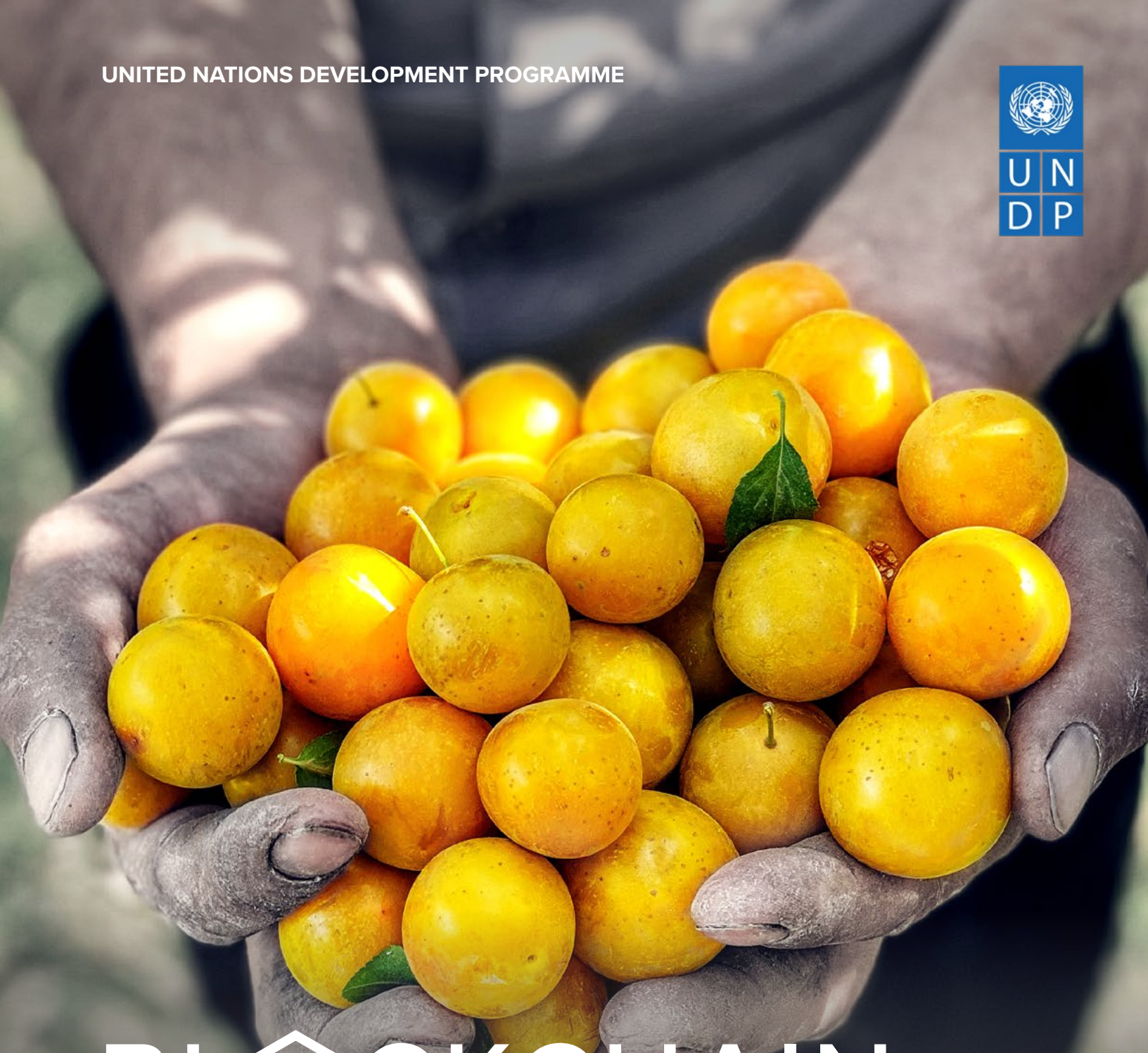
UNITED NATIONS DEVELOPMENT PROGRAMME



BLOCKCHAIN FOR AGRI-FOOD TRACEABILITY

Exploring the Technology's Potential for Sustainable Development

Blockchain for Agri-Food Traceability is a product of the UNDP Global Centre for Technology, Innovation and Sustainable Development, Singapore.

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FOREWORD



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Global agri-food systems need transformation. Almost 80 percent of the world's poor live in rural areas and mostly depend on agriculture for their livelihood. FAO estimated that as of 2018, agriculture directly contributed 17 percent of global greenhouse gas (GHG) emissions, thereby contributing significantly to climate change. Agriculture is also the major cause of environmental degradation and biodiversity loss globally.

Agri-food supply chains are complex and involve a large number of actors—from small-scale farmers, primary processors, and traders to product manufacturers, distributors, retailers, and consumers. This complexity limits farm-to-table traceability, which is key to identify sustainability-related issues in agri-food systems including extreme inequality and poverty, human rights violations, and environmental degradation.

Blockchain—the distributed ledger technology powering cryptocurrencies like bitcoin—is becoming a game-changer for supply chains. Its unique features make it a potent technology to reduce supply chain inefficiencies, enhance trust among diverse stakeholders, and contribute to cost savings. While blockchain's benefits for the private sector are perhaps clearer, its potential for addressing sustainability-related issues in the agri-food sector remains underexplored.

UNDP has been a pioneer in testing and demonstrating the feasibility of blockchain for advancing the Sustainable Development Goals (SDGs) in several agri-food value chains, such as cocoa, coffee, cashmere, and fisheries. To materialise its Strategic Plan 2022-2025, UNDP is invested in developing integrated solutions towards structural and inclusive transformation; blockchain technology is proving to be a key enabler for this objective.

Increased supply chain transparency enabled by blockchain and other digital solutions empowers stakeholders to spot and tackle the complex issues in agri-food sector. But the technology itself is only a piece of a larger puzzled—a common and thorough understanding of contexts, access to digital and stakeholder ownership are fundamental to long-term approaches to tackle inequality, so that no one is left behind.

I hope that this report sheds light on the potential of blockchain-enabled traceability can for value chains. We look forward to hearing your thoughts, ideas and embark together in the systemic transformation of agri-food supply chains to make them more resilient, fair, and inclusive.

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EXECUTIVE SUMMARY

Agri-food systems are under tremendous pressure. By 2050, the world's population is estimated to increase to about 9.7 billion. Feeding it will require increasing current food production by up to 98 percent. However, present agri-food supply chains—from 'farm to fork'—suffer from several inefficiencies and contribute to a number of socioeconomic and environmental problems.

The vast majority of small-scale producers, including smallholder farmers worldwide, often receive only a small fraction of the final market value of their produce. At their worst, inequities like these manifest as extreme poverty among farmers as well as human rights abuses at the farm-level in the form of slavery, child labour, and hazardous work environments.

Current agricultural practices also place undue pressures on the environment. Agri-food supply chains contribute 26 percent of anthropogenic release of greenhouse gases while using 50 percent of Earth's habitable land and 70 percent of freshwater. Moreover, agriculture is the largest contributor to the loss of biodiversity on Earth. In opaque supply chains comprised of a large number of suppliers, inequities and unsustainable practices at the first-mile are often masked.

The integrity of agri-food supply chains is often compromised through food safety incidents resulting from adulteration, dilution, tampering, or counterfeiting. Food fraud results in damages of up to $40 billion annually. Worse, the source of the problem is often not easily identifiable given the opacity of supply chains.

The above issues underline the common challenge of ensuring traceability and transparency in agri-food supply chains. There is growing global demand for sustainably sourced agri-food commodities (e.g., organic, slave free) among consumers, who are often willing to pay a premium for such products if they are convinced of the positive impact of their purchase. There is also growing interest among regulators and policymakers in traceability for ensuring a safe, sustainable, and resilient supply of food.

Blockchain—the technology at the heart of cryptocurrencies like bitcoin—is finding several applications in supply chain management. A blockchain is essentially a decentralised ledger distributed among all actors in the supply chain—unlike centralised databases and enterprise resource planning (ERP) systems controlled and operated by individual actors in siloes. In a blockchain, new transaction records and other relevant information is stored in the form of a 'block' which is cryptographically 'chained' to previous blocks. Once a record has been added to the ledger as a block, it cannot be secretly altered by any single actor. A blockchain is thus immutable and can act as a single source of truth with full data visibility possible for all stakeholders, thereby increasing supply chain efficiency, enhancing trust in the system, and reducing the likelihood of disputes.

These features make blockchain technology valuable for agri-food supply chains. Use of blockchain allows supply chain visibility till the farm-level, which can bring to light several inequities faced by small-scale producers. This visibility also enables upstream actors and policymakers to monitor for deforestation and other environmentally degrading farming activities. In case of detection of food contamination, blockchain-enabled traceability significantly improves the ease of identification and recall of the contaminated batches in the supply chain, immensely reducing costs from loss of sales and harm to human health.

Blockchain also enable 'smart contracts'—a self-executing mechanism embedded in the blockchain through which transactions can be automatically executed once pre-set conditions are met, removing the need for intermediaries. With smart contracts, disadvantaged stakeholders like smallholder farmers can benefit through regularly scheduled payments to support their livelihood. Additionally, transaction information can be securely and transparently shared among stakeholders who become aware of fair payments made to the farmers.

However, a number of important factors must be considered before opting a blockchain-powered supply chain traceability system. For instance, a traditional centralised database for recording transactions might be sufficient in case of relatively simple supply chains comprising of a limited number of actors or where there exist entities that trusted by all supply chain actors who can validate all transactions.

Moreover, implementing an end-to-end traceability system requires participation by all actors in a supply chain—from farmers, cooperatives, and processors to manufacturers, distributors, and retailers. This is often the harder part to manage than the technology itself as it requires careful assessment of the diverse incentives of all stakeholders for participating in a system that promotes transparency. Stakeholder engagement is crucial for aligning expectations and creating mechanisms of consensus building, data governance, and dispute resolution among parties.

Finally, when leveraging the technology for improving developmental outcomes, project managers should ensure that the most disadvantaged stakeholders—often the small-scale producers and smallholder farmers—do not get left behind. A traceability system requires the presence of basic digital infrastructure like internet connectivity and electricity at the first-mile, which might be a challenge in rural areas in developing countries. Also, literacy and digital skills of end-users must be taken into account when designing solutions.



1. TRANSFORMING AGRI-FOOD SYSTEMS

ISSUES WITH CURRENT AGRI-FOOD SYSTEMS

AGRICULTURE IS THE MAIN SOURCE OF INCOME FOR MOST OF THE WORLD'S POOREST PEOPLE, LIVING IN RURAL AREAS ON LESS THAN $1.25 DAILY.

With a projected world population of almost 10 billion in 2050, existing agri-food systems are unable to sustainably meet the nutritional demands of a burgeoning human civilisation.[1] Despite improving productivity in several commodities, the agricultural systems have not delivered in improving nutritional status globally. In order to achieve SDGs, it is imperative to look at agri-food systems holistically, from production, aggregation, and processing to distribution, consumption, and disposal. The sustainable expansion of agri-food systems is impeded by a number of challenges, including the inequity in benefits to small-scale producers, human rights issues, environmental degradation, and concerns on food integrity.

Inequity in the agri-food supply chain manifests in unfair compensation to small-scale producers, including smallholder farmers, at the origin of supply chains. For example, cocoa farmers on average receive only 3 percent of the market value of a chocolate bar.[2] Smallholder agriculture is the main source of income for 70 percent of the world's poor living in rural areas living on less than $1.25 daily.[3] With limited access to market, financing, and insurance opportunities, small-scale producers often rely on middlepersons who carve into their profits. Small-scale producers are also poorly protected against the risks of weather-dependent agricultural production.[4] More and more evidence points

1 Henri Leridon, "World population outlook: Explosion or implosion?" Population Societies 573, no. 1 (2020): 1–4, https://doi.org/10.3917/popsoc.573.0001.

2 Oliver Nieburg, "Paying the price of chocolate: Breaking cocoa farming's cycle of poverty," ConfectioneryNews, July 10, 2014, https://www.confectionerynews.com/Article/2014/07/10/Price-of-Chocolate-Breaking-poverty-cycle-in-cocoa-farming.

3 Nigel Poole, Smallholder agriculture and market participation (Rugby, UK: Practical Action Publishing, 2017), https://doi.org/10.3362/9781780449401.

4 Gerard Sylvester, ed., E-agriculture in action: Blockchain for agriculture (Bangkok: FAO and ITU, 2019), http://www.fao.org/publications/card/en/c/CA2906EN.

FOOD FRAUD RESULTS IN DAMAGES OF UP TO $40 BILLION ANNUALLY.

towards dependencies on markets for daily supply of food and nutritional security for a majority of small-scale producers. In opaque agri-food supply chains comprised of a large number of actors, inequities at the first mile are often masked.

At its worst, extreme inequity may manifest as human rights violations in the form of hazardous work environments and slavery. Children too often suffer from such violations. For instance, 25 percent of children aged 5 to 17 in Peru are being employed as child labour while 63 percent of working children in Philippines are being employed in hazardous conditions.[5] Such cases violate Article 11 of the International Covenant on Economic, Social and Cultural Rights (ICESCR), which protects the rights of everyone to a decent standard of living.[6] Unfortunately, such exploitative conditions remain concealed by the difficulty of monitoring labour conditions and the asymmetric power distribution between large agri-food actors (e.g., corporations) and small-scale producers.

Another problem with current agricultural practices is the undue pressure they place on the environment. The global agri-food supply chain contributes 26 percent of anthropogenic release of greenhouse gases while using 50 percent of Earth's habitable land and 70 percent of freshwater taken from ground or surface water sources such as rivers and lakes.[7] Moreover, agriculture is the largest contributor to the loss of biodiversity. A 2021 Chatham House report identified agriculture alone as the threat to 86 percent of all species at risk of extinction.[8]

With increasing consumer awareness about various environmental problems including the climate crisis, agri-food systems are increasingly under pressure to monitor and reduce their environmental impacts incurred during various supply chain operations. With growing concern on GHG footprint, it is important for agri-food systems to transition towards sustainable practices and tighter supply chains.

Finally, the integrity of agri-food supply chains is often compromised through food safety incidents. Stakeholders in the agri-food supply chain may intentionally or unintentionally alter the food distribution process—through adulteration, dilution, tampering, or counterfeiting—compromising the quality and safety of food. Food fraud results in damages of up to $40 billion annually.[9] Worse, the source of the problem is often not easily identifiable.

For instance, a foodborne outbreak caused by the Shiga toxin-producing E. coli was detected in Germany in 2011. Multiple lengthy investigations had to be conducted to determine the culprit—fenugreek seeds from Egypt. 50 people lost their lives and more than 4,000 fell ill. The incident caused the food industry in the European Union (EU) $1.3 billion. A ban on import of fenugreek seeds along with 15 other food products from Egypt cost the country about $4.2 billion.[10]

EXPLOITATIVE CONDITIONS REMAIN CONCEALED BY THE DIFFICULTY OF MONITORING LABOUR CONDITIONS AND THE ASYMMETRIC POWER DISTRIBUTION BETWEEN LARGE AGRI-FOOD ACTORS AND SMALL-SCALE PRODUCERS.

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