is a variety of more specific impact activities that fall within each of the seven core themes (see Figure 5). Each of these activities can be measured, verified, and tied to performance-based financial payments, with certain activities presenting more potential than others to include key metrics that impact investors and other funders will be interested in.

Figure 5: Key agricultural impact themes and activities

IMPACT THEMES	IMPACT ACTIVITIES

 CLIMATE CHANGE MITIGATION
Avoid greenhouse gas emissions (CO_2, methanes and nitrous oxide) and increase carbon sequestration through agricultural production processes.
	• Forest action:
	  • Afforestation and reforestation
	  • Avoid deforestation
	• Soil carbon sequestration
	• Reduction of enteric fermentation emissions
	• Manure management
	• Optimisation of fertilizer application
	• Reduction of emissions in rice production
	• Energy smart food systems
	• Reduction in food and agricultural supply chain emissions

 NATURE AND BIODIVERSITY CONSERVATION
Preserve natural capital. Protect and restore natural habitats and ecosystems, especially from the effects of human exploitation, contamination and industrialization.
	• Conservation of natural habitats, water related ecosystems and biodiversity:
	  • Land conservation easements
	  • Payments for ecosystem services
	  • Biodiversity offset credits
	  • Carbon credits
	  • Conservation-friendly certifications and labelling schemes

 SUSTAINABLE FOOD PRODUCTION Produce safe, high quality food and agriculture products in a way that conserves and improves the natural environment and preserves natural capital.	• Sustainable crop production • Sustainable livestock production • Sustainable fisheries & aquaculture • Sustainable forestry • Pro-biodiversity sustainable agricultural investments
 INDUSTRY INNOVATION & AGRICULTURAL TECHNOLOGIES Develop technological innovations across the food and agriculture sector and accelerate technology adoption to enable more efficient and more sustainable agriculture and food systems.	• Biological agricultural inputs and green chemistry • Digital precision agriculture • Precision machinery & robotics • Weather data and information technologies • Water management technologies • Traceability solutions for sustainable food supply chains • Blockchain applications for sustainable agriculture • Biomaterials • New alternative proteins • Sustainable urban and indoor agriculture

 FOOD SECURITY & CLIMATE CHANGE ADAPTATION
Help ensure food security so that all people have access to sufficient, safe and nutritious food. Develop resilient food production systems in response to climate change.
	• Climate resilient agriculture
	• Integrated production systems:
	  • Agroforestry and silvopastoral systems
	  • Integrated crop/livestock or rice/aquaculture systems
	• Reduction of food waste and food loss along the value chain
	• Increase in food production through sustainable intensification

 SOCIAL EQUITY IN AGRICULTURE
Foster fairer, healthier and more inclusive agricultural livelihoods.
	• Financial access: microfinance and small commercial loans
	• Microinsurance and agricultural insurance
	• Fair trade & market access
	• Mobile communication technologies for social inclusion:
	  • Mobile financial services
	  • Mobile information platforms
	  • Mobile trade platforms
	• Equality & empowerment in rural labour
	• Learning and knowledge sharing
	• Employment of local communities and indigenous farmers

 NUTRITIOUS, HEALTHY AND SAFE FOOD Produce high quality and safe food, that is produced in a more natural way, with lower exposure to chemicals and antibiotics, and that provides people the nutrients they need to maintain themselves healthy, feel good and have energy.	• Organic agriculture • Sustainable alternative proteins and plant-based foods • Sustainable grassfed meats • Biofortified nutritious crops

Source: Valoral Advisors, 2018.

To spur private sector investment and fill the funding gap needed to create broadly sustainable agricultural supply chains, a larger pool of investors will need to see impact investing as an attractive option. One way to promote impact investment is to specifically define, measure, and verify impact associated with private sector funding, ideally through technology-based data collection, and make the investments more accessible with a higher total return. In addition, blockchain technology can be a tool to transparently verify impact achievement at each step of the supply chain, providing further confidence in investments.

The rest of this section breaks these concepts down into a series of five core characteristics that set the stage for an ideal impact investing environment:

4. **Meaningful output measures for impact**
5. **Data as proof of impact**
6. **Technology-based data collection**
7. **Impact verification**
8. **Blockchain to maximize attribution and transparency**

The combination of these methods and technologies, when implemented properly, present significant opportunity to streamline, strengthen, and scale innovative performance-based financial models that can unlock the capital needed to move the needle on the SDGs.

Case study background: defining and verifying impact in the agricultural supply chain

This case study is intended to provide an example scenario that concretely demonstrates how impact along the agricultural supply chain can be measured, verified, and built into performance-based impact investing models. In this case study, a fictional furniture brand, Bamboozled, specializes in the retail sale of sustainably sourced, produced, and distributed bamboo furniture. Fictional bamboo furniture supplier, Sustain Chain, shares Bamboozled's impact values for creating a sustainable bamboo furniture supply chain. Every year, Bamboozled hires an auditor to check its suppliers against a set of defined impact metrics. Assuming Sustain Chain passes the audit, Bamboozled continues to place monthly purchase orders of Sustain Chain's furniture. Sustain Chain needs investment capital (i.e. loans) to pay for the upfront sourcing, production, and distribution of its bamboo furniture. Fictional impact investor, Sustainable Agrifund, considers a new partnership with Sustain Chain to provide this upfront capital at a seven percent interest rate. Although the annual audit helps to ensure Sustain Chain's compliance, the impact

metrics are only assessed once per year and are not viewed as meaningful indicators of impact; Sustain Chain wants to become more active in collecting data that demonstrates its impact and improvement over time (e.g. to have a more satisfied and productive workforce and less of an environmental footprint). Sustainable Agrifund also wants to become a leader in the impact measurement, management, and investing movement by incentivizing its portfolio suppliers to achieve greater impact. How can all three parties achieve their goals?

Meaningful output measures for impact

"What do we measure?"

Measuring and quantifying impact has historically been a complex and resource-intensive process. Measuring outcomes (e.g. improved air quality, improved health, longer life expectancy), generally conducted as part of formal evaluations using experimental or quasi-experimental comparison group designs, are ideal to ensure that impact has actually been achieved. However, this measurement approach is highly costly, takes long periods of time before outcomes are realized, and is currently not widely scalable. When considering the trade-offs between different evaluation designs, opportunity costs should be considered; funds spent on a randomized controlled trial (RCT) are funds diverted away from creating impact, and research has shown that RCTs cost on average 25 percent of total program budgets (Zandniapour and Vicinanza, 2013).

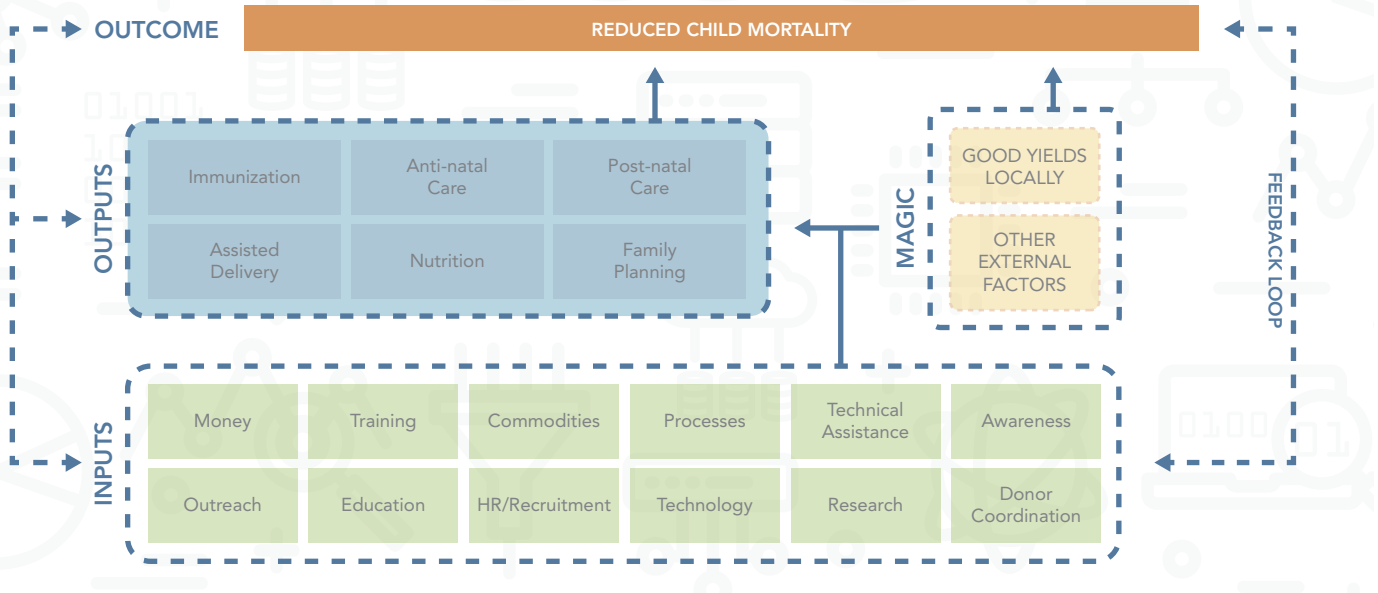
There is an important need for rigorous comparison group evaluation to identify true causal effects and determine which interventions or services created the largest impact, but to achieve scale and efficiently address the urgent problems facing our world every day, organizations and individuals on the ground delivering impact (hereinafter referred to as "implementers") by and large must use the evidence currently available to deliver the services or programming that ultimately achieve their missions. The experimental, comparison-group, and outcomes-focused measurement standard is not feasible for most implementers, and the expectation for this level of impact measurement often can exclude (or discourage) engagement in the measurement process. On the other end of the spectrum, many implementers will focus their efforts on measuring inputs (e.g. training courses completed, fair labor policies instituted, overhead costs being low), as those tend to be data points they already collect and can easily prove. However, inputs in many cases can be achieved and reported on paper with little to no connection to concrete results.

As demonstrated in Figure 6, there is a middle ground between measuring inputs and measuring outcomes. Instead of focusing too heavily on the short-term inputs or the long-term outcomes, measuring outputs creates an opportunity to track metrics that matter in a more feasible, real-time, and scalable fashion, and rallies implementers to achieve these metrics in the most efficient way possible to achieve broader outcome targets (McGraw, 2018). Outputs can take many different forms, and it is important to differentiate between outputs that are closely enough connected to outcomes versus outputs that have no material connection. Thus, a key step in the evolution of the impact measurement field is towards meaningful outputs. Meaningful outputs are those where the metric is highly correlated with a longer-term outcome, as supported by a combination of research

evidence from outcome evaluations that indicate which interventions are most effective, insights from best practices or guidance manuals on how to deliver the interventions with fidelity, and field expertise. In addition, stakeholders involved in impact investment development should consider selecting or aligning impact measures with the common impact investment measure sets, such as the Global Impact Investment Network's IRIS+ Catalogue of Metrics (IRIS, 2020).

There is no silver bullet for determining what qualifies as a meaningful output, and correlation does not always imply causation, but for certain impact areas (particularly in developing countries), there are many cases where the verified achievement of certain output measures doesn't require in-depth analysis for implementers, investors, and other stakeholders to reasonably assume – with a sufficient level of confidence – that impact is present or will soon follow. For example, an implementer in a developing country that objectively measures its workers' pay at the beginning of the supply chain to ensure they are paid above subsistence wages does not require an outcome evaluation to know that the family's health and social outcomes are highly likely to be impacted. In a living wage report in Kenya, for example, estimates showed that most rural families would struggle to pay for health expenses should they encounter them (Anker and Anker, 2016).[5] A living wage would allow people to afford critical healthcare and basic needs. Another example of a meaningful output would be high-quality vaccinations delivered to children, where there is well established evidence that the standard immunization trajectory is a highly correlated predictor of life expectancy (Rappuoli *et al.*, 2014).

Figure 6: Difference between inputs, outputs, and outcomes



Source: Circo, 2019.

[5] *For context, an average small family farm in Ethiopia generates a gross annual income of about 1 246 USD.*

With a lower level of evaluative rigor comes a greater need for checks and balances that support the validity of a meaningful output measure. Thus, another necessary step in determining the quality of an impact investment is a thorough due diligence and vetting process. Aside from traditional financial due diligence, one of the more common techniques in assessing an implementer's ability to effectively deliver its target outputs is through a structured set of evaluative criteria. For example, investors and stakeholders may assess implementers based on their track record in achieving these outputs previously, their existing data collection capabilities, and any prior experimental studies in which the implementer has participated. In addition, verification bodies should collect supporting data points (i.e. relevant input and secondary output measures) that can be used to ensure the implementer is delivering impact with fidelity and following best practice protocols in alignment with evidence-based practices.

The process of quantifying an organization's impact in terms of measurable outputs is one that may require one-on-one design support. As with any program development and implementation effort, it is important to balance fidelity with feasibility, and maintain flexibility in the process of output quantification and adaptation. Many implementers may not be ready or may not be a good fit for performance-based impact investment models. The implementer selection process is a key step in the development of an impact investment model, and accessibility to high quality data that can be collected and provided by the implementer can become a determining factor in this decision-making process.

Case study: meaningful output measures for impact

Sustain Chain, Bamboozled, and Sustainable Agrifund agree to form a partnership focused on creating a performance-based financing model. Collectively, the three parties identify meaningful impact outputs at three stages of the supply chain:

1. At the production stage, the number of laborers who are working 60 or fewer hours per week (including overtime). As demonstrated in the literature, the number of hours worked serves as a proxy for worker stress, illness, and mortality (Goh *et al.*, 2014).
2. At the processing stage, the working facility maintains stable temperatures to ensure fair working conditions are met. Studies have shown that a 1 °C increase in maximum workplace temperature was associated with a 1.0 percent to 1.4 percent increase in workplace injury (Sheng *et al.*, 2018; McInnes *et al.*, 2017).
3. At the packaging stage, recycled paper is substituted for plastic to wrap the products for distribution. As both plastic and paper production leave a sizable carbon footprint, utilizing recycled paper would reduce additional carbon emissions emitted while avoiding the environmental effects of plastic (McGrath, 2008). In situations where packaging options are limited, utilizing recycled packages is a realistic and environmentally friendly option (FAO, 2014b).

These meaningful outputs are quantified and selected by the three stakeholders as metrics that can feasibly be tracked. Sustain Chain has also demonstrated a positive track record for paying its workers steadily increasing wages and maintaining proper working conditions, and has already pilot tested its transition to recycled paper packaging.

Data as proof of impact

"How do we confirm that the outputs have been achieved?"

After meaningful outputs have been selected, funders and implementers need to know that output targets have, in fact, been achieved. The impact sector has traditionally relied on evaluators to create a study design and identify existing, pre-validated administrative data sources with supporting data. However, most businesses, organizations, and family farmers in the agricultural supply chain (especially small and medium-sized enterprises) do not have an existing data collection infrastructure, do not report to data validation entities, and do not have the resources to hire evaluators for this purpose. In order to rapidly scale to meet the SDGs, there are additional methods for collecting data that can help to build a sufficient level of proof that measurable output targets have been met.

One such approach involves the process of collecting a combination of relatively low effort data points that help to demonstrate the achievement of each individual output. By collecting a series of supporting data points for each unique output that's achieved, the implementers can build an evidence base that ultimately can be used by independent third parties to triangulate and verify impact achievement, which then can ultimately trigger performance-based output payments. Examples of supporting data points may include a combination of the following, as feasible:

1. Date and time of the impact
2. Location of the impact
3. Photo of impact preparation
4. Photo of impact distribution
5. Product serial number
6. Receipt from third party
7. Invoice from third party
8. Signed confirmation letters or partner agreements
9. Usage data from a mobile device
10. Social media confirmation.

These data points can be standardized across different settings and different steps of the supply chain, and there is a growing opportunity for enhanced mobile data collection tools that organizations can integrate into their workflows and use for direct data entry and analytics. These tools (described in more detail in the "Methods for Technology Based Data Collection") may also allow for passive data collection using shared locations capabilities, collection of Exchangeable Image File Format

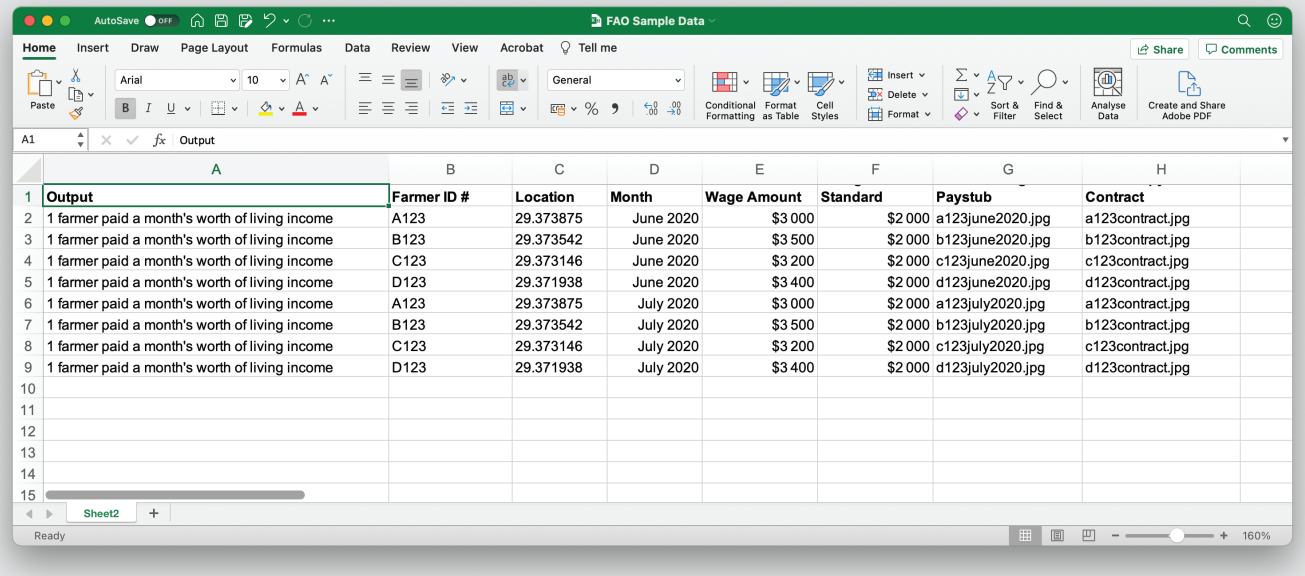
(EXIF) metadata (i.e. embedded timestamped and geotagged data) from photos, and direct API connections to third party systems (e.g. payment transaction or accounting systems). These methods generally increase the validity and reliability of data. Wider access to mobile phones and technology among businesses, organizations, and family farmers in developing countries has created further opportunities for large scale, objective, and real-time data collection in agrifood supply chains. Broadly speaking, the most valid and reliable supporting data points fall into two categories:

1. **Over-humanized data** is data coming from multiple human-controlled mobile devices or consensus among multiple participants who are part of the impact delivery on the ground. An example of over-humanized data is mobile app data pulled in real time from multiple farmers on the ground that substantiates detail of an activity.

2. **Dehumanized data** is objective data coming directly from non-human sources. Examples of dehumanized data are IoT data, satellite imagery of farms, and automated sensor data (see the "Methods for Technology Based Data Collection" section for more detail on the different types of dehumanized data collection).

As illustrated in Figure 7, the supporting data collected by implementers should be tied directly to each individual output, and the data should be as granular and specific as possible. Ultimately, this level of data granularity allows third party verifiers to confirm the validity and reliability of the impact achievement (see the "Impact Verification in Agrifood Supply Chains" section for more information), and allows for the use of performance-based financing methods by impact funders who are interested in incentivizing and paying for results. Ideally, implementers and verifiers should collect data points that serve a dual purpose of both verifying impact achievement and creating opportunity for data analysis. This allows implementers to identify new ways to improve their business, maximize their impact, and engage in active performance management.

Figure 7: Sample data points supporting output achievement



	A	B	C	D	E	F	G	H
1	Output	Farmer ID #	Location	Month	Wage Amount	Standard	Paystub	Contract
2	1 farmer paid a month's worth of living income	A123	29.373875	June 2020	$3 000	$2 000	a123june2020.jpg	a123contract.jpg
3	1 farmer paid a month's worth of living income	B123	29.373542	June 2020	$3 500	$2 000	b123june2020.jpg	b123contract.jpg
4	1 farmer paid a month's worth of living income	C123	29.373146	June 2020	$3 200	$2 000	c123june2020.jpg	c123contract.jpg
5	1 farmer paid a month's worth of living income	D123	29.371938	June 2020	$3 400	$2 000	d123june2020.jpg	d123contract.jpg
6	1 farmer paid a month's worth of living income	A123	29.373875	July 2020	$3 000	$2 000	a123july2020.jpg	a123contract.jpg
7	1 farmer paid a month's worth of living income	B123	29.373542	July 2020	$3 500	$2 000	b123july2020.jpg	b123contract.jpg
8	1 farmer paid a month's worth of living income	C123	29.373146	July 2020	$3 200	$2 000	c123july2020.jpg	c123contract.jpg
9	1 farmer paid a month's worth of living income	D123	29.371938	July 2020	$3 400	$2 000	d123july2020.jpg	d123contract.jpg
10								
11								
12								
13								
14								
15								

Source: Authors' own elaboration, 2021.

An important factor to consider when collecting supporting data is the quality of the data points being collected. Quality of the data points will hinge on whether the data is self-evident in showing that an impact has indeed occurred. For example, pictures of signed pay stubs from a third party payment system displaying a farmer's income directly substantiates the impact output's achievement of a farmer being paid a month's worth of living income.

By transparently tokenizing the supporting data on a public blockchain, impact investors can have an added layer of confidence that the impact they have funded has actually occurred and is unique to their funding, subject to the scrutiny of any public observer or potential duplicate funder. At the same time, given the public nature of most blockchains, it is imperative that all data be de-identified prior to being tokenized (e.g. with unique identification numbers instead of names, blurring out faces in photos, blacking out personally identifiable information in screenshots) and proper safeguards are in place to ensure the protection of sensitive data during the impact verification process.

Case study: data as proof of impact

Sustainable Agrifund and Bamboozled want assurance that the outputs reported by Sustain Chain have actually occurred. To do so, Sustain Chain and an independent verifier identify the following supporting data points that will serve as evidence of its three core outputs being achieved:

1. For the number of laborers who are working 60 or fewer hours per week (including overtime), data points include: Date range, number of laborers working during this week period, work location, photo of laborer timesheets, and video footage inside the facility (to verify time of laborers' entry and exit).
2. For the working facility maintaining stable temperatures, data points include: Readings from smart thermostat, date of reading, time of reading, and photo of the signed facility policy commitment to maintain stable and comfortable temperatures.
3. For recycled paper being substituted for plastic to wrap the products, data points include: Date of packaging, facility location, number of products packaged, photo receipts of paper packaging, and photos of packaged products.

Technology based data collection

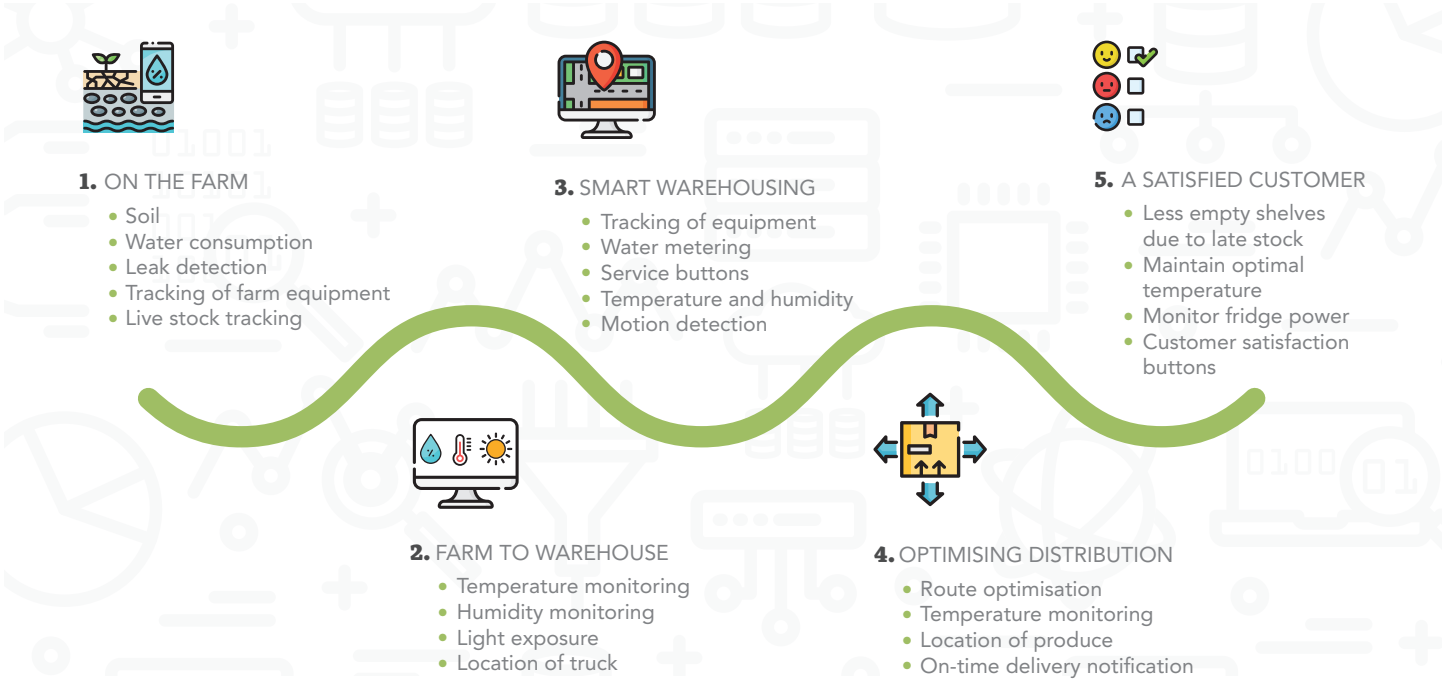
"What is the best way to measure impact?"

Across all sectors, data collection is rapidly evolving from paper records and manual data entry to digital tracking of supply chains and service delivery. It is predicted that the global market for smart agricultural technologies will reach 15.3 billion USD by 2025, nearly tripling its size from 2016 (Goyal, 2019). Along with increasing data integrity, technology-based collection methods allow for companies to streamline their data and disseminate it to relevant stakeholders. As these technologies

are becoming more commonplace and accessible across agricultural supply chains, organizations can leverage technologies that serve a dual purpose of making supply chains more efficient and reliable, and generating the data needed to demonstrate impact and trigger performance-based financing payments (Filatov, 2019). As a result of increased utilization of technology within the agriculture sector, there are greater opportunities to use data analytics for both business and impact purposes. One study, for example, showed that farmers who have utilized farming analytics experienced a 15 percent decrease in costs and a 13 percent increase in average farming yields (Lee and Mendelson, 2017).

While paper or manual data collection is often the default choice for many organizations along the agricultural supply chain due to capacity and feasibility constraints, there are significant benefits of technology-based data to accurately and objectively measure impact. Technology-based data collection can allow for faster information integration and more precise data infrastructure, which can improve the integrity of companies' data and enable consumers and investors to conduct due diligence on business practices. In a 2017 Deloitte survey of hundreds of chief procurement officers from 25 countries, respondents cited quality of data and lack of data integration as the two biggest respective barriers to achieving procurement objectives (Handfield, 2017). Technology-based data collection allows for real-time data to be synchronized from end to end across a supply chain. Organizations of different sizes, locations, and places along the agricultural supply chain may find operational benefits of smart agriculture technologies for different purposes. Figure 8 provides an example of how different devices can be used at different points along the supply chain for data tracking and proof of impact. Parent companies or technical support organizations likely will be needed in most cases to help fund the technology integration and expand the capacity among smallholder farmers.

Figure 8: Technology-based data collection along the supply chain – farm to shelf



Source: Sqwidnet, 2020.

Organizations across the agrifood supply chain can use a spectrum of technologies, progressing from basic to more advanced data collection methods (see Table 2 for examples). Photos and videos from smartphones could be used initially to document steps across the supply chain; for instance, taking photos of products prior to shipment. On larger farms, drones could be used to more easily gather photos of crops or videos during harvesting. Satellites and IoT sensors are more advanced technologies that are gaining popularity in the agricultural sector, usually for climate monitoring. For example, SigFox, a global IoT service provider, boasts various smart agriculture solutions and devices, such as the MeteoHelix® IoT weather station designed to track temperature, humidity, radiation, and rain levels (Sigfox Partner Network, 2019). From the farm through the last mile distribution of agriculture products, wage payments to workers along the supply chain can be tracked via mobile money service providers, such as M-Pesa, or digital HR solutions, like PaySpace. These tech enabled solutions can provide both greater reliability of payments to workers alongside the ability to enhance data collection around wages that can be used to validate fair pay is occurring along the agrifood supply chain.

Table 2: Examples of current smart agriculture technologies

TECHNOLOGY	DATA TRACKED	EXAMPLE USE CASE (SELF-REPORTED RESULTS)
Sqwidnet smart livestock collars ...link	Tracks livestock's real-time location, speed, body temperature, and stress levels in mobile app.	Decreased animal loss, reduced costs, improved birth success, and herd safety (Sqwidnet, n.d.).
Sensoterra soil moisture probes ...link	Tracks soil moisture and calibrates data to create more accurate moisture readings for different soil types (Sensoterra, 2020).	Using hourly data to make more precise irrigation decisions, led to 3x expected increase in post-drought crop yield for Canadian hop grower (Sensoterra, 2021).
Greenhouse indoor sensors and China Mobile IoT network ...link	Tracks light intensity, air conditions, temperature, and leaf moisture and allows for precise control of water use and humidity and moisture levels to facilitate best growing conditions.	Increased strawberry production by 100 percent, reduced manual labor costs during observation period by 50 percent, reduced water and fertilizer use by 50 percent/kilogram (Roy, 2019).
PrecisionHawk drone mapping for agriculture ...link	Gathers data on 1000 acres in one day, including plant counts, assessments of plant/livestock health, and infrastructure assessments.	Allows for full survey of plots rather than sampling, 2.5x more efficient and 25 percent more accurate than hand counts (PercisionHawk, 2020).
PhotosynQ ...link	Small $100 device can be used to track various photosynthesis efficiency measurements, such as analyzing chlorophyll content in leaves or nitrogen levels in plants (PhotosynQ, n.d.).	Smallholder farmers in developing countries given device by Michigan State University researchers to use PhotosynQ; 3,800+ have shared data on plant health on website and collaborated on management techniques and plant choices (Rudolph, 2020).

When implementing new technologies, members of the agricultural supply chain must consider the context of their work to determine which technologies would be most applicable. The ideal candidates for performance-based financial models will have already tested one or more technologies for other business purposes, which can then also be used for impact measurement and verification purposes. The evolution to technology-based data collection can ultimately serve as a complement for or, in some cases, a substitute to traditional means of manual data tracking and in-person audits. There is significant opportunity to leverage technologies to streamline and strengthen this traditional monitoring and evaluation process. In each use case, stakeholders must determine whether the advantages of implementing technology-based data collection collectively outweigh the disadvantages (see Table 3).

Table 3: Key advantages and disadvantages of technology-based data collection

KEY ADVANTAGES	KEY DISADVANTAGES
Real-time information	Expensive (in the short-run)
More granular data	Requires training
Increased reliability and validity of data	Requires workflow adjustments
Can lower costs over time and increase efficiency	May require existing infrastructure (e.g. Internet access)

Source: Authors' own elaboration, 2021.

For many implementers, especially small agricultural businesses in developing countries, there are significant financial barriers to investing in new technologies or a lack of perceived need. Alternatively, these implementers (and other stakeholders involved in developing performance-based financial models) can consider alternative platforms that allow for streamlined data tracking. Capterra, for example, has a comprehensive list of farm management software designed to help farmers automate business management (Capterra, n.d.). KoboToolbox and Dimagi CommCare are two other data collection platforms that offer mobile data collection and impact measurement services along the agricultural supply chain (see the following link for a relevant case study: www.dimagi.com/case-studies/naatal-mbay/) (KoboToolbox, n.d.; Dimagi, 2021).

The value of technology-based data collection can be seen in its reliability and efficiency gains, as it generally provides more objective and transparent data than paper records or manually-entered data. This increases the confidence of impact investors and other funders, as it assures them that certain levels of impact have been achieved and sufficiently substantiates results-based payments. These technologies can also increase the ability to reach individual consumers, who feel more incentivized to act as funders due to the increased transparency (further legitimized by impact tokenization) and understanding of the ground-level impact. Because this added value opens the door to creating a better impact investment product, implementing technologies that serve as indicators of impact achievement is the ideal scenario for stakeholders within the agricultural supply chain.

Case study: methods of technology-based data collection

In identifying the methods for data collection and impact verification, Sustain Chain first looks at the technology it has already invested in for other operational purposes. This includes a security camera and biometric timesheet technology (which can help demonstrate that laborers are working 60 or fewer hours per week), a smart thermostat (which can help show a stable temperature inside the working facility), and an online receipt tracking software (which can also be used to verify the purchase of the recycled paper for packaging). These data points, extracted periodically directly from the technology systems by the independent verifier, serve as core data points that help to confirm the consistent occurrence of the three key impact outputs.

Impact verification

"How do we know that the impact has occurred?"

Independent verification is a critical component of impact measurement and performance-based financing. Independent verification can not only reduce the chance of fraud and data misrepresentation, but more importantly, it can help to identify unintentional data discrepancies, lack of quality data capture, and differences in data interpretation. Verification in the context of impact measurement closely relates to the process of monitoring and evaluation (M&E). However, whereas traditional M&E typically involves developing tailored project-specific study designs, collecting administrative data on a quarterly or annual basis, and conducting highly manual and site-specific data validation, verification typically involves the use of automated, technology-based data collection, automated validation (through standard, machine-based data definitions), and real-time (or near real-time) confirmation that an impact target was achieved. In this way, verification has the potential to be more widely scalable, accessible, and cost-effective. In addition to fulfilling a necessary requirement in providing impact investors with confidence in their investment, the independent verification process is critical to prevent false, inaccurate, and inconsistent data from being tokenized on the blockchain and brought to market (i.e. preventing the "garbage in garbage out" problem that remains even with tokenization) (Circo, 2018).

The impact verification process begins during data collection at the beginning of the supply chain. By collecting the right data points, verifiers can ensure they have a sufficient number of data points and detail to reasonably assume that impact occurred. As such, two key features to consider when designing data collection for impact verification include:

1. A focus on unit-level impact with multiple supporting data points. As described in the "Data as Proof of Impact" section above, a series of granular, supporting data points associated with the completion of each impact unit sets the stage for a robust verification process. Impact measurement that intentionally captures data points directly supporting the occurrence of the impact (e.g. temperature readings from the facility thermostat), as well as data points that indirectly support the impact occurrence (e.g. copy of company policy indicating that temperature will remain within a reasonable temperature range) can allow for verifiers to

triangulate data points, parse out potential errors or inconsistencies, and confirm with a reasonable level of confidence and evidence that the impact was achieved.

2. Collection of self-evident data points. Many M&E processes rely on periodic, site-specific audits of program level data to confirm the occurrence of impact events. Due to technology and data collection limitations, most of these data sets are limited to self-reported text taken at face value without verifying the underlying source data. In contrast, verification relies more heavily on self-evident data points that directly support the unit of impact being achieved – for example, photos of crops growing over time with the same background landscape, videos of workers leaving the facility at reasonable hours, and screenshots of payment transaction confirmations that can be traced back to the payment processor. These self-evident data points allow for virtual impact verification at the source, increasing funder and stakeholder confidence that data accurately represents reality.

Linking product data with the physical product to ensure authenticity

As described in the "Blockchain to Maximize Attribution and Transparency" sub-section below, verified impact can be tokenized onto the blockchain in a number of ways. One of the more promising methods involves the tokenization of physical product data at each step of the supply chain (e.g. via mobile devices that collect uniquely identified product data, such as QR codes), and then linking all of those uniquely tokenized data points to the end product, thereby completing the chain of data at each step of the supply chain. One example of such an approach is the bext360's bextmachine, which assesses and tracks data about coffee origin and quality, and tokenizes data at each step of the supply chain (Allison, 2017). As described by the Founder, Daniel Jones, "When farmers deposit their harvest at the coffee washing station, we use a bextmachine (which leverages machine vision, A.I., IoT and blockchain technology) to analyze coffee cherries and parchments...Based on how ripe and how big the coffee cherries are, the machine generates a quality profile for every bag, which is then tokenized so that each transaction related to that bag of coffee is recorded and tracked on the blockchain, from the farmer all the way to the coffee roaster" (Sustainia, 2018). This granular machine-based data, tokenized at each step of the supply chain, can then be shared with a verification entity for third party confirmation. Another example of linking product data with the physical product is a new approach referred to as crypto tags (described in further detail below, "An Emerging Opportunity in Blockchain-Based Data Collection: Crypto Tags"). In order to provide object authentication and assign ownership, crypto tags get affixed or embedded into the physical product (e.g. directly onto the bag of coffee cherries, coffee beans, and final packaging). To create a new entry to the blockchain, the crypto tag gets provisioned (i.e. the process by which the key pairs are created) and attested (i.e. the process by which the public key of the tag is registered on the blockchain of choice and set up for smart contracting) with relevant metadata (e.g. date, location) on the blockchain. Finally, provenance validation is achieved through checking authenticity and ownership of the object by simply scanning the tag with a near field communication (NFC)-enabled phone. Therefore, the crypto tag secures ownership and provenance of physical goods of all kinds (as well as all associated metadata) by using blockchain technology in combination with non-removable crypto tags and a NFC-enabled phone (Koppel, 2020).

Types of verification

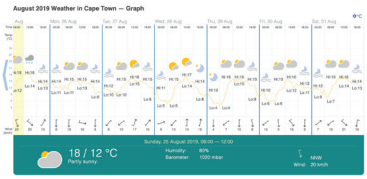
Once data is collected, the process of verification splits into two core functions: validation and third-party confirmation.

Validation

In the context of impact verification, validation refers to the process of conducting rigorous data quality assurance, including longitudinal and cross-sectional checks of self-reported data against external sources. The three primary types of validation checks that verifiers should consider include completeness (i.e. no missing data), uniqueness (i.e. no duplicate data), and consistency (i.e. no anomalies or outliers, and data follows expected patterns). For example, if a farmer reports a daily yield of 10-15 kilograms per day for weeks, and then reports 100 kilograms in one day, this would raise a flag indicating a potential error in the data. Technology-based data collection that is less prone to human error can help to minimize these issues, but the need for in-depth data validation remains.

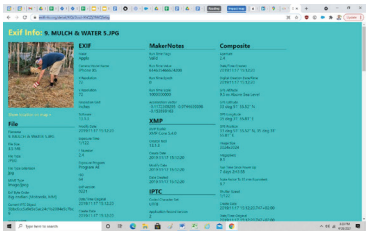
On top of basic data quality assurance, verifiers can leverage technology to enhance the validation process. Table 4 highlights a few examples of these enhanced validation checks.

Table 4: Examples of enhanced validation checks

VALIDATION CHECK	STATUS	EXAMPLE DATA POINT	VALIDATION RESULT
Weather in photo matches historical weather data	Fail	Sunny image:[6] 	Historical weather data showing a rainy/cloudy day in this location:[7] 

[6] *SUGi Project (Beirut Riverless Project): www.sugiproject.com*

[7] *www.timeanddate.com (2019).*

VALIDATION CHECK	STATUS	EXAMPLE DATA POINT	VALIDATION RESULT
Background in photo matches landscape of location on Google Maps	Pass	Image with supporting background that matches google map: 	Google map zoom in on the matching background:[8] 
Exif metadata of the photo matches date of the impact occurrence	Pass	Date of impact provided with image (November 17, 2019):[9] 	Screenshot of EXIF metadata: 

There is a significant opportunity to streamline and rapidly automate this process. During the data collection phase, verifiers can standardize the types of data points to be collected and require entry of all required data points in the desired format. The types of validation checks can also be standardized and run with automated scripts in backend databases to immediately notify implementers of any errors. Implementers can correct the errors real-time on the ground or address the errors later in a shared platform for data reconciliation prior to the data being approved. This whole process, which traditionally happens manually between implementers and verifiers (e.g. via email correspondence), can become fully automated in a centralized end-to-end mobile environment that displays errors, allows for comment sharing, and approves impact units once they have passed all of the validation checks. Such a solution has potential to revolutionize the M&E industry and generate large efficiency gains for impact funders in the form of financial resources and speed to viewing and monetizing results.

[8] *Google Maps. Coordinates: 33°51'55.0"N 35°31'55.9"E. www.google.com/maps*

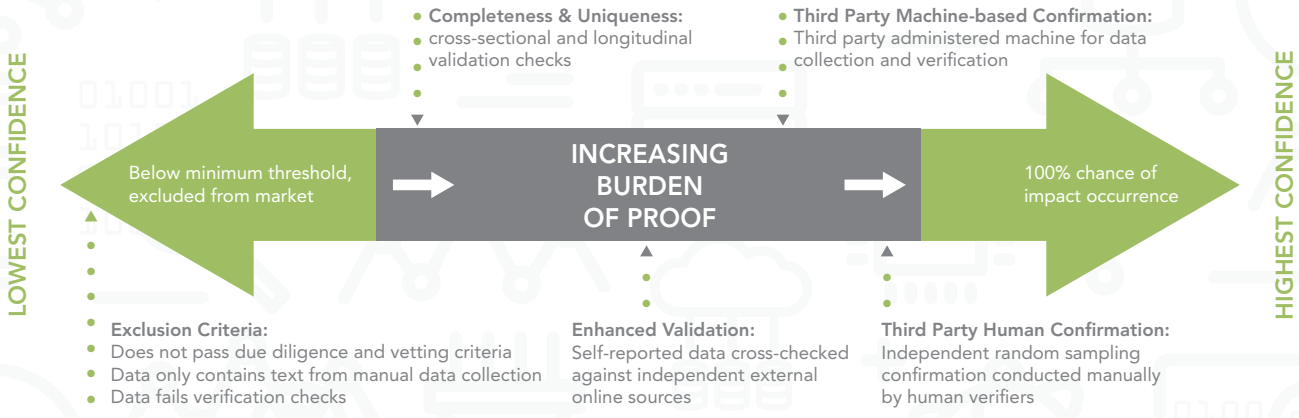
[9] *SUGi Project (Beirut Riverless Project): www.sugiproject.com/*

Third party confirmation

Confidence in the integrity and accuracy of data is also strengthened by the addition of third-party confirmation. One significant efficiency gain in the current M&E process is the transition from in-person audits to fully virtual verification. In many cases, virtual verifiers who collect the most relevant data points can routinely cross-check those data points against a third-party database or software, which can serve as a stronger proof point than an annual in-person site visit. For example, impact that involves shipping a product could be independently verified with third-party tracking numbers to ensure every package was shipped and received, and then confirmed virtually by the package recipient; this process can be fully automated to create a consistent and seamless real-time verification loop.

Impact can also be verified through the on-site installation of third-party machine-based data sources, such as independently placed sensors that monitor factory working conditions. These third-party techniques can be viewed as options to be used in different use cases among different implementers or projects. As visualized in Figure 9, verification that relies on technology for both data collection and verification typically will provide the highest level of proof that the impact was achieved. With a sufficient number of machine-generated, self-evident data points verified against external sources, the third-party verification process can be strengthened and adapted from one reliant on physical site visits to one reliant on objective machine-generated data.

Figure 9: Verification continuum

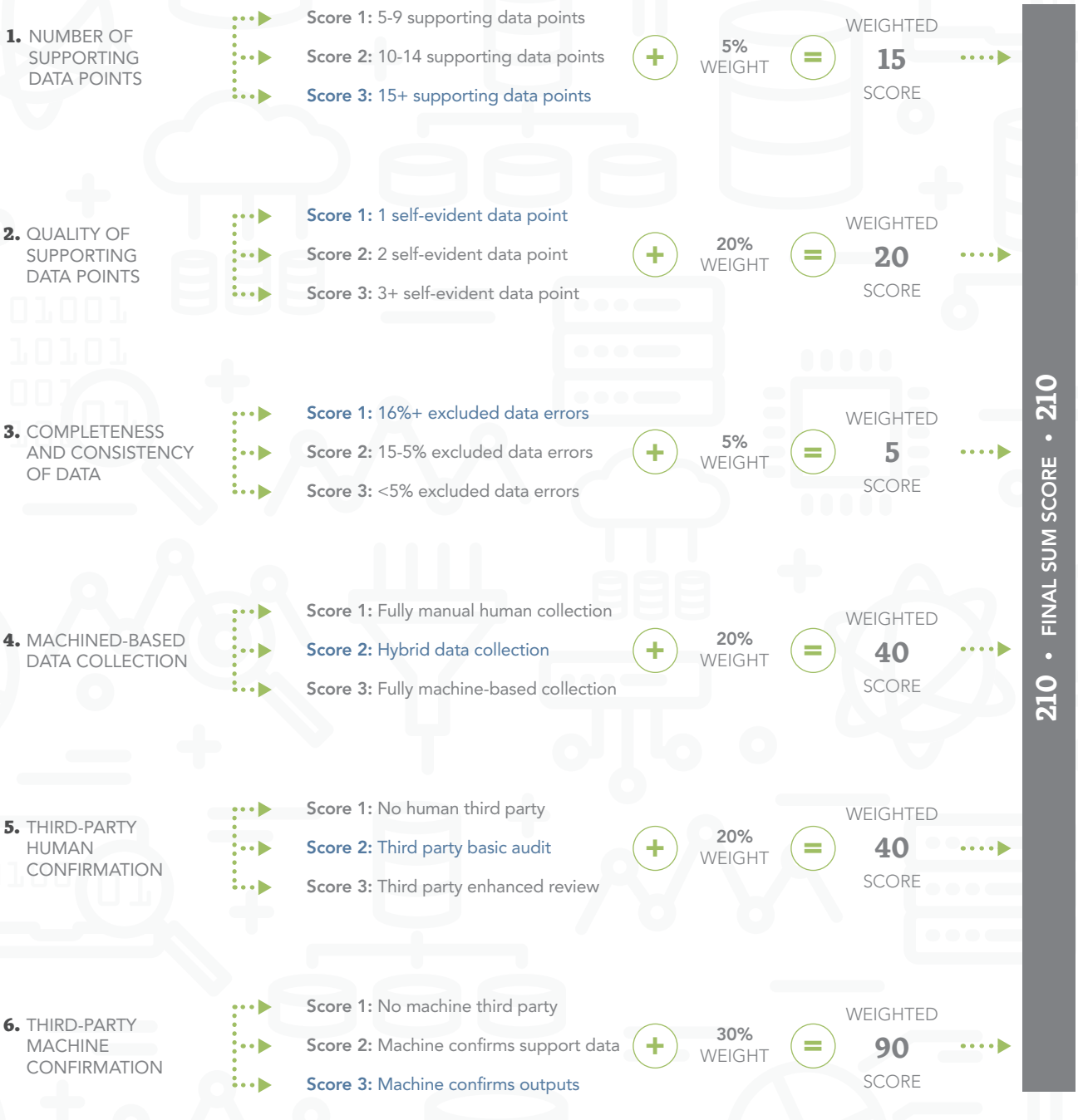


Source: Authors' own elaboration, 2021.

Confidence scoring

Verification relies on a number of different factors that collectively build a burden of proof depending on the capacity and context of each implementer and project. The culmination of the factors can be operationalized into an algorithm that calculates a numeric confidence score for each impact unit, with higher confidence scores signifying a stronger combination of data collection and verification techniques; this gives funders a higher level of confidence that the impact was achieved. Key factors and a sample approach to confidence scoring are included (but not limited) in Figure 10. As illustrated in the figure, the confidence score for this project was 210 (on a scale from 100 to 300), which factored in the six key criteria on the left-hand side of the graphic, with the supporting rationale for each criterion's score.

Figure 10: Sample approach to confidence scoring



Source: Authors' own elaboration, 2021.

This example demonstrates how a combination of verification factors can collectively build a stronger evidence base supporting the achievement of impact, and shows how a fully transparent approach to verification can help to reduce information asymmetry and provide funders with the opportunity to make informed decisions based on the confidence score, data collection protocols, and types of data collected. Due to the enhanced flexibility and decentralized transparency of the process, this approach to verification also creates a more accessible impact measurement and verification system for small businesses, workers, and farmers along the agricultural supply chain.

Case study: impact verification

Sustain chain works with an independent verifier to aggregate, transmit, and confirm the accuracy of the data. After completing necessary data sharing agreements, the third party verifier connects directly to Sustain Chain's video, thermostat, and online receipt tracking systems to pull real-time machine-based data. In addition, Sustain Chain submits supporting data points into the independent verifier's impact data management system, structured around the achievement of the measurable impact outputs. The verifier then conducts data validation (e.g. reviewing video feeds, extracting temperature data from the smart thermometer supplier, and reviewing receipts from the payment management software), manages data corrections with Sustain Chain, and calculates a confidence score with supporting rationale for Bamboozled and Sustainable Agrifund. Bamboozled and Sustainable Agrifund are provided with a performance tracking dashboard that transparently shows the impact metrics achieved and the supporting data points. This impact verification has created an opportunity for performance-based financing that is dependent on the achievement of (and improvement upon) measurable impact targets.

Blockchain to maximize attribution and transparency

Blockchain technology is a foundational technology that makes it possible to verify unique and individual units of impact, which is important for attribution (i.e. impact ownership) and transparency. Once verified (and to make unique impact units attributable), each unit of impact requires a digital confirmation that contains all of the unique variables; in other words, a digital representation of the real life, verified event. This digital representation is called a token. Each time a farmer is paid a living wage, or an acre of land is converted to regenerative agriculture, for example, there is a new token issued.

Digital entries into a ledger, however, are not enough – simple digital entries can be copied, multiplied, or tampered with. This would present a risk to performance-based financing models, where individual impact outputs are monetized and therefore need to maintain unicity. Such risks can be addressed with checks and balances, audits, and governance protocols, and if the purpose would be simply to track these events (i.e. as a smarter alternative to traditional monitoring and evaluation), centralized public databases would be the best model to adopt.

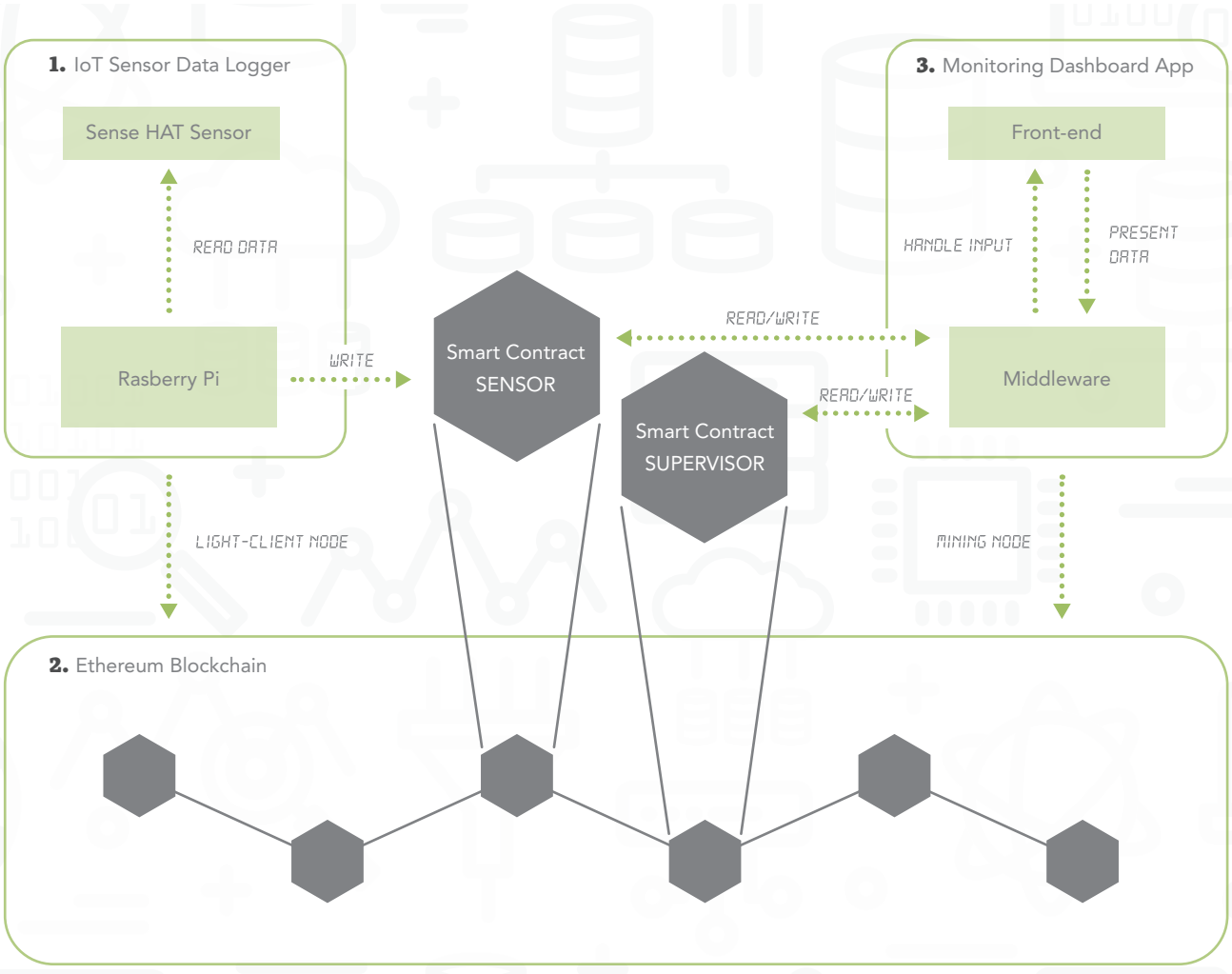
Because these tokens are valued and monetized to make trading possible, impact investors need the option to hold impact tokens — essentially holding full attribution for unique impact units — without having to have any relationship with any organization or entity, or having to understand or evaluate reliability of any one monitoring database.[10] As long as the impact investors prove they hold a token, then they prove attribution and ownership. This means that they can trade these tokens, essentially taking their money out and passing the attribution to someone else. And because all tokens are listed on a public, immutable ledger, they can trust that the tokens are genuine and can even track

[10] *This principle remains true even in scenarios where an independent verifier maintains custody of the tokens on behalf of users, in "hot wallets."*

the tokens' history if they are trading on a secondary market. This will accelerate the emergence of global impact capital markets accessible to anyone, anywhere in the world.

Figure 11 below illustrates one approach to leverage blockchain technology to increase funder confidence and transparency. The conceptualized system consists of three major components in total, each providing individual functionality. The IoT sensor data logger component is responsible for reading temperature and humidity data using a sensor board, which communicates with a Raspberry Pi single-board computer. The Raspberry Pi was configured as a light-client node for an Ethereum blockchain, which constitutes the blockchain layer serving as data storage and processing infrastructure. Two smart contracts deployed thereon are responsible for logging the data values and registering events (e.g. temperature threshold violations) as well as storing the Ethereum addresses of registered IoT devices (i.e. Raspberry Pis). The monitoring dashboard component then communicates with both contracts and acts as a mining node on the blockchain. It displays the sensor data and related information to an end-user through a web application (Lockl *et al.*, 2020).

Figure 11: Sensor data monitoring system high-level architecture



Source: Lockl et al., 2020.

An emerging opportunity in blockchain-based data collection: crypto tags

Crypto tags (Riddle and Code, 2018) ensure that the digital twin corresponds or belongs to the product intended through a crypto hardware tagging solution. Crypto tags (either as near-field communication (NFC) or ultra high frequency (UHF) radio frequency identification (RFID) tags) are attached to the physical product, and different form factors of the hardware can cater to different environmental circumstances. A digital twin is a virtual replica of a physical object or system; a pre-existing necessity is the Internet of Things (Becker, 2018). But also other tagging methods can be applied, depending on the security needs and the physical set-up of the agricultural supply chain segment in question. From the manufacturer, the product can then travel to different suppliers and in the end, after having typically been processed and aggregated into a final product, then reach its final customer. This allows for an end-to-end track and trace solution (to ensure data consistency along the value chain) with a tag-to-tag handover management. As part of this, the process engine can guarantee that the product and the underlying commodities qualities do not change between supplier A to B, so that the continuity of all information that is collected within the digital twin is correct, complete, and in line with all regulatory and business policy requirements as laid out by the OECD-FAO guidance.

Case study: blockchain to maximize attribution and transparency

Once Sustain Chain's independent verifier has validated the data and confirmed the occurrence of the event with a defined confidence score, each impact output achieved – and all of its verified, supporting data points – can be packaged together and tokenized onto a blockchain as one token representing the unique unit of impact. Tokenizing each impact output and its supporting data allows Sustainable Agrifund to publicly and transparently demonstrate the impact it has created through its performance-based financing system, while at the same time helping to ensure unique ownership and sole attribution for the impact they have financed.

Monetizing tokenized impact as an investment

The five core characteristics above set the stage for a scalable performance-based impact investing environment. While all five characteristics might not be feasible for many impact investors and small and medium-sized enterprises involved in the agrifood supply chain, this section has provided a roadmap of key considerations for public, private, and non-profit entities involved in these spaces.

There are many different types of performance-based impact investing models that rely on varying levels of evaluative rigor and different performance expectations to trigger success payments

(e.g. performance relative to annual targets, performance relative to industry benchmarks, improvement in project performance over time, and performance relative to a comparison group). Performance-based models also vary widely in their accessibility, replicability, and regulatory feasibility. The next section analyzes and compares the most promising performance-based impact investing models for the field to consider piloting and building capacity around in setting up more sustainable and responsible agrifood supply chains.

Case study: monetizing tokenized impact as an investment

With consistent, machine-based, and independently verified data measuring Sustain Chain's impact, Sustainable Agrifund pilots a performance-based financing model. Under this model, Sustainable Agrifund agrees to reduce Sustain Chain's interest rate on its loan for upfront capital by 0.5 percent if Sustain Chain achieves 90 percent or more of its defined impact targets each quarter. Sustainable Agrifund also offers an additional 0.05 percent reduction in the loan's interest rate for each 10 percent year-over-year improvement that Sustain Chain makes on a set of core impact metrics. Through this performance-based arrangement, Sustainable Agrifund continues to make a financial return on its investment, but also incentivizes the Sustain Chain to reach concrete, measurable impact targets that ultimately help to create a more sustainable and responsible supply chain.

Chapter 5.
Decision analysis on innovative financial models

This decision analysis serves as a structured framework to compare the advantages, disadvantages, and limitations of innovative performance-based financial models in the agrifood supply chain. The financial models described in this analysis are broadly applicable to both agrifood supply chain use cases and other impact areas. In addition, due to the fixed function of blockchain technology as a tool to strengthen ownership and verification of impact across financial models, impact tokenization is assumed to remain a constant in this analysis.

As outlined in Table 5, this analysis focuses specifically on performance-based financial models in which some degree of impact or financial return is based on the achievement of measurable, verified impact results. This analysis also focuses on financial models that are – or have the potential to be – broadly accessible among both qualified (i.e. accredited, registered) institutional investors as well as retail investors.

Table 5: Performance-based financial models

	PERFORMANCE-BASED	NOT PERFORMANCE-BASED
INTEREST-BEARING	• Pay for Success (PFS) models (e.g. Impact Security, social impact guarantee) • Interest-bearing loan	• Equity investments in impact-focused companies • ESG fund investments • Fixed income bonds • Loan guarantee or loan insurance • Crop or price insurance
NON-INTEREST BEARING	• Performance-based donations • Principal-only PFS models	• Principal-only loan • Traditional grants and donations

This analysis assesses each financial model based on a set of standard evaluative criteria, with the overarching goal to help identify the model (or models) that have the most promise in scaling impactful practices and routing private capital to help achieve the Sustainable Development Goals. Each financial model will be defined and then scored based on the evaluative criteria. Ultimately, through the analysis this report aims to provide a recommended financial model that can be tested and more broadly implemented by practitioners in the field.

Evaluative criteria

Each performance-based financial model is evaluated based on four criteria: financial return, accessibility, replicability, and regulatory feasibility. Each criterion will be scored on a scale from 0 to 4, with 0 representing low, 1 as low-moderate, 2 as moderate, 3 as moderate-high, and 4 as high.

Financial return

While above market rate returns may not be the main priority for some impact investors, it is important to weigh the ability for a financing model to generate a positive financial return on investment to incentivize the mobilization of greater amounts of private impact capital. Each financial model will be evaluated based on the model's potential to provide financial return to investors relative to expected market rate returns. For the purposes of this analysis, market rate returns are assumed to be 10.1 percent, in line with the performance of the S&P 500 over the past six decades (Perianan, 2020). A score of 0 will indicate that the investor will not receive a financial return and will not have any their invested principal returned (although they will receive measurable impact return on investment). A score of 4 will indicate that, on average, an investor may reasonably expect financial returns that meet or exceed average market rates.

Accessibility

Accessibility is a measure of who has access to investing in this model. The ability for any investor to invest will vary depending on the financial model, asset type, jurisdiction, net worth of the investor, and legal status. To mobilize increasing sums of private capital, investment models ideally should be accessible by all potential investors (e.g. institutional and individual retail alike). If accessibility is increased, implementers will have access to more channels of funding, which can lead to greater impact creation. Each financial model will be evaluated on its ability to mobilize funding across all investor types, taking into account both the range of investors that can participate in this model, along with existing infrastructure to facilitate their participation. A score of 0 will indicate that the model can only be accessed by a select few impact funders. A score of 4 will indicate that the model can be easily accessed by any funder, including both institutional funders and individual retail funders across multiple geographies.

Replicability

If the impact investing industry is to grow and evolve, it is necessary that the financing models be replicable. Within the context of a performance-based financing model, replicability is a measure of the ease to implement a similar model across multiple use cases and implementers. Factors that were considered when evaluating the replicability of a model included the design and structuring of impact metrics, standardization and ease of implementing verification protocols, determination of terms around repayment of principal, and stakeholder buy-in on variable interest rates. Models with high replicability will have a lower time to implementation and will ease administrative burden on the financial intermediary of the investment, as well as the investee. Each financial model will be evaluated on its ability to be replicated. A score of 0 will indicate that a model can only operate within a narrow context and would be ineffective or not feasible to replicate outside that context. A score of 4 will indicate that a model can operate across a multitude of scenarios with relative ease of implementation.

Regulatory feasibility

In examining the ability to structure performance-based financing models it is vital to identify the risk of regulatory friction and barriers that must be addressed prior to launch. Each financial model will be evaluated on its ability to operate with minimal regulatory barriers. A score of 0 indicates that a model violates regulations that are common in many countries (or needs explicit approval by government bodies to proceed). A score of 4 indicates that a model is highly unlikely to run into any regulatory barriers and does not need any explicit government approval to launch the model.

Financial models

The four models included in this report represent four distinct approaches and structures of performance-based financing. The models are presented in order from the most philanthropic to the most financially driven. Each model may be inclusive of different sub-models that have slightly different parameters, but operate off the same general rules and principles. Each model and its associated sub-models is described in detail with visual representation of how the models work.

Performance-based donation model

In traditional philanthropy and grant making, funders often provide general operating dollars to implementers who they trust, or who have otherwise demonstrated their ability to achieve the goals of the funder (e.g, through a competitive bidding process). These sources of unrestricted funds are critical for a large majority of implementers, many of whom are small non-profits or businesses that don't have the capacity or resources to collect robust data or engage in impact evaluation. However, performance-based forms of philanthropic giving and grant making have started to emerge as a way to supplement and incentivize implementers to collect new data that demonstrates their impact and use that data to improve their impact over time.

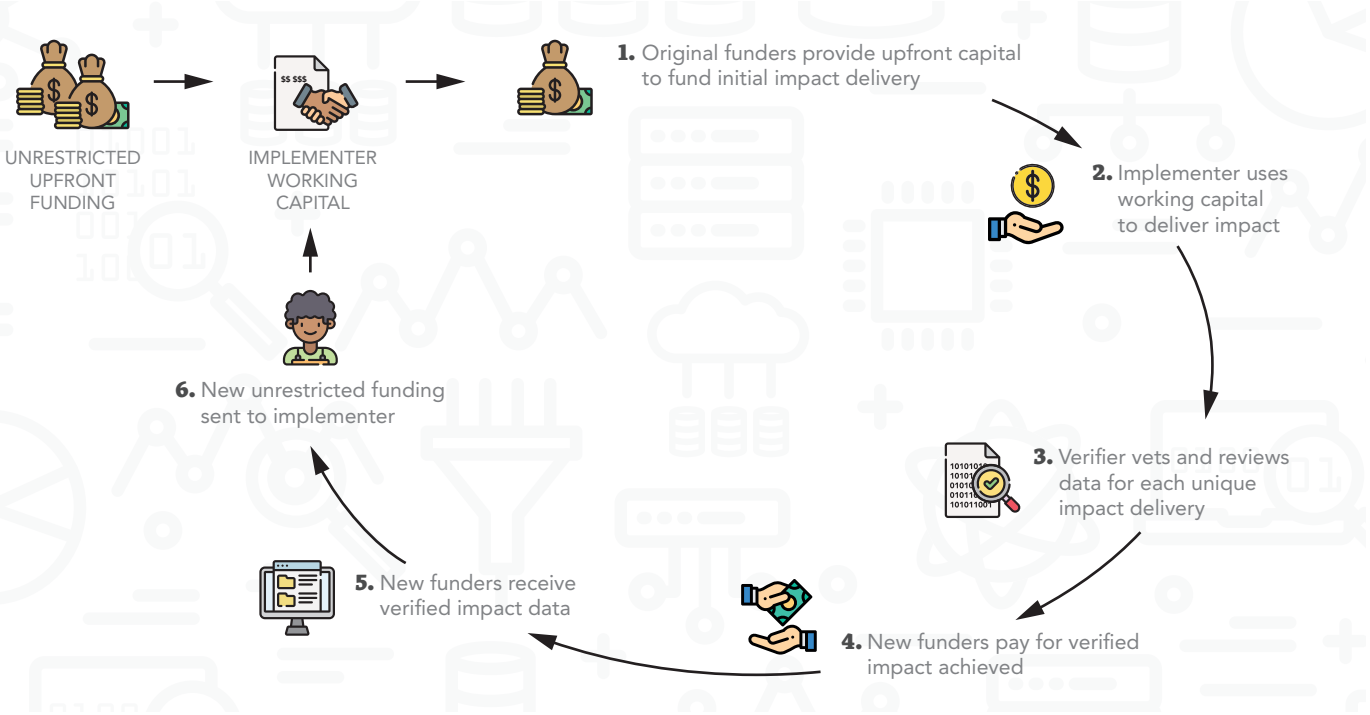
This model broadly describes performance-based donation approaches in which some or all of the funding being released to implementers is dependent on the achievement of measurable impact results. One notable example of this model is the Soil and Water Outcomes Fund, which rewards farmers and landowners for implementing sustainable, carbon-reducing agricultural management best practices only after the environmental benefits are verified (Soil and Water Outcomes Fund, 2020). This report will focus on two sub-models described below.

Conditional retrospective donations

Under this sub-model, funders provide unrestricted funding that implementers can use however they need and best see fit (e.g. to invest in technologies that make their operations more efficient, to scale existing operations), but implementers must provide data that demonstrates previous quantifiable impact achievement for the funds to be released. This sub-model is retrospective because implementers may use upfront (i.e. catalytic) unrestricted funds from a different funder to deliver the initial results, but as long as the original upfront funder approves, the implementer can reassign the initial impact generated to new funders, who can then pay for and claim unique ownership and sole attribution for the measurable impact that was generated (with the original upfront funder thereby relinquishing ownership of or claim over the impact to prevent double

attribution). In this way, new funders only pay for verified results with zero risk that the impact will not be achieved. As illustrated in Figure 12, this sub-model still requires delivery of results for the new funds to be released, but provides significant flexibility to the implementer to use the funds in the way that they see fit. This model also incentivizes implementers to continue delivery of measurable results, and provides funders with transparent, measurable, and verified impact data that they can use to quantify the actual impact of their funding.

Figure 12: Conditional retrospective donation sub-model

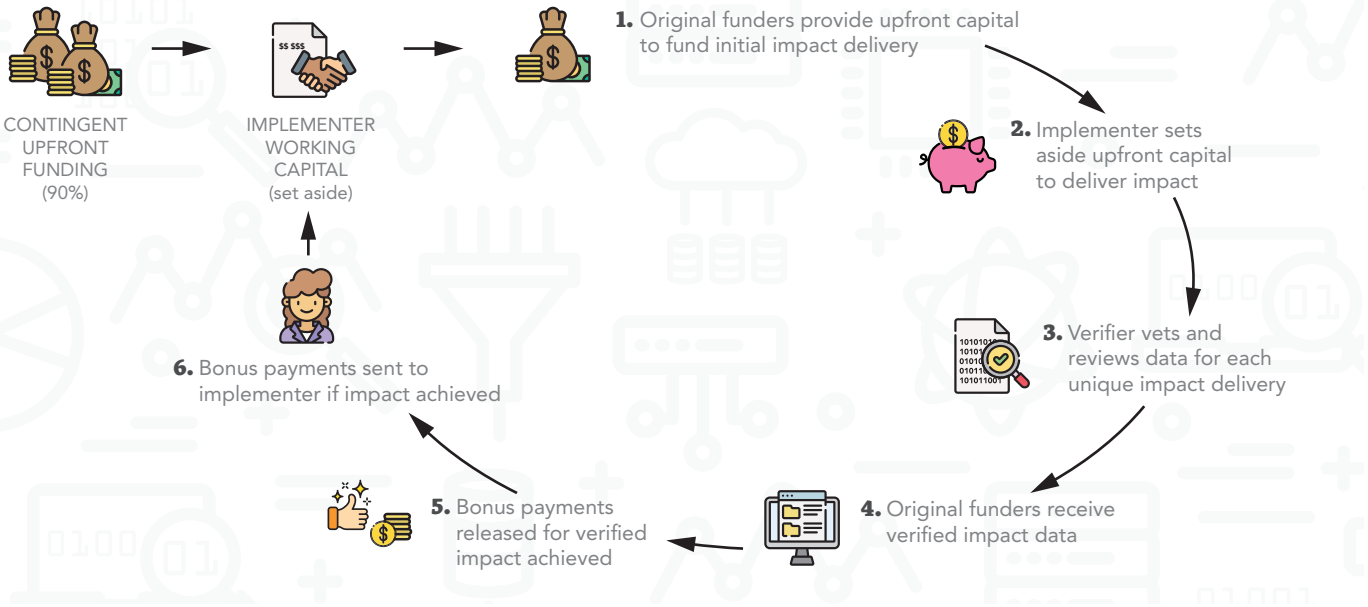


Source: Authors' own elaboration, 2021.

Conditional prospective donations

As illustrated in Figure 13, the conditional prospective donation sub-model builds on the conditional retrospective donation in two ways: first, this sub-model only focuses on the upfront funding provided to the implementer, who then uses the funding to deliver future impact results (i.e. prospectively); and second, in order to incentivize implementers to deliver the results (versus receiving the money unrestricted and not necessarily delivering the impact), this sub-model holds a percentage of the funds as bonus payments, which are only released to the implementer once the agreed upon results are delivered (e.g. 90 percent of funds provided upfront to implementer and 10 percent released only if and when impact is delivered and verified). Whereas the previous unrestricted retrospective donation model does not necessarily require an upfront project design to agree on the results and timeline of delivery prior to the new funder purchasing the results, the contingent prospective sub-model requires that project design details and timelines are worked out beforehand between the funder and the implementer. This sub-model typically works better for funders who are willing to accept a slightly higher risk that the impact will not be achieved in return for the unique 1-to-1 attribution and ownership of the impact, and the assurance that only their funding was involved in the completion of the project.

Figure 13: Conditional prospective donation sub-model



Source: Authors' own elaboration, 2021.

Scoring

The performance-based donation model does not provide any expectation of financial return to the funder (thus receives a score of 0 for financial return). This is a model of financing that anyone can legally participate in, but conditional performance-based financing platforms are not as common or accessible among philanthropic funders or retail donors as simply giving directly to an implementer, making the model only moderately to highly accessible to funders (i.e. score of 3). The conditional release of funds, which in itself requires impact verification, adds a moderate complexity beyond a traditional philanthropy model. The performance-based donation model generally requires initial determination of the relevant impact measures and data points needed to verify impact occurrence, ongoing data collection and impact monitoring, and financial structuring around the holding and release of funds upon impact achievement. For this reason, the replicability of this model has been scored as moderate-high (i.e. score of 3). Due to a permissive regulatory environment across continents, this model is rated as highly feasible from a regulatory perspective (i.e. score of 4).

Principal-only pay for success model

The Pay for Success (PFS) model is still a relatively new financial model (with the first PFS project launched in 2010). However, the market has quickly captured the attention of stakeholders across the private, public, and non-profit sectors. As of June 2020, the Brookings Institute Global Impact Bond Database tracked 194 projects as either completed or in implementation across 33 countries with nearly 421 million USD provided in upfront capital (Gustafsson-Wright *et al.*, 2019). Since 2010, the PFS market has continued to mature and governments have provided funding to expand capacity in support of the model, but despite the progress, the number of PFS projects completed or launched remains relatively low in comparison to the promise of the model and relative to other impact investment products in the market.

The traditional interest-bearing PFS model works as follows: One or more investors provide upfront capital to fund an impact project with the guarantee that they will be paid back – plus a financial return on their investment – by an end payer (i.e. government or philanthropy), only if agreed upon outcome targets are achieved over an agreed upon time period. If the outcomes are not achieved, the backend payer does not pay back the investors (or only pays back a portion of the funds). In this way, backend payers are only paying for projects that work, and investors are financially incentivized to bear the risk of funding the projects. There are also intermediaries that help to structure the deal and design the project, and evaluators that independently assess whether the outcomes were achieved. Three core challenges of the traditional PFS model are 1) they are highly complex to structure and set up, which has prevented widespread adoption and replication, 2) they are only accessible among institutional or accredited investors, which has prevented widespread scaling, and 3) government or philanthropic payers are paying a significant premium, factoring in the interest, setup, and evaluation costs, for an evidence-based project they could have funded through a normal grant.

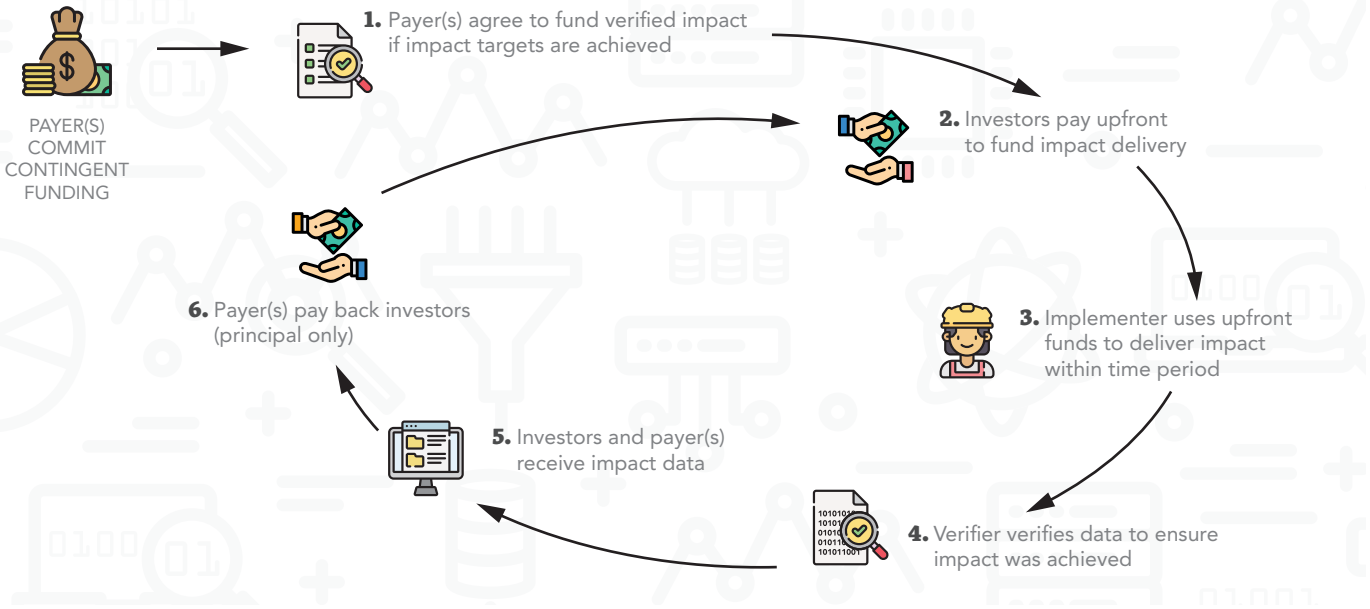
The concept of a principal-only impact bond is an attempt to correct for these three challenges associated with the traditional impact bond. The principal-only impact bond operates the same way as the traditional impact bond with one key difference: instead of investors being repaid their principal back plus a financial return once the impact targets are met, investors are only paid back their principal (see Figure 14). This is a critical adaptation to the model that reduces some of the complexity associated with the financial structuring of each tailored project, expands accessibility to allow non-accredited everyday investors to participate,[11] and reduces the effective cost paid by the end payers. One example of this model is the Oklahoma Women in Recovery PFS project, where the investor – the George Kaiser Family Foundation – agreed to only receive back principal from the State of Oklahoma if the outcomes were achieved, and agreed to reinvest that principal back into the program (Social Finance, n.d.).

Kiva, a crowdfunding platform that provides principal-only returns to non-accredited lenders, has validated that a robust investor market exists for a product that offers principal back to investors, with retail lenders providing over 1.3 billion USD in loans through the Kiva platform since 2005 (Hijazi, n.d.). There is a significant opportunity for a related platform that automates the costly, tailored back and forth between payers, investors, and implementers that often prevent rapid scaling. On such a platform, terms could be selected and negotiated between payers and implementers on the front end, due diligence and impact vetting could be completed by a third party entity, and only then would the platform transparently display the product offering to investors, who could review the risk profile and due diligence details and then seamlessly invest. Such a platform could also allow for a secondary product that provides principal back to payers in the form of impact tokens, which must then be reinvested through the platform in another project. These impact token products could offer better terms to attract investors; for example, a portion of the upfront investment could be covered by a first loss guarantee for the investors by the payers or philanthropic partners. The principal only

[11] *As explained in a legal opinion regarding the precedent set by Kiva (a crowdfunding platform that provides principal-only returns to everyday lenders), "The Poplogix letter affirms Kiva's position, explaining that the SEC considers a security to be present only where the investor expects to earn a profit as a result of a third party's efforts" (Han, 2011). This is further substantiated in the following legal analysis: "...Sites like Kiva that offer investors no interest or other return, only a return of their principal, are probably not offering securities" (Bradford, 2012). However, professional expert legal opinion should be considered prior to launching this product as a crowdfunded instrument.*

impact bond offers a new approach to democratization of impact investing and performance-based financing.

Figure 14: Principal-only impact bond



Source: Authors' own elaboration, 2021.

Scoring

Principal-only impact bonds provide the potential for an investor to receive up to the principal back upon completion of impact targets. Unlike the philanthropy model, there is some expectation for a financial return after investing with the principal-only impact bond, but because the amount cannot exceed the principal, the expected return relative to market rate returns is low-moderate (i.e. score of 1). In theory, this model can have a high degree of accessibility, since fewer regulatory restrictions exist relative to other financing models (i.e. private equity investments). However, despite widespread retail participation in this model being possible from a regulatory perspective, there are currently no scaled platforms that provide investors access to investing in principal-only impact bonds, thus placing the accessibility score at moderate-high (i.e. score of 3).

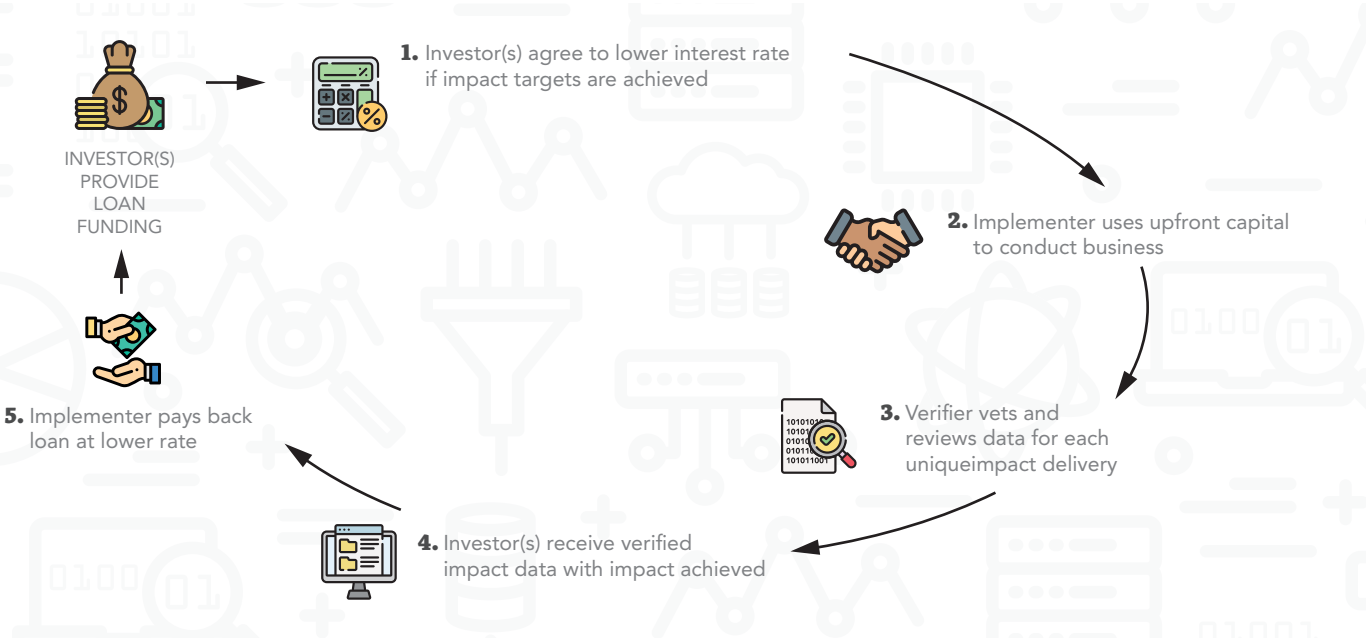
All of the initial structuring requirements listed for contingent philanthropy also apply to the principal-only impact bond model. However, this model has the additional requirement to structure repayment of principal from the payer to the investor. As a result of the added complexity in structuring this model, the replicability was scored as moderate to moderate-high (i.e. score of 2.5). The authors did not identify regulatory constraints applicable to this model within the United States, but given the lack of precedent for this model in other countries, this model received a moderate-high score (i.e. score of 3) for regulatory feasibility.

Interest-bearing loans

There are many interest-bearing loan products in the market that provide capital to social enterprises or businesses with a core focus on impact. This model has evolved to crowdfund interest-bearing loans among non-accredited retail investors, although such crowdfunding platforms (e.g. Lendahand) only allow investors from certain countries. In the context of performance-based interest-bearing loans, there is an emerging opportunity to further incentivize and reward implementers in their efforts to create more sustainable agrifood supply chains.

Figure 15 outlines how a performance-based interest-bearing loan would work, using the case study described in the Defining and Verifying Impact in the Agrifood Supply Chain section above. Under this model, the investor agrees to provide the implementer with a lower interest rate on a purchase order financing loan if the implementer achieves the agreed upon impact metrics during the defined time period. This model could be adapted and applied to a number of other use cases at different points along the agrifood supply chain, and one key advantage of this model is this flexibility to layer on the performance-based element to an existing loan structure. One similar example of such a model is the Michael and Susan Dell Foundation's Impact Linked Debt Instrument, also referred to as an interest rate rebate. Under the program, the Foundation lent to the Indian School Financing Company (ISFC) to improve learning outcomes among children in India, and after two years if the school met its educational impact targets, it gets back 5 percent to 10 percent of the loan amount as an incentive payment (Michael and Susan Dell Foundation, n.d.).

Figure 15: Interest-bearing loan model (Example)



Source: Authors' own elaboration, 2021.

Scoring

Unlike the previously evaluated models, interest-bearing loans have a moderate-high (i.e. score of 3) potential for financial return, as the principal in addition to interest will be repaid to the investor. Successful achievement of impact will result in a lower return on investment than failure to achieve impact targets, therefore interest rates may still fall below or near market rate returns. However, it is important to note that different types of loans (e.g. education loan, purchase order financing, microloan) may have significantly varying interest rates with some exceeding and some falling beneath market rate returns.

As stated earlier, depending on jurisdiction, this model may only be available to institutional and high net worth investors, while in other areas retail investors may have access. Due to the variability in restrictions globally, this model's accessibility is moderate to moderate-high (i.e. score of 2.5). Since there is increased complexity in structuring a performance financing model with a multi-return scheme over principal only or no-return models, the replicability was scored as moderate to moderate-high (i.e. score of 2.5). The maturity of loan markets and the relative ease with which loans are structured today suggests the fundamentals of this model would be feasible from a regulatory perspective, but given the lack of precedent for a performance-based loan conditional on achievement of impact targets, this model was scored as having a moderate-high regulatory feasibility (i.e. score of 3).

Interest-bearing pay for success (PFS) model

The traditional interest-bearing PFS model continues to offer promise as perhaps the highest fidelity performance-based financing model.[12] As defined in this report, PFS arrangements include any performance-based financial models that tie payment to impact achievement, are funded upfront by private capital, and involve an outcomes payer that pays for impact if impact targets are achieved. One example of this model is the Sustainable Cocoa and Coffee Production Development Impact Bond in Peru. This project aimed to reduce the negative impact of fungus and improve production for farmers in Peru by building facilities for planting fungus-resistant coffee strains and improving post-harvest infrastructure. The project was funded upfront by the Schmidt Family Foundation, outcomes payments committed by the Common Fund for Commodities, and payments tied to farmer production and yield (Instiglio, 2017).

For purposes of exploring the most innovative financial models, this report features two sub-models that have adapted the traditional interest-bearing PFS model.

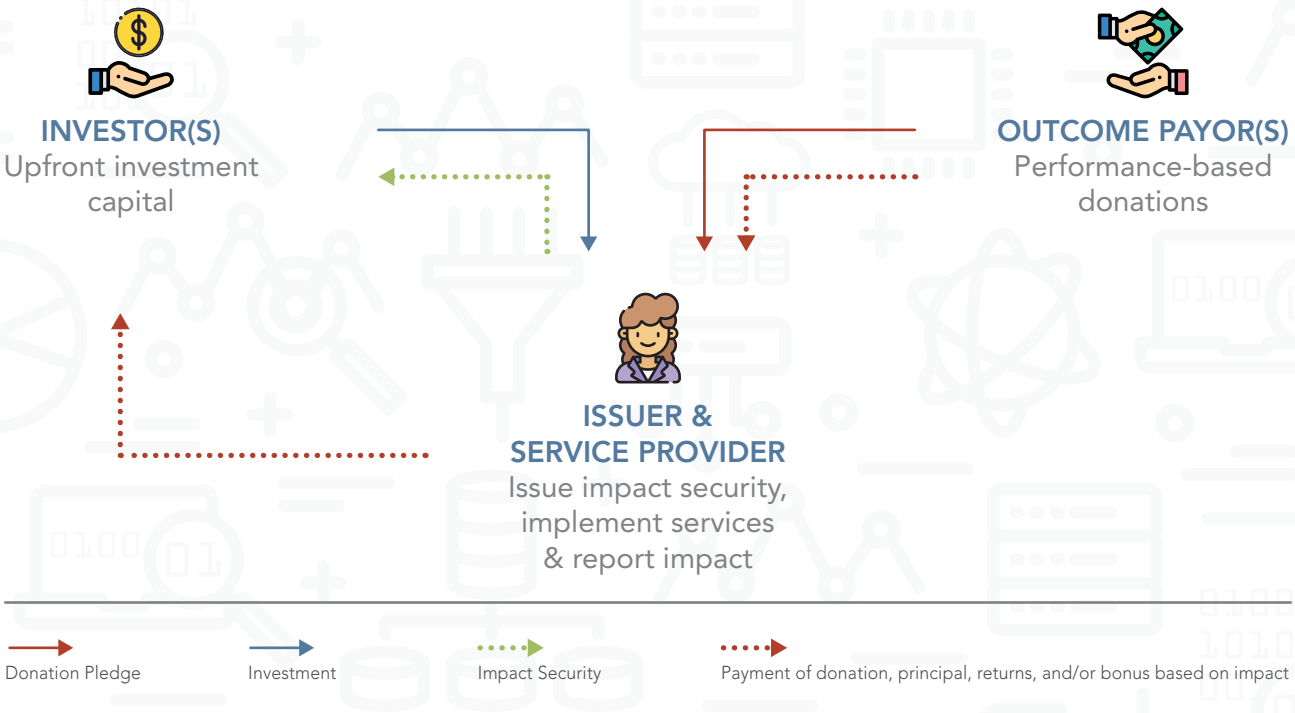
Impact security

This sub-model operates similarly to the traditional impact bond, with financial returns provided to investors subject to, and based, on the achievement of measurable impact targets. However, a key difference is that this product is considered a debt security and is issued by a non-profit organization, foundation, government, or supranational entity, which repays any obligations in respect of the debt, subject to impact metric achievement, over time with philanthropic capital raised from donors (see Figure 16). As such, this product is exempt from US Securities and Exchange Commission (SEC)

[12] *Examples of the first 25 Pay for Success projects in the United States can be found at: https://nff.org/invest-in-results.*

registration requirements (NPX Advisors, n.d.). For this reason, both accredited and non-accredited investors can participate in this impact investment product, and there is significant potential for this sub-model to scale, including through a crowdfunding platform. US-based NPX invented the Impact Security and is currently the only facilitator of Impact Security transactions.

Figure 16: Impact security flow of funds



Source: Authors using NPX information.

Social impact guarantee

An alternative model to the traditional impact bond is the social impact guarantee (SIG). This sub-model effectively operates the same way as the traditional impact bond, but instead of payers (i.e. government or philanthropy) committing to pay back principal and return to investors if impact targets are achieved, the investors commit to pay back the payers if impact targets are not achieved. Thus, this sub-model operates as impact insurance, where payers pay a small premium to investors (i.e. impact insurers) to guarantee impact, and if the impact targets are not achieved, then the investors cover the costs of the failed program.

The key advantages of the SIG are twofold. First, whereas the traditional impact bond forces payers to engage in performance-based multi-year contracting that they are not traditionally accustomed to, the SIG allows payers to simply reallocate a portion of their existing budget directly to programs that already exist, making the setup and contracting process simpler for the payer. Second, traditional impact bonds typically require payers to set aside success payments in escrow accounts to guarantee to investors that the funds are ready for pay-out, but this process defeats the purpose of benefiting cash-strapped governments with upfront investment capital. Instead, the SIG allows government payers to follow their existing appropriations and budgeting processes, while at

the same time allowing investors to hold and make interest on their own funds, thus eliminating a "double capitalization" problem (Overholser, 2016).

As stated by George Overholser, Co-Founder of Third Sector Capital Partners, Inc., "Indeed, the central role of a SIB [social impact bond] (and certainly of a SIG) is insurance. It insures against the risk of the government allocating precious taxpayer money to programs that do not work. And it insures vulnerable non-profit service providers from the financial peril of potentially never being paid...With the SIG, everything begins to make more sense. It is not an interest payment; it is an insurance premium. And it is easy to explain how paying a 5 percent premium for something that might pay back 100 percent is a good deal… especially in a world where so many social programs, when rigorously evaluated, are revealed to have been ineffective" (Overholser, 2016).

Scoring

Interest-bearing PFS projects have the ability to provide at or above market rates, and thus have a high (i.e. score of 4) potential for financial return, with successful achievement of impact resulting in increasing returns for the investor. While there are currently no platforms for investors to invest in interest-bearing PFS projects, the Impact Security sub-model is exempt from SEC registration, which indicates that all investors, including retail investors, could participate in this investment. While all investors may be able to access this, the absence of a scaled platform results in a moderate-high (i.e. score of 3) score for accessibility.

The complexities in setting up this model align with those listed for the models mentioned above, with the additional requirement of holding and determining pay-outs between the investors and payers. As a result of the additional structuring requirements, the replicability score of this model is low-moderate to moderate (i.e. score of 1.5). From a regulatory perspective, this model was scored as moderate to highly feasible (i.e. score of 3), as it has already been executed in multiple countries around the world, but traditionally structured interest-bearing PFS projects often require explicit regulatory approval, and the Impact Security has only been tested in the United States.

Decision matrix

As outlined in the matrix below (Table 6), there is different weighting for each criterion. The potential for financial return (30 percent) and the regulatory feasibility (30 percent) of a given model were weighted more heavily than the accessibility (20 percent) or replicability of a model (20 percent). Financial return was weighted more heavily because it serves as an indicator for the ability of a model to incentivize the mobilization of capital, an essential component in driving achievement of improved sustainability of agrifood supply chains and the UN's SDGs more broadly. Similarly, the ability to legally launch with the least number of regulatory barriers across multiple countries and jurisdictions is essential to ensuring the ease of deployment of a given financial model, and increasing the number of potential investors able to participate.

The final score is the average weighted score of the four criteria. The interest-bearing PFS model received a score of 3.0, the highest final score of all the models evaluated. The interest-bearing loan had a final score of 2.8, followed by the performance-based donation with a score of 2.4 and the principal-only PFS model with a score of 2.3. The criterion with the greatest difference in scores

between models was the financial return, with the interest-bearing PFS model and interest-bearing loan scoring significantly higher – 4 and 3 respectively – in contrast to both the performance based donation and principal only model, with scores of 0 and 1. Compared to the other criteria, there was the least variability between the models from an accessibility perspective, with most being evaluated as having moderate-high accessibility.

Table 6: Scoring matrix with final results of analysis

	FINANCIAL RETURN (30 %)	ACCESSIBILITY (20 %)	REPLICABILITY (20 %)	REGULATORY FEASIBILITY (30 %)	FINAL SCORE (average weighted)
PERFORMANCE BASED DONATION	0	3	3	4	**2.4**
PRINCIPAL-ONLY PAY FOR SUCCESS MODEL	1	3	2.5	3	**2.3**
INTEREST-BEARING LOAN	3	2.5	2.5	3	**2.8**
INTEREST-BEARING PAY FOR SUCCESS MODEL	4	3	1.5	3	**3.0**

Chapter 6.
Conclusion

As governments, impact investors, philanthropies, and implementers around the world search for innovative financial models that mobilize private capital and incentivize more sustainable agrifood supply chains, one significant emerging trend is the shift towards performance-based financial models – where payments are dependent on measurable impact targets – which provide significant opportunity to generate both impact and financial return. In parallel, the rapid growth in the use of blockchain technology across agrifood supply chains has opened the door for impact achievement to be tokenized on a distributed ledger, further strengthening the ability for funders to see, own, and eventually trade the impact they have funded.

This report has two concrete, actionable recommendations for policymakers, regulators, and the broader industry to consider to accelerate the transition to a more sustainable global agrifood supply chain.

Recommendation #1: Support the development of a democratized pay for success investment platform

As demonstrated by the results of the analysis, the interest-bearing Pay for Success (PFS) model received the top score across the evaluative criteria. Both the interest-bearing PFS model (and more specifically the Impact Security) and the principal-only PFS model would be broadly accessible by any impact investor, and thus these models present a significant opportunity to democratize impact investing to an entirely new market of smaller institutional or retail investors interested in crowdfunding performance-based impact.

These models could be hosted on an online platform, bringing together government, philanthropy, implementers, and investors into one space to facilitate end-to-end deal structuring, execution, and payments. Upon finalized design, deal structuring, and agreed upon terms between payers and implementers, the platform could package the design details and terms into an easily digestible page for each PFS project that any investor could review and transact directly in the platform to pool the investment capital prior to disbursement to the implementer. On the platform, each investor would have an account with a dashboard that tracks the amount invested, the amount paid back (as success payments), and total impact achieved over time. Verified data would also be shared directly and transparently with investors and payers, and ownership of the verified impact would be tokenized on the blockchain and provided to each unique funder. As more projects are added, the platform could become a marketplace for investors around the world to browse different PFS offerings, invest, and track their financial and impact return all in one centralized location.

Policymakers could support the development of such a platform through capacity building resources, commit to serve as the first payer in launching the first digital PFS project, or serve as the issuing body for an Impact Security on the platform. As noted by Wainer (2020), "...the sector needs a central DIB platform where entities interested in taking on one of the various DIB roles can coalesce. These entities may include investors, outcome funders, intermediaries, evaluators, and local and international implementers." The recommended platform in this report takes this idea one step further by providing a full end-to-end experience and marketplace for investors to come and invest directly in PFS projects.

Recommendation #2: Promote the piloting of performance-based interest-bearing loans

As demonstrated in the analysis, one of the other promising performance-based financial models is the interest-bearing loan (i.e. interest rate rebates). The broad applicability of this financial product, particularly in agrifood supply chains, makes it a good fit for layering on performance-based adjustments to existing interest rates. The ability for the agricultural sector to build upon existing, commonly used, and simple financial instruments will be critical for scaling. This model not only continues to provide a financial return for investors, but it also aligns incentives to encourage implementers to measure new impact metrics and improve performance over time.

To help accelerate the testing of this innovative model, FAO could possibly support the development of a policy analysis tool for policymakers and practitioners that investigates in greater detail how and where such a model would ideally be piloted (i.e. with a focus on technology- and blockchain-based verification), the most conducive regulatory environment for such a model, and the policy changes that would position the sector for success. This would directly inform the launch of the first pilot of this model focused on sustainable agrifood supply chains. If successful, the policy analysis and accompanying pilot could help to catalyze and rally the impact investment industry around a highly scalable and broadly applicable model that can move the needle on creating a more sustainable global agrifoodsupply chain.

In conclusion, the recommended paths forward paint a detailed picture of an impact investing and tokenization ecosystem that prioritizes rigorous impact measurement and management, performance-based financial models that incentivize impact achievement, and democratized impact investing that is broadly accessible. Through these overarching goals and specific recommendations, this report aims to advance the evolution of impact investing in global agrifood supply chains (and social and environmental impact space more broadly), encourage the industry to consider the use of blockchain for impact purposes, and promote cross-sector collaborations that ultimately accelerate realization of the 2030 Agenda and achievement of the Sustainable Development Goals.

Areas for additional research

Future research in the following areas could extend the applicability of the current paper in real world settings and enhance the potential for mainstream scale of innovative financial models in current capital markets:

1. **Liquidity:** In order to further incentivize and leverage the full potential of private capital markets to invest in sustainable agriculture and other impact causes, impact investing and other innovative financial models must have high liquidity (i.e. the ability for an asset to be quickly bought and sold by investors). The current impact investing market, and especially performance-based financial models, is still illiquid in many circumstances, with investors needing to commit their capital for long periods of time without the ability to buy or sell their investment. Further research on promising impact investment models that have explored this question in further detail, particularly around potential regulatory barriers and requirements (e.g. registration requirements among financial institutions and ability to create liquid products listed on financial exchanges for retail investors), would add further detail to the vision, reach, and applicability of this report.

2. **Financial regulation:** In addition to regulatory questions related to liquidity, many of the innovative financial models listed in this report have not been broadly tested among retail investors, in multiple countries and jurisdictions, or in agricultural supply chains. For this reason, the regulatory mapping of each model would need to occur in depth with legal and policy experts prior to widespread testing and implementation. Further research on this topic could fill an important knowledge gap in the industry. For example, specific questions to explore would include which factors would prohibit retail investing outside of the United States (e.g. could the Impact Security, which has variable returns, be offered to retail investors in Europe), is the principal-only Pay for Success model in fact exempt from SEC registration in the United States, and what is the ideal regulatory environment for an impact-based interest-bearing loan. As new means of deploying, investing in, and distributing financial assets become possible via the blockchain, additional regulatory guidance will also be required to ensure continued innovation and compliance in leveraging this emerging technology for impact financing purposes.

3. **Agricultural technology:** The breadth of agricultural, financial, and other business support technologies is far reaching, which creates a significant opportunity for data collection, blockchain integration, and application to performance-based financial models. Exploring in greater detail which technologies could be made interoperable among each other, and investigating which verticals of the supply chain would be most prepared for a real-time verified performance-based financing model is a logical next step to applying the recommendations in this paper to the real world.

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Appendix
Interviewees and takeaways

NAME	ORGANIZATION/ROLE	TAKEAWAYS
Aliya Das Gupta	IOV 42/ Head of Research	• IOV 42 uses blockchain for CO2 tracking and certificates in order to release meaningful CO2 certificates and prevent double counting. • IOV 42 solution is a government grade solution which cre-ates zones and zonal code. • Verification of non-human data is possible and true in 99 percent of the cases. • Human data inputs contain up to 30 percent data when injecting data into a blockchain solution. • Hybrid solution is possible through embedded code on the blockchain and having the blockchain governance model of pre identified zones within the technical solution. • Blockchain solution contains the PoW consensus model and uses the multisignature approach for verifying infor-mation from transactions. • Usage of satellite images to train AI algorithms to estimate biomass is an emerging data collection technique. • Blockchain infrastructure provider with IOV42 blockchain so-lution is proprietary. • Redesign blockchain solution according to the use case.
Alain Diffo	Camzim Enterprises/ CEO	• Blockchain technology would even the playing field for companies which produce in Zimbabwe and want to sell to the international market • Local infrastructure needs to be taken into consideration when implementing new technologies such as blockchain since cold chains for example cannot be guaranteed. • Middlemen in Zimbabwe concentrate a lot of market power currently which creates substantial barriers for local producers and farmers • The topography of Zimbabwe allows for high quality production of citrus fruits and berries such as raspberry. • Renewable energy can play a substantial role in the overall energy consumption of farmers in Zimbabwe. • Other technologies as soil sensors or self-driving trucks are already in use for the farming techniques. • Political class needs to protect foreign direct investment by law and create farmer-centric legislation in order to promote sustainable practices.

NAME	ORGANIZATION/ROLE	TAKEAWAYS
Carrie Richards	Richards Grassfed Beef/ Vice President of Compliance & Marketing	• Family ranch on 6000 acre property in the Northern Califor-nia area that is tracking their ability to sequester carbon in soil and improve water filtration. • Two certifications to help ensure beef is 100 percent grass fed and grass finished using regenerative farming practices: American Grassfed Association and the Savory Institute's Ecological Outcome Verified certificate. • Two certification entities help to track measurements: PointBlue (every two years) and the Savory Institute (every year for short-term measurements, every five years for ex-tensive measurements). • PointBlue's measurements include: water filtration and car-bon measures via in-ground soil probes, soil absorption tests, before/after photos of plant diversity (w/ photo metadata), plant diversity counts, and diversity of bird spe-cies (as a proxy for a healthy ecosystem). • Savory Institute's measurements, in partnership with Cornell University, include: water filtration, diversity of grasses, di-versity of wildlife, before/after photos for short-term yearly assessments. For five-year assessments, techniques in-clude a post in the middle of the farm for consistent track-ing, plant species diversity, evidence of wildlife, soil absorp-tion, soil compaction, and 360 GPS photos of background. • Streamlined methodology could serve as a proxy for long-term impact of regenerative agriculture practices. Stream-lined methodology could include: seed list, seed growth via photos, grazing plan with notes, using PastureMap as a website for cattle management, and GPS-tracked pictures of pasture.
Claudio Di Ciccio	Sapienza University Rome/ Assistant Professor	• Pilot in the pharmaceutical industry for traceability. • GS1 creates a blockchain standard. • New blockchain solution is able to decode info, and make it possible for various parties to participate. • Real data stored off chain in order to make sure the blockchain solution is not clogged up. • Assignment of private and public keys needs to be managed. • Integration of oracles is essential to provide certain data inputs. • Various projects in Sri Lanka and Georgia. • Interesting use case from Rome where plastic bottles can be used to pay for public transport, interesting incentive mechanism with far-reaching benefits. • Decision rights in a blockchain governance model should promote good citizen behaviour. • Smart contracts need to be designed very carefully and with the right amount of diligent work processes.

NAME	ORGANIZATION/ROLE	TAKEAWAYS

Claudio Tessone	UZH Blockchain Center/ University of Zurich/ Academic Director	• Blockchain technology can serve as the technical founda-tion for incentives schemes which allow steering of inde-pendent agents in a defined system.
		• Interoperability is a trend because a lot of different solutions already exist in the agricultural supply chain.
		• Government, private sector and academia team up in Swit-zerland to create prototypes which can become full-fledged solutions for providing transparent records and preventing misbehavior.
		• Several pillars are important in a blockchain governance model:
		  • Business model which combines blockchain tools with automation and allows for data-driven deci-sions, taking into consideration the various members of such a consortium.
		  • A consortium is typically composed of various actors which are heterogeneous and assume different roles in such a blockchain-based model.
		  • Preventing imbalances in power and proportional access to voting rights must be designed for, for a well-functioning blockchain consortium.
		  • Disagreement resolution must be solely based on in-formation and disagreement can be helpful when consensus is in question. The life of the consortia needs to be capable of change and have a set of rules which guides the behavior of the participants.
		  • Blockchain ownership and responsibility is part of the governance model and different stakeholders react to different incentives, whereas the rules of ownership must be clearly stated upon the govern-ance principles.
		  • Accountability and rules need to be clearly defined.
		  • Rating system needs to be integrated into the gov-ernance principles to provide further trust into the functioning of the model.
		  • Transaction enforcement needs to be designed in order to create a data market which can be lever-aged by all participants. Another incentive scheme needs to be designed carefully to provide incentives to share data and even provide the possibility for third-party providers to provide data analytical ser-vices to the various actors.
		  • Establishing neutral participants such as the UN FAO or academia can be part of a system of checks and balances needed in order to create a trustwor-thy network of neutral institutions.
		  • Blockchain-based consortiums provide consensus and create indirect trust between different peers in a decentralized way.
		  • Suggested approach: Start with a few nodes and implement a gradual approach for new members. Establish clear trust, incentives and while new mem-bers are onboarding, provide them with little effect on the entire system. Permissioned-based systems in the context of agricultural supply chains make sense and no drastic changes should happen. The incentive alignment must work for the different stakeholders and provoke the right behavior which is set in the guiding principles of such a blockchain-based consortium. System development and maintenance need to be accounted for by the right incentives in the consortium. UN FAO could assume such a neutral role as a system provider to the par-ticipants. Participants should pay the system provid-er in order to have a well-functioning system. Busi-ness model of the consortium must be profit-oriented in order to provide the right incentive for all stakeholders to participate.

NAME	ORGANIZATION/ROLE	TAKEAWAYS
David LeZaks	Croatan Institute/ Senior Fellow	• Use of technology (e.g. drone surveillance) should serve business purposes for farmers beyond the impact measurement and verification purpose in order to become sustainable in the long-term. Other technology, such as satellite imagery, is cheaper and can track land attributes, and there are methods that can also supplement this data with measures on the well-being of farmers. • Data burden for farmers in reporting for current certification standards is becoming an increasing challenge, as farmers don't have the capacity to report manually across all the different certifications and platforms. Technology-based data collection could reduce data burden (and allow for passive data collection) while at the same time strengthening the impact verification process. • There has been a lot of emphasis on the carbon impact of agricultural practices, mostly around non-soil impact measurements because soil carbon has been hard to measure. However, there has been growing attention on regenerative, land-based agriculture practices, and in parallel a growth in estimating soil carbon storage through innovative estimation models.
Emiliano Mroue	WARC Group/ CEO & Founder	• WARC provides inputs (seeds, fertilizer), access to mechanization equipment, and training in regenerative farming via loans to smallholder farmers in developing African countries as part of a regenerative farming agriculture package. The goal is to onboard every farmer into a 5-7 year journey to make every acre of land into regenerative agriculture, and ultimately increase each farmer's income by 2 500 USD. • WARC Group conducts baseline and impact surveys with each individual farmer and conducts analyses (e.g. difference-in-difference) to introduce new crops and then assess farmer income before and after. • Total farmer yield is a better measure of impact than total farmer income due to difficulties in measuring income and price fluctuations. In addition, certain commodities are easier to estimate total farmer yield than others (e.g. it is difficult to estimate yield for commodities that are a staple food of the farmer, such as rice in East Africa compared to maize). • A coalition of large agricultural companies in the United States are launching credit systems on conservation and regenerative agriculture for farmers: *https://ecosystemservicesmarket.org/*
Ethan Hallberg	NPX/ Associate	• NPX designed and tested an emerging impact investment model called the Impact Security. • The Impact Security operates in a way that is similar to an impact bond, except that the financial product is issued by a nonprofit organization, foundation, government, or suprana-tional entity, and thus is considered a debt security, which allows for greater standardization. Given that the instrument is a debt security, and not a partnership interest, LLC or be-spoke contract, standardization is easier. • This product is exempt from US Securities and Exchange Commission (SEC) registration requirements. For this rea-son, both accredited and non-accredited investors can par-ticipate in this impact investment product. • NPX has launched one Impact Security thus far (*https://npxadvisors.com/impact-security/the-last-mile/*) and is currently launching two funds using Impact Securities to drive capital to nonprofit organizations. • NPX targets philanthropy (versus government) as the prima-ry payer (i.e. donor) in an Impact Security arrangement.

NAME	ORGANIZATION/ROLE	TAKEAWAYS
Fabian Wahl	Agroscope/ Head of the 'Food Microbial Systems' Strategic Research Division	• Switzerland is known for high value agricultural products such as Swiss cheese. • Agroscope is a research-oriented association from the Swiss federal government which focuses on agricultural supply chains as well as pharmaceutical products. • New methods lead to higher output per acre in Switzerland while also using microbiomes for authentication of agricul-tural products. Focus is also on creation of new species of plants which are more suitable to the new conditions. • New farming techniques like urban gardening or indoor farming are being explored to grow salat for example in 24 days with less consumption of resources such as water, electricity or pesticides. • Usage of new digital technologies such as blockchain and IoT allow for traceability of agricultural products from farm-to-fork which increases overall food safety for end consumers. • Taste of customers is an emotional part of the successful digital transformation of the agricultural supply chain since reproduction of goods can be stored and replicated. • High focus on international collaboration with the Nether-lands, Germany and Belgium for research and European networks. • Precision farming can lead to reduced consumption of pes-ticides and yield higher output while improving soil quality. • Intelligent packaging can result in better consumer infor-mation while also indicating lifecycle information through a QR code which the end consumer can check via an App. • Agricultural consortia based on blockchain need to be care-fully designed in order to define the rules, governance model and defined escalation process. • Public-private partnerships can be a successful model for the future when roles are clearly defined. Agroscope devel-ops the research while other companies focus more on the translation of the new model while managing the lifecycle. • Blockchain can also play a vital role in land ownership with the help of UN FAO in African countries. This would result in more sustainable business practices where no child labor and other unethical business practices are not possible. Overall, such blockchain-based models would empower a new generation of young farmers.

NAME	ORGANIZATION/ROLE	TAKEAWAYS
Horst Treiblmaier	Modul University Vienna/ Professor International Management	• UN FAO could promote a private/permissioned blockchain solution in order to make sure that only pre-selected actors are within the consortium increasing also the data validity. Provide neutral servers for the overall blockchain pilot project. • Create a pilot project where everyone involved sees the clear benefit from participating in such a blockchain consortium. • Hyperledger blockchain is one of the few real blockchain projects with global scale and enough technical maturity. It provides a technical solution where access needs to be granted in case of participation. • Rules in a blockchain solution need to be decided on in the beginning. The proper form of consensus algorithm needs to be selected (proof of work, proof of stake, bzyantine fault tolerant, etc.). • Disputed transactions shall be resolved via traditional means. Institutions should be included in a blockchain consortium where role and ownership should be clearly defined. • UN FAO could take on the coordinating role in a blockchain consortium when formed for sustainable agricultural supply chains. • Benefits of transaction cost reduction should be split among all participants in order to provide an incentive for all participating stakeholders. • Establish an incentive alignment which serves the needs for everyone in the consortium because it can trigger enough stakeholders to participate and form a strong interest for new business models that can develop from it.
Jesus Crespo Cuaresma	Vienna University of Economics & Business/ Macroeconomics Professor	• Using crowd-sourced data for enriching satellite data and other data sources to help verify data points for farmers (Agri Tutor). Enriching and getting more granularity of socio-economic models and reaching the 50 times 50 meter level, which helps farmers to better manage their agricultural plot and hedge risk (optimal plot work based on data). • Remittances currently take up to 20 percent of the total amount, with blockchain technology and cryptocurrencies, the per-centage can be lowered substantially (e.g. to 0,2 percent or low-er) and allowing families to use that capital to increase the current living standard. Modeling remittances globally with the African Development Bank to see how the capital is be-ing used and how the economic connection is between dif-ferent countries. • Lowering the remittances can improve the impact invest-ment case because blockchain technology in the form of cryptocurrencies and tokenization lowers the cost of trans-action substantially. • Enhancing data with google streetview data together with IoT data sensors and geo-coding the data. Time-series data showcase urban development over time and allows insights about the development of poor rural areas. • Forecasting of agricultural products for commodities (e.g. coffee) markets based on evidence-based econometric models. • Gamification of apps in order to get a better quality of local pictures through devices. • Price forecasting of agricultural commodities such as arabica coffee based on modeling and farmers can adapt their crop planting behavior based on price prediction parameters. • Achieve granular data through the mashup of various data sources such as daylight satellite images, macroeconomic data, and drones.

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Katie Naeve	Root Capital/ Director of Partnerships & Social Impact	• Root Capital is responsible for creating and overseeing due diligence for all investments. • Root Capital makes sure investments pass the negative screen (not creating negative impact for people or planet) – and positive screen (generating positive social and environmental impact) – loans require the investments to pass both screenings. • There is a growing movement among impact investors to ensure investments are measuring impact, with the goal to ensure consistency in approaches and the rigor in which people are using this data. The Impact Management Project (IMP) is a leader in all things impact measurement and management. • There are a number of tactics deployed to monitor the higher risk companies; existing certifications help to determine risk level and expected impact in due diligence and monitoring. • One recent emerging trend is climate vulnerability mapping, using weather, altitude, and other data points to determine the need for climate resiliency support. • Impact investment models should not be focused purely on financial return. • Traditional social impact bonds have a lot of potential, but lack scalability due to administrative burden.
Marc Buckley	United Nations/ Advocate for the SDGs	• New UN/WEF project called digital ecosystem for the earth combines various technologies such as geospatial data (soil, temperatures, moisture, weather), blockchain, AI, IoT and many more, in order to create synergies and real-time data. Various companies are involved on a global level. • New agricultural sustainable supply chains can be created through closed loop supply chains where rainwater is being used and other forms of having a circular water supply chain for creating food. • Share a meal project by the World Food Programme (WFP) uses blockchain and cryptocurrencies to feed refugees. The project is highly successful and principles can be leveraged for a blockchain solution in order to create a meaningful im-pact for agricultural supply chains. • Two different concrete models: (1) Innovation impact uses different technologies, in a closed supply chain system and vertical farming which uses energy which was harvested in a sustainable way (solar energy, hydro energy and other re-newables). (2) UN FAO should create a global new infra-structure for sustainable agricultural supply chains on non-finite resources such as energy and water. • Reduction of costs of goods sold is important to have an economic incentive to change the current system. • New development among corporates to go carbon negative (started with Microsoft) which means that corporates will en-gage in impact investment in order to achieve these goals. The movement gained traction with over 87 companies combining in 2.4 trillion USD which gains exponential growth to go carbon negative by 2030 and also focusing on UN SDGs. • OURZ (blockchain startup from Hamburg) focussing on traceability and transparency for food companies.

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Mark Furniss	Enveritas/ Senior Director of Partnerships	• Enveritas uses a combination of geospatial satellite imagery and ground-level surveys to identify coffee farmers in selected countries and determine baseline adherence to sustainability and coffee farming standards. • Enveritas conducts random sampling of 1) the coffee farmers, 2) the ground-level farmer verification visits/surveys, and 3) "back-checking" (i.e. Enveritas staff conducting the same survey) for a subset (5 percent) of the verifiers/surveyors results; these help to efficiently extrapolate conclusions and establish confidence among corporate roasters. • A combination of interviews and observations is necessary for ground-level determination of whether sustainability standards are being met; data is submitted by contracted verifiers into a mobile app and then data quality is assessed the same day so verifiers can re-collect proper data if needed. • Most smallholder farmers (97-99 percent) are open to unannounced visits by ground-level verifiers (and they do provide informed consent). • Farmer yield is a better measure of impact than farmer income (as it's less likely to be affected by price swings in the market), and generally farmers' self-responses are the best way to measure yield (Enveritas has checked this against the amount of land on a farm and national export numbers).
Mark Lambert	Quantified Ventures/ Director of Agriculture	• Non-return impact investments are significantly less desirable to institutional investors, who care a lot about the financial returns. • There is a big opportunity for Program-Related Investments (PRIs) and Mission-Related Investments (MRIs) among foundations as investors. • Corporations operate more as payers of impact in an impact bond model vs. investors. • Democratized (i.e. crowdfunded) impact investing has complexities and challenges that make it a more difficult asset to structure, but there is a huge opportunity in this space. • Environmental Impact Bond (EIB) in Atlanta allowed high net worth accredited individual retail investors to invest in impact and make a return; EIB model more broadly is scalable in the US, but it's harder to use EIB model for farmers that operate across municipalities. • There is a big opportunity for real-time output verification that's more efficient and reliable (e.g. instead of quarterly evaluations, decrease frequency with real-time sensors).
Melissa Sesana Grajales	ASIRI SAS/ Founding Partner	• Technological integration in agriculture to improve processes and verify impact is rapidly being advanced and adopted (e.g. cow facial recognition). • The reward-based token model -- where investors can get their principal and/or returns back in the form of online tokens to re-invest -- has a lot of promise for more impact-minded investors and funders. • Corporations typically impact invest through endowments (or foundations). • One new potential impact investing model includes tying release of equity impact investments in companies based on achievement of measurable targets (e.g. X% women hired); similar to loans or purchase orders where interest rate being lowered is contingent on the achievement of measurable impact results in the supply chain (such as working standards).

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Michael vanCutsem	BeeOdiversity/ CEO & Founder	• BeeOdiversity monitors and develops projects that help to regenerate biodiversity and reduce pollution. • One of primary monitoring tools is linked to bees. Traditional ecological surveys are difficult to monitor large surfaces for plant diversity, and for pollution you have traditional sensors focusing on small particles, but not pesticides or heavy industrial pollutants. • BeeOdiversity developed a tool to collect pollen on bees that have traveled within a 1.5 kilometer radius and analyze the pollen for air pollution and plant biodiversity on a granular level. This allows for tracking of impact in these two areas over time. • Key impact measures in an innovative financial model could be the number of plant species in a given area or the amount of pollutants reduced.
Peter Johnson	Ayadee/ FinTech4Good/ Founder Advisor	• Ayadee.io could be utilized for proof point tracking and impact verification. • Plaas.io is a potential use case for overlap of agricultural supply chain and blockchain. • Kiva was working with Sierra Leone to create blockchain-backed digital IDs so that they can give out microloans (can't give microloans unless people have IDs, and most people in Sierra Leone don't have IDs). • Use of IOT/tech-based data collection for agriculture might be more effective and feasible in factories than out on the farms due to the designated entry and exit points where data can be collected (e.g. at entry/exit, can track with sensors or videos to ensure proper working conditions). • In Africa, certain countries are more open than others to new impact investing models where the law permits more flexibility.
Robert Schwertner	Austrian Blockchain Landscape/ Co-Founder	• DAO based on ethereum guided by the UN FAO and en-forced to the existing stakeholders. • Use 0BSnetwork for throughput and technical speed for a blockchain-based solution. • UN FAO should provide the blockchain infrastructure for all stakeholders. • Create an agricultural token in order to incentivize the be-haviour in the right way. • Create a new blockchain-based standard for the agricultural funding mechanisms. • Connect the blockchain solution to a swarm of drones. • Imagine a future of fully autonomous farms. • Clear ownership needs to be established in a blockchain-based solution for responsible agricultural supply chains. • Link it to automated insurance / payment and other ser-vices.

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Srdjan Kupresanin	0bsnetwork/ Founder	• Provide a solution to the UK parliament in form of the Agromex platform where an agricultural supply chain platform is formed where commodities can be traded such as corn, soy, wheat and provide blockchain-based security for the information provided. • Blockchain-enabled platform where all stakeholders are connected and provide one source of information to the users. Proof-of-origin is possible through the usage of blockchain standard format. • 0BSnetwork provides a standard data format and privacy of data. • AgroMex also serves as a backbone for the entire business process. • Blockchain solutions need to be embedded into the regulatory environment. • Deems smart contracts as a dangerous concept because the level of expertise on the regulatory side is low. • Creation of tokenization for agricultural machinery and make machines available to more smallholder farmers. Ownership will be shared among farmers of communities in the same geographic area. • Clear difference between technical area and business logic where the technical part can be used for tokens, transactions, events, documents etc. • Bring crowd investing to the blockchain technology which provides the ground for new types of business models.
Stephan Karpischek	Etherisc/ Founder	• Insurance product based on ethereum blockchain which in-sures against risks associated with planting crops (crop in-surance) called etherisc. • Tailor insurance products based on local knowledge and adapt the concept in a way that it is easily understood for the local farmer who might not be aware of the insurance concept. • Insurance dimension gives the impact investment model another dimension and makes it more financially attractive since there is a possibility to hedge against risks caused by natural influences such as drought, flood, hail etc. • Parametric insurance application based on ethereum which is triggered by an event or API or oracle, this trigger then automatically releases a payment. • Insurance projects together with AON and Sanasa in Sri Lanka and contact with over +200 different insurance com-panies. • Discussion with insurance regulation is necessary in order to legitimate insurance applications based on ethereum block-chain. • Smart contracts make the insurance product efficient, cheaper and transparent. • Bring insurance to a public infrastructure which is based on a public blockchain such as ethereum. • The concept of microinsurance could be tailored to a block-chain solution.

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Thad Simons	Yield Lab/ Managing Director	• Yield Lab invests in equity of early stage ag-tech companies; the investments are not tied to the achievement of defined impact targets given the early stage of many of the companies, but all are social enterprises with impact at the core, thus when a company succeeds, impact is achieved. • Yield Lab is launching a manure innovation challenge (one example use case is the conversion of manure into clean coal). • The best measures for investors have both environmental and economic impacts (e.g. on top of the positive environmental effects of specific soybean practices, farmers also receive a higher value added to their bottom line as a percentage of total soybean value). • It is important that impact measures are standardized and can cut across different use cases in order for impact investing models to scale, but many have very different measures and data; thus, starting with a limited set of core impact measures can help to narrow the scope of financial schemes. • Corporations typically don't invest in impact unless it's equity in a company that brings them business value and that they can then acquire; most corporations will invest in impact through nonprofit foundations or endowments.
Tom Adlam & Edward Isingoma	Palladium/ Team Leader Pearl Capital Partners/ Managing Partner	• The rewards-based token donation model, where investors can get their principal and/or returns back (only if impact targets are achieved) in the form of online tokens that they then must use to re-invest, could mobilize the market of philanthropically minded funders and investors. • Test pilots should be in a market where there is a lot of visibility over pricing, and where commodities have universal value (like coffee, tea or cocoa). • Crop disaster or price insurance programs are becoming a larger impact investing trend and gaining interest in the field. • There is value in measuring outcomes over outputs as actual indicators of change, but there is also potential for scaling output-based projects verified by technology.

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William Jacobsen	Kiva Capital/ Senior Director of Strategic Investments & Investor Relations	• Kiva is a nonprofit organization based in the United States. Kiva operates an online platform that allows individual retail funders to provide interest-free loans to individual borrowers around the world. The loans are interest-free (i.e. individual retail lenders only get back their principal if and when the loan is paid back) and designed for borrowers who other-wise may not have access to traditional financing. • Current loans for borrowers in developing countries go through local field partners (usually microfinance institutions) who then charge interest to the borrowers. Loans in the United States can be provided directly from individual retail lenders to the borrowers (albeit with a higher risk of default). Kiva is currently exploring the possibility of providing loans in developing countries directly to borrowers given the expan-sive data the organization has available to assess credit risk. • Kiva is expanding upon its traditional interest-free loan model through two subsidiaries: 1) Kiva Protocol, which was piloted in Sierra Leone to create digital identities using the blockchain, which helps expand access to financing for people who otherwise wouldn't qualify due to lack of credit information; and 2) Kiva Capital, which is piloting a Refugee Investment Fund for qualified purchasers (not all individual retail investors) that provides financial returns on the loans. Kiva Capital aims to expand this offering to the individual re-tail market in the United States through a charitable issuer exemption. • Kiva can crowdfund their loans from individual retail funders in the United States because the loans only pay back prin-cipal (not financial returns). A zero-interest performance-based impact bond could be feasible in the United States because it doesn't offer financial returns. • Offering impact funders and investors a financial return on their investment (versus just a return of principal) will appeal to a larger group of potential funders and allow for scale. Offering a model where financial returns are contingent on achievement of measurable impact targets is even better, and ultimately is where the impact investing field is headed.

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