

# Rebuilding trust with tamper-proof traceability in supply chains

November 2024



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# 1 Introduction

India has emerged as the fifth-largest economy in the world. International trade has played a key role in fuelling India’s economic growth, with the share of merchandise and services in India’s gross domestic product (GDP) increasing from 15% in 1980 to 46% in 2023, making supply chain a crucial part in any organisation or industry.<sup>1</sup>

The Indian supply chain management market was approximated at **USD 3.4 billion** in 2023.<sup>2</sup> The market is projected to expand at a compound annual growth rate (CAGR) of **11.1%**, reaching **USD 6.4 billion** by 2030. Other sectors such as healthcare, IT and software services have a similar CAGR, ranging **between 10–12%**.<sup>3</sup>

Supply chains – which are traditionally designed for cost, time and quality optimisation – are experiencing disruption due to environmental risks, regulatory changes, technological advancements, demand fluctuations, labour disputes and logistics issues. Several regulations have thus come into effect, mandating companies to bring transparency into their operations to help them combat these challenges.

For example, the German Supply Chain Act, which previously applied to companies with at least 3,000 employees, now (in 2024) applies to companies with more than 1,000 employees.<sup>4</sup> Moreover, the EU’s Corporate Sustainability Reporting Directive (CSRD) will require non-EU companies with subsidiaries in the EU to audit the impact of their corporate activities on the environment and society from 2025 onwards. Given these developments, companies across all industries are reshaping their supply chains to be more regulatory compliant.

There are several challenges in supply chain processes such as ensuring transparency, traceability and sustainability which arise due to the involvement of multiple stakeholders and intermediaries. Counterfeiting is also a major concern under supply chain which needs to be addressed, as it undermines product integrity and trust. Moreover, lack of automation in supply chains leads to inefficiencies and errors. Therefore, addressing these issues requires technological integrations, coupled with robust regulatory oversight.



1. <https://www.pwc.in/assets/pdfs/viksit-v1.pdf>
2. <https://www.forbes.com/sites/daveevans/2024/05/20/indias-rise-in-the-global-supply-chain/>
3. <https://www.financialexpress.com/business/industry-india-as-the-rising-giant-in-the-supply-chain-industry-emerging-opportunities-and-challenges-3536812/>
4. <https://www.csr-in-deutschland.de/EN/Business-Human-Rights/Supply-Chain-Act/FAQ/faq.html>



## 2 The need for tamper-proof traceability across the supply chains of different industries

### Textile industry

The Indian textile and apparel market size was estimated to be around USD 165 billion in 2022, with the domestic market constituting USD 125 billion and exports contributing USD 40 billion.<sup>5</sup> Organic produce and exports of textiles require tracking of provenance and verifiability of the conditions of production.

#### Important regulations and guidelines

- **Guidelines from the Agricultural and Processed Food Products Export Development Authority (APEDA):** APEDA outlines the standards and procedures for the export of agricultural and processed food products from India to ensure quality and compliance with international regulations.
- **Textile Fiber Products Identification Act (TFPIA), US:** The Textile Fiber Products Identification Act (TFPIA) in the US mandates accurate labelling of textile products, including fibre content, manufacturer information and country of origin, to protect consumers and ensure transparency.
- **Regulation (EU) no. 1007/2011:** Regulation (EU) No. 1007/2011 standardises the labelling and marking requirements for textile products within the EU to ensure consumers receive accurate information about the fibre composition.

### Pharmaceutical industry

Counterfeiting of drugs is a major problem in the industry, which has resulted in regulatory authorities establishing strong regulations on quality compliances. This means that drugs need to be tracked and traced diligently throughout the supply chain.

#### Important regulations and guidelines

- **Drug Supply Chain Security Act (DSCSA), US:** This act establishes requirements for the traceability and verification of prescription drugs throughout the supply chain to enhance drug safety and prevent counterfeit medications.
- **Guidelines on good distribution practices for pharmaceutical products by Drug Controller General of India (DCGI):** DCGI guidelines outline the standards for the storage, transportation and distribution of pharmaceuticals to ensure their quality and integrity throughout the supply chain.
- **Regulation (EU) 2016/161:** Regulation (EU) 2016/161 mandates safety features, such as unique identifiers and anti-tampering devices, on the packaging of certain medicinal products for human use within the EU to prevent counterfeiting and ensure supply chain integrity.

5. <https://www.investindia.gov.in/sector/textiles-apparel>



## 2 The need for tamper-proof traceability across the supply chains of different industries

### Gems and jewellery

Upcoming regulations will impose more stringent restrictions around the procurement and processing of precious stones such as diamonds from conflict and war-affected regions of the world. Therefore, there is a strong need to prove the origins of diamond and precious stones to comply with these regulations as they differ across borders and circumstances.

#### Important regulations and guidelines

- **G7 Diamond protocol:** The G7 Diamond Protocol refers to a set of guidelines and best practices established by the G7 countries to enhance transparency, traceability and ethical sourcing in the diamond supply chain, aiming to prevent conflict diamonds from entering the market.
- **Kimberley Process Certification Scheme (KPCS):** The Kimberley Process Certification Scheme (KPCS) is an international initiative that aims to prevent the trade in conflict diamonds by ensuring that diamond shipments are certified as conflict-free through a rigorous system of controls and documentation.
- **EU Conflict Minerals Regulation (Regulation (EU) 2017/821):** This regulation mandates due diligence and transparency requirements for EU importers of tin, tantalum, tungsten and gold to ensure these minerals are sourced responsibly and do not finance armed conflicts.

### Automotive

There is a strong push for circularity in the industry, together with regulatory compliances around ensuring traceability of auto parts.

#### Important regulations and guidelines

- **Automotive Industry Action Group (AIAG) Standards, US:** The AIAG Standards in the US establish guidelines and best practices for quality, supply chain management and business processes within the automotive industry to enhance efficiency, safety and interoperability.

- **ISO/TS 16949:** ISO/TS 16949 is an international quality management standard specifically designed for the automotive industry, focusing on continuous improvement, defect prevention and reduction of variation and waste in the supply chain.
- **European Union Deforestation Regulations (EUDR):** EUDR requires the automotive industry to ensure that rubber and other raw materials used in manufacturing are sourced from supply chains free from deforestation and forest degradation, promoting environmental sustainability.

### Fast Moving Consumer Goods (FMCG)

Consumer safety is one of the primary concerns in the FMCG industry. Regulations across the globe require traceability of products, especially food products, and non-compliance to these can have an adverse impact on the margins.

#### Important regulations and guidelines

- **EU Regulations 178/2002:** This regulation in the EU requires traceability of food and feed products throughout the supply chain.
- **US Food Safety Modernization Act (FSMA):** Businesses are required to maintain traceability records for certain designated foods with the objective of identifying and removing contaminated food from the market.



# 3 Reinventing supply chain using blockchain technology

Supply chains using blockchain technology can address numerous challenges faced across industries, such as inefficiencies, lack of transparency, fraud, and difficulties in tracking and verifying the provenance of goods. These issues can reduce trust among stakeholders. Blockchain technology can resolve these by recording each transaction in a decentralised and immutable ledger. This feature also ensures transparency, as all concerned stakeholders can view and check the same data in real time. Furthermore, agreements between stakeholders can be automated using smart contracts in order to reduce the risk of fraud and errors. The immutable nature of blockchain records also ensures provenance that can be traced correctly, thus enhancing trust and accountability across the supply chain.

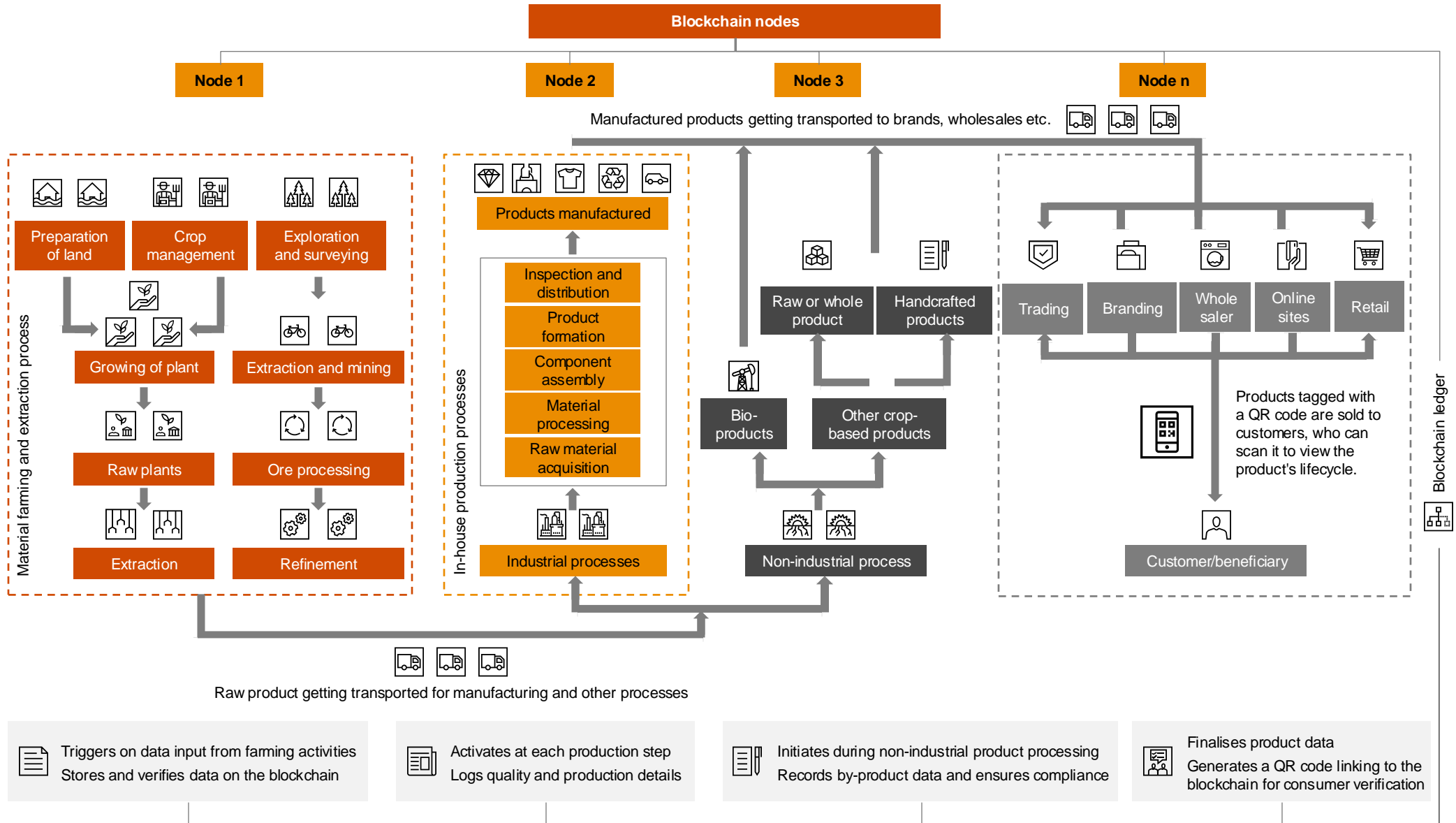
**Table 1: Blockchain accelerators solving supply chain challenges**

Challenges/Blockchain features	Immutability	Decentralisation	Digital threading	Digital identity	Automation (smart contracts)	Encryption
Data in disparate systems		✓	✓			
Security and privacy of shared data						✓
Manual work and inefficiencies					✓	
Visibility in supply chain		✓	✓	✓		
Sustainability	✓		✓	✓	✓	
Regulatory compliance	✓		✓	✓		
Risk of counterfeiting	✓	✓	✓	✓		



# 4 Blockchain-enabled supply chain for traceability

Figure 1: High-level architecture of blockchain-enabled supply chain



## 4 Blockchain-enabled supply chain for traceability

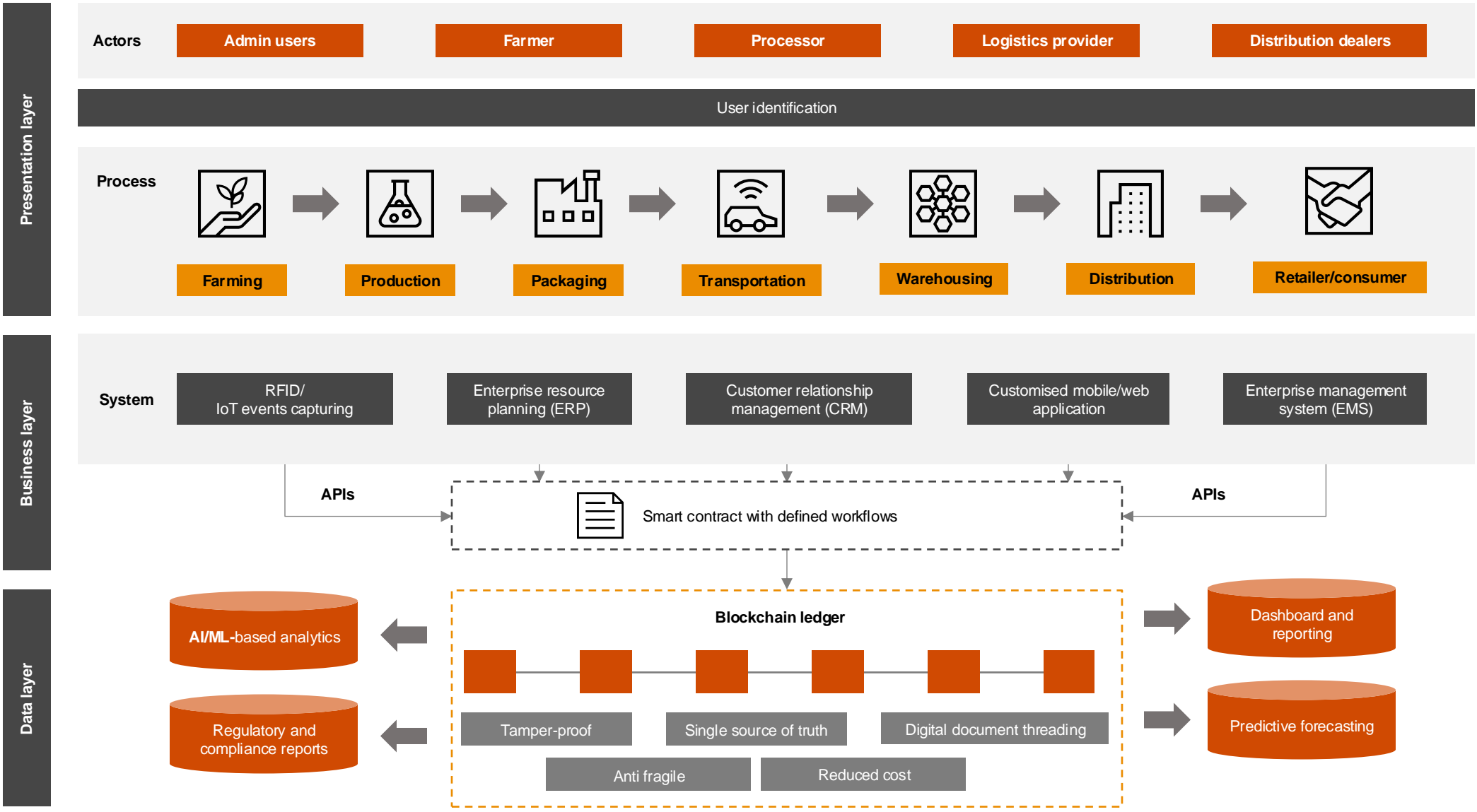
- Supply chains comprise the flow of multiple materials and goods while involving multiple tiers of suppliers. At each stage, one can expect the aggregation (many to one), distribution (one to many) or transformation of products. Each of these suppliers have siloed information systems with very limited visibility across other supply chain participants.
- This information asymmetry can be solved by the blockchain ledger, which acts as an information highway connecting the disparate systems of each of these participants.
- Smart contracts at each stage capture the data related to the product, location, conditions etc., and record that on the blockchain.
- At each stage of the supply chain, the details of the materials used to produce the transformed product are digitally threaded using blockchain. Regulators and consumers can therefore verify the origin of the raw materials and details of the product transformations.





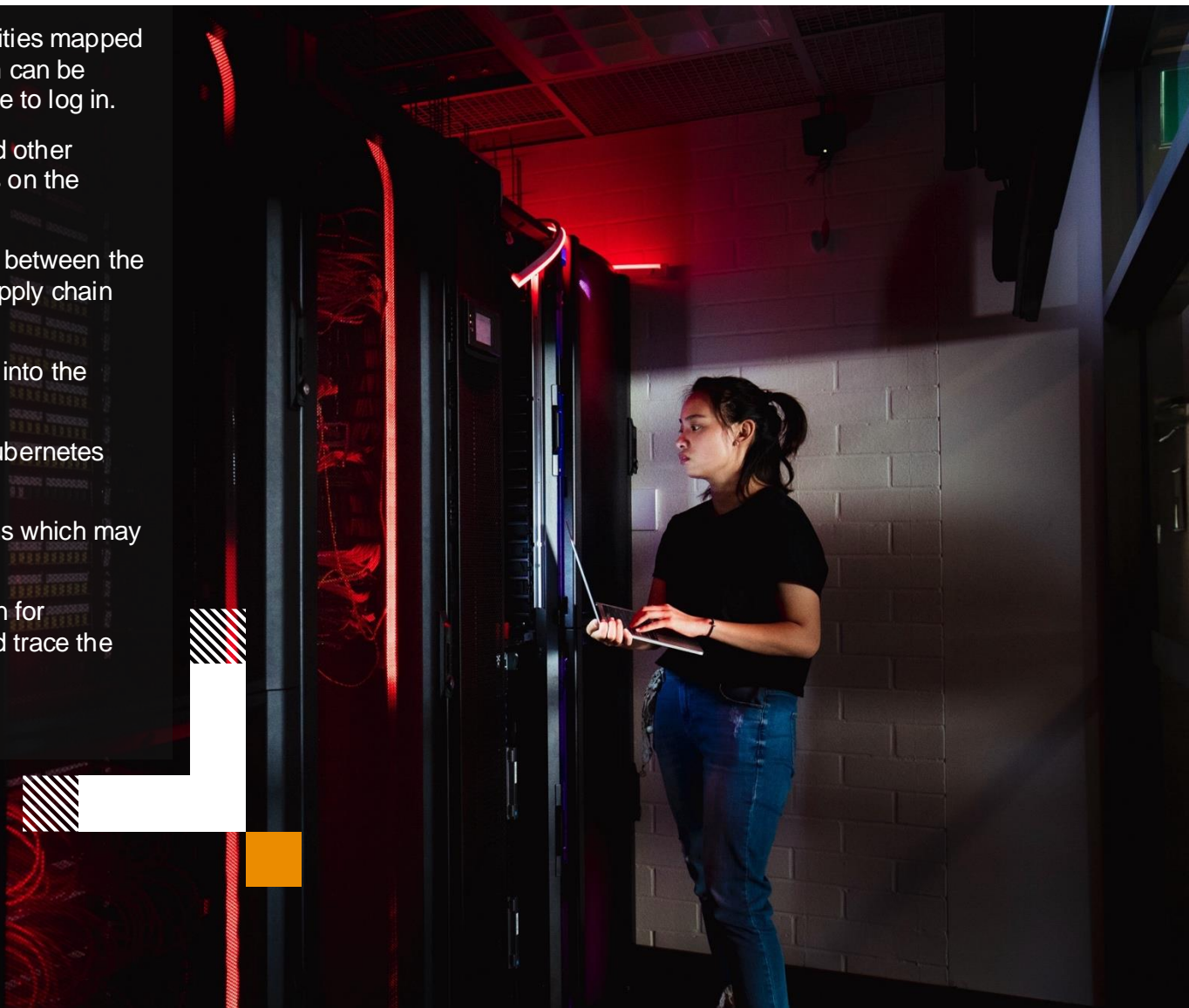
# 5 Emerging technologies' triad for supply chain traceability

Figure 2: Supply chain traceability and emerging technology triad (illustrative agro supply chain)



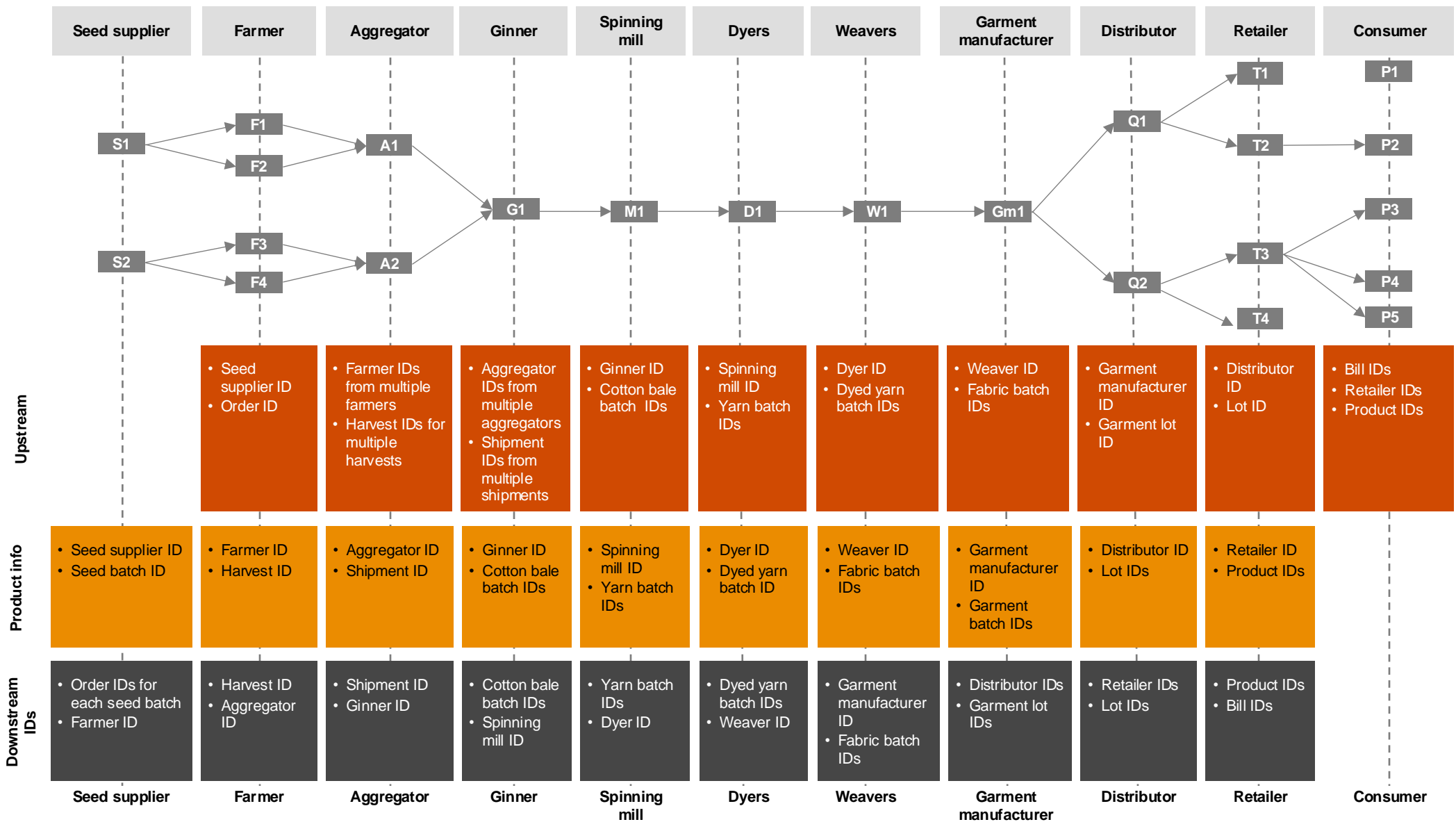
## 5 Emerging technologies' triad for supply chain traceability

- Every actor across the supply chain will have digital identities mapped to the blockchain infrastructure, using which each of them can be identified, irrespective of the systems the stakeholders use to log in.
- The business logic layer consisting of smart contracts and other functions can exist in the docker container-based clusters on the cloud/on-prem service infrastructure.
- The blockchain ledger will act as the information highway between the individual IT systems and IoT devices used by various supply chain actors integrated with the ledger.
- The ledger and its functions can be owned and managed into the cloud/on-prem infrastructure.
- The core blockchain layer will be developed in multiple kubernetes clusters to scale and orchestrate the system.
- Information from blockchain can be fed into AI applications which may result in more accurate analysis and predictions.
- Compliance reports can be generated from the blockchain for regulatory authorities who can use it to verify the data and trace the entire product journey.



# 6 Digital threading of information across the supply chain

Figure 3: Digital threading of information across the supply chain (illustrative textile supply chain)



# 6 Digital threading of information across the supply chain

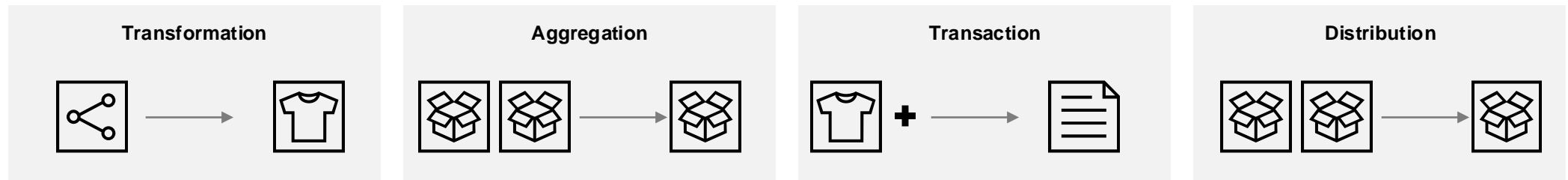
The IDs at each stage in Figure 3 are linked to the data in Figure 4 which applies across any type of event occurring in that stage.

**Figure 4: Data and events to be captured on blockchain**

Data				
When	Where	Who	Why	What
<b>Date time</b>	<b>Location</b>	<b>Party</b>	<b>Business step</b>	<b>Object</b>
Order date, order expected date, invoice date	Source/destination address, shipment description, mode, geocode (latitude, longitude)	Buyer name, supplier name, address, profile, certificates	Order placement, shipment, audit, tracer test, tag request	Product name, description, lot number, blend percentage, metres per gram, grams per square metre, grams per linear metre
				<b>Event element</b>
				Quantity, input quantity, output quantity, unit of measure, loss calculations



## Events



# 7 Principles for shared ledger to complement existing systems

## Scalability

Scalability considerations should be made for both horizontal and vertical scaling to onboard multiple parties and to adopt multiple use cases. The architecture should be scalable enough to cater to the above requirement to execute transactions involving multiple supplier partners in an efficient manner.

## Extensibility

Blockchain implementations should be extensible and cater to any future requirements of integration with any other IT system. The architecture should allow for easy integration with external systems in order to onboard new stakeholders, as and when needed.

## Usability

The front-end portals for the blockchain solutions should focus on simple UX design, be compliant with the guidelines, and should be reusable and modular. Intuitiveness and simplicity should be prioritised so that end users are able to use the application easily, irrespective of their digital literacy levels.

## Security and privacy

Security of the blockchain-based system which contains confidential data of multiple value chain partners and operational data should be ensured while building such an infrastructure. Moreover, supplier partner information should be private and only have limited visibility according to the requirement with respect to supply chain tracking.

## Availability

As the system will be accessed by multiple parties throughout the year, considerations should be made for all time availability of the system, which may be ensured by the cloud-agnostic, Kubernetes cluster-based architecture design.

## Agility

The architecture of the solution should help quicken the verification and validation of the contracts. Agility in the transactions, storage, workflows and processes needs to be considered while re-engineering the system on blockchain infrastructure.

## Modularity

Modularity will help in ensuring better maintainability of the blockchain application and infrastructure in the long run. Modularity of a solution will also help in future upgrades and enhancements in specific functional layers in a seamless and efficient manner.

## Interoperability

The blockchain solution should be capable of integrating seamlessly with the enterprise resource planning (ERP) of the various value chain partners and relevant external entities. Consideration for interoperability through the provision of REST APIs and web services should be made.



## 8 Way forward and key takeaways

Web 3.0 can enhance the trust and transparency in the traceability of cross-sector global supply chains. It can potentially integrate with the existing applications and complement the existing processes for tamper-resistant verifications in real time.

- Web 3.0 has proven itself to be an impactful technology in solving problems related to the supply chain of various industries such as retail and fast-moving consumer goods (FMCG), semiconductors, oil and gas, consumer healthcare, and electrical and mechanical equipment. Solutions that enhance the visibility of supply chain networks and ensure a tamper-proof record of transactions will foster an environment of trust and improve the ease of doing business.
- Regulation and compliance changes made by the governments of different countries or reputed organisations must be incorporated by industries, which have the responsibility to cross-verify and report on their adherence. These are very important factors that need to be taken care of by every industry and their supply chain network. Due to its immutability and consensus-based record-keeping mechanism, blockchain can become an essential tool, allowing industries to smoothly adopt regulatory changes in their domain. Blockchain provides a robust methodology for adopting these changes and provides a mechanism for generating reports with very high accuracy and reasoning.
- Companies' supply chain units constantly face significant problems that they cannot seem to resolve. A few years ago, several major industries faced the challenge of supply chain disruption. It was a major setback for industries whose businesses depended solely on the supply chain network. Blockchain has the capability to create a bulk of accurate and tamper-proof datasets that will be valuable and relevant in accordance with the industry segment. This will help in making frameworks related to demand planning and preparing risk and mitigation strategies that will prove to be effective techniques in tackling these disruptions beforehand – to a considerable extent.

### Takeaways

- The implementation of blockchain can fix the lack of visibility and enhance traceability in complex, multi-tier supply chains.
- The verifiable and immutable digital thread of data created by blockchain can prove the adherence of regulations to authorities.
- The traceability established by blockchain can improve the brand image of the firm, attracting customers who are keen on sustainability and quality. This will also generate investors' trust and alleviate the concerns of greenwashing.



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