Blockchain for trade facilitation

A user implementation guide for Governments

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Executive summary

The implementation of blockchain technology for the purpose of facilitating international trade is a major initiative that involves multiple stakeholders and encompasses several steps. Coordination among stakeholders within the trade ecosystems of countries is thus key. Blockchain could simplify the administrative and procedural functions of public trade agencies, improve traders' experiences and bring noticeable efficiency gains in Governments' trade processes. However, implementation requires careful planning, design and deployment to meet multiple stakeholder needs, specific use-case requirements, international best practices and compliance standards; to ensure interoperability with existing legacy systems; and to allow for future technical reforms of the trade infrastructure.

The present guide is a multi-stakeholder document for Governments who have an interest in developing blockchain-based systems of their own for trade facilitation purposes. Comprising seven sections, the guide sets out key technical, policy and regulatory steps for implementing the technology. Part one presents the objectives of the guide and a technical overview of blockchain implementation processes. Part two details how a blockchain needs and readiness assessment can be undertaken to identify trade measures that could lead to efficiency gains and to establish a country's readiness to implement blockchain. Part three focuses on technical implementation guidelines. It outlines the practical steps of the implementation process; discusses planning and design, testing, and forward and backward integration frameworks; and presents a technical work breakdown structure that meets international standards. Part four addresses the policy dimension, primarily focusing on stakeholder dynamics. It touches on both inter-agency and intra-agency coordination mechanisms, as well as the process of building appropriate implementation teams for a successful and sustainable blockchain infrastructure. Part five sets out the regulatory steps of the implementation process that should guide any Government's regulatory framework design. Part six presents sample use-cases, key implementation considerations and common challenges faced by blockchain implementing bodies. Finally, part seven concludes the guide and outlines technical, policy and regulatory recommendations.

Coordination among stakeholders within the trade ecosystems of countries is thus key.

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Introduction, objectives and the implementation process

CHAPTER 01

A Introduction

Trade revenue still constitutes a significant source of income for many developing country Governments.

The streamlining, simplification and general improvement of trade processes has long been acknowledged as a significant driver of efficiency at national borders. These processes, and the use of modern technology within them, are considered key factors in the reduction of the time and cost of trading in most countries. However, developing countries – and sometimes their developed counterparts – face many challenges in streamlining trade processes using emerging technologies. While this is sometimes due to technical and regulatory difficulties, challenges can also arise from the sheer speed of change within the global trade landscape, lack of technical expertise and resource constraints. Many trade procedures still lack the required simplicity, transparency, compliance and quality assurance that could support traders, sustain Government revenue, broadly reduce the time and cost of trading, and improve the overall trader experience.

Furthermore, trade revenue still constitutes a significant source of income for many developing country Governments. But new developments, such as the proliferation of cross-border e-commerce, have presented new challenges on compliance, quality controls and revenue collection. At the same time, new technologies such as blockchain could assist Governments to improve their overall trade processes, while helping to specifically deal with emerging challenges arising from high-volume, low-value trades driven by e-commerce. This could improve overall trade compliance and prevent potential revenue leakages.

Cross border trade is becoming a mix of bulk containerized shipments and high-frequency e-commerce – individual items that cross borders at ever higher volumes— making the current trade landscape complex and trade compliance assurance difficult for Governments. Consequently, new technologies are required for Governments to successfully ensure quality controls, manage trade risks and sustain trade revenue. Digital technology – in the form of trade portals, trade reform trackers and single windows – already helps many Governments in significant ways, and blockchain has powerful capabilities that could further empower Governments to build infrastructure resilience, secure their paperless trade endeavours and smoothly process all forms of trade flows, whether bulk containerized trade or e-commerce.

The primary technical features of blockchain – such as hash functions, timestamps, smart contracts and default encryption – are well-suited to various trade processes, including risk management, post clearance audits, data protection and process automation. More on the critical features of blockchain and how they can support Governments' trade facilitation efforts is elaborated in the Global Report on Blockchain and its Implications on Trade Facilitation Performance, published by the United Nations Conference on Trade and Development in 2023.

Blockchain is a relatively nascent technology that is considered complex. But there is already prevailing scepticism around the potential returns on investment, and this is coupled with a lack of insight into the proper implementation procedures. There are also general resource

constraints around the expertise and funding needed to undertake these implementation processes. Thus, several Governments are not yet investing in building the technology, the technical expertise required, the regulatory environment or stakeholder preparedness to be able to implement it in their trade processes. Leveraging the technology's capabilities to facilitate trade will require most Governments to put in place a number of regulatory, technical and policy measures for successful implementation and sustainable use. The potential of blockchain for the new age of cross-border trade, however, remains compelling, albeit with some challenges. Challenges exist around the legal and regulatory frameworks, technical incompatibilities with legacy infrastructure, scalability limitations of the technology, data privacy and security concerns, shortage of appropriate talent and expertise, user acceptance difficulties, resource constraints and cost concerns. Both developed and developing countries need to resolve these policy and technical challenges in order to achieve success in the implementation process as well as optimal use of the technology.

According to a joint survey by the World Customs Organization (WCO) and the World Trade Organization (WTO) in 2022, blockchain technology has already drawn the attention of several Governments, with 19 per cent of customs authorities exploring the technology's potential through a proof of concept, 14 per cent testing solutions through pilot projects, and 24 per cent planning to explore its potential within the next three years.

B Objectives

Existing guides about blockchain implementation are generally broad in scope and lack specificity and depth in terms of practical steps for implementing the technology. Thus, the present guide aims to:

Give Governments a framework for the successful and sustainable implementation of blockchain-supported trade facilitation ecosystems.

Present implementation steps, a stakeholder engagement approach, and technical and regulatory requirements for the implementation of blockchain for trade facilitation.

Outline the development, deployment and adoption process of blockchain for trade facilitation.

Outline areas where blockchain can bring potential value and efficiency gains in trade in terms of quality, controls, compliance, security and infrastructure resilience.

Provide technical details on complementary workflows that can accompany the implementation of blockchain for optimal utility of the technology.

Outline the technical implementation options available to Governments as well as the technical and regulatory trade-offs of all implementation considerations.

Provide use-case scenarios and implementation considerations in accordance with international standards.

Provide measures for ensuring backward and forward integration with existing and future trade infrastructure.

Delve into the processes and requirements of undertaking blockchain needs and readiness assessments for trade facilitation.

C
Understanding blockchain

Blockchain is a digital database that holds information in a secure and distributed manner with numerous copies saved on many machines. While this creates redundancy, it also increases the resilience of applications built using the technology. The functional security, resilience and reliability of the applications deployed on blockchain are ensured by the strength and dependability of the blockchain itself. They are generally considered shared, immutable databases that facilitate the process of keeping records and tracking these records in real-time and in a shared environment, and thus they can build a trustworthy service in a not necessarily trustworthy environment (Clavin and others, 2020). Stakeholders in a blockchain keep servers/nodes and use them to validate and store data in the form of block-type data structures while inter-stakeholder coordination generates and updates the data through consensus algorithms and the security and integrity of the data is ensured through encryption (Lu, 2019). The code that runs and establishes a blockchain between the many different stakeholder computers ensures security by making unauthorized entries on the ledger very difficult and tampering nearly impossible (Green, 2022). These technical features and functionalities of the technology make blockchain particularly useful for certain Government and industry use-cases, such as supply chain management, trade processing, automation, record keeping, quality assurance, compliance and data protection.

Key features of blockchain that can add value and yield efficiency gains in terms of trade facilitation are summarized in table 1.

Table 1. Key features of blockchain and their use-case suitability in trade facilitation

Blockchain features	Use-case suitability within trade
Data encryption	Data exchange among key stakeholders. User data and identity protection. Compliance and audits of key authorizations. Fraud detection, forgery prevention and counterfeit elimination. Prevention of unauthorized stakeholder activities.
Timestamps and hash functions	Creation, verification and acceptance of originals and electronic copies of trade documents. Detection of intellectual property theft and substandard goods. Preservation of data integrity. Detection of damaged or expired goods. Tracking and tracing of supply chains and goods' life cycle.
Multiple storage of data and records	Resilience of digital trade infrastructure. Preservation of critical trade data in extreme cases, such as natural disasters. Business continuity during system outages, cyberattacks or data breaches.

Source: Compiled by ESCWA.

The Trade Facilitation Agreement and blockchain technology

The Trade Facilitation Agreement (TFA) of the WTO not only sets out obligations for countries to undertake necessary trade reforms but also serves as a key global technical and legal structure that provides significant guidance to countries looking to reduce the cost and time to trade, enhance their competitiveness and reach trade revenue targets. Digital technologies such as trade portals, single windows and reform trackers are generally implemented in the context of TFA provisions and have helped many countries meet TFA obligations. Harnessing the key technical functionalities of blockchain could help countries towards their TFA ambitions as well. Table 2 presents some of the functionalities of blockchain that are relevant to TFA provisions.

Table 2. Blockchain functionalities relevant to the Trade Facilitation Agreement

TFA Provisions	Relevant blockchain functionalities
Article 1: Publication and Availability of Information	Distributed data redundancies protect key data and make them available to key stakeholders.
Article 7: Release and Clearance of Goods	Secure encrypted payment, secure storage and transfer of data, and the immutability of data in storage and in transit can expedite declarations and release of goods.
Article 7.1: Pre-arrival Processing	Secure transfer of trade declarations, documents and information within and across borders could support pre-arrival processing.
Article 7.2: Electronic Payment	Secure and encrypted payment rails on blockchain represent one of the most common uses of blockchain in finance.
Article 7.4: Risk Management	Data encryption, hash functions, timestamps and encryption can prevent falsification, alterations and corruption, while enhancing compliance and risk management.
Article 7.5: Post-clearance Audit	Hash functions, timestamps and encryption can prevent falsification and alterations, support the checking of authorizations and protect records.
Article 7.7: Trade Facilitation Measures for Authorized Operators	Certifications, identifications and declarations can all be secure and provisioned by the blockchain database.
Article 7.8: Expedited Shipments	Availability of information, elimination of cumbersome in-person processes and creation of paperless processes through a shared blockchain database can promote expedited shipment.
Article 8: Border Agency Cooperation	Distributed and secure shared databases of blockchain can enhance cooperation among key stakeholders at the border.
Article 10: Formalities Connected with Importation, Exportation and Transit	Digitalization and automation of processes by smart contracts and other blockchain features can help cut the time and cost of formalities for importers, exporters and transit processes.
Article 11: Freedom of Transit	Blockchain databases that allow for cross-border data harmonization, controls and data sharing can improve trade in transit.
Article 12: Customs Cooperation	Distributed shared databases of blockchain make cooperation among key stakeholders, especially across borders, easier than proprietary closed systems.

Source: Compiled by ESCWA.

D
Overview of the implementation process

The complexity of implementing blockchain is a common disincentive for the adoption and use of the technology. At the same time, a technical understanding of the technology shows that it is more resilient than conventional computer networks. It also has several parallels with legacy technologies such as cloud computing and other mesh networks. The distinction lies in blockchain's primitives – in other words, the security protocol components – reliability guarantees and technical architecture. While it is currently limited in storage capacity and processing speed across a number of computational indicators, the security, transparency, resilience, quality assurance, auditability and improved compliance of blockchain, as well as its ability to protect process continuity, make it particularly useful for certain trade facilitation purposes. As a decentralized technology by default, blockchain usually presents several implementation challenges for centralized entities like Government, especially in relation to design and architecture.

The present sub-section of the guide briefly presents technical, policy and regulatory implementation options and considerations. To build a blockchain system that meets international standards and ensures that Governments get the most value from this digital infrastructure, the following aspects need to be understood:

A

The areas of need and level of readiness for the technology

B

The implementation options

C

The technical trade-offs of implementation considerations

D

The steps required to build suitable stakeholder dynamics

E

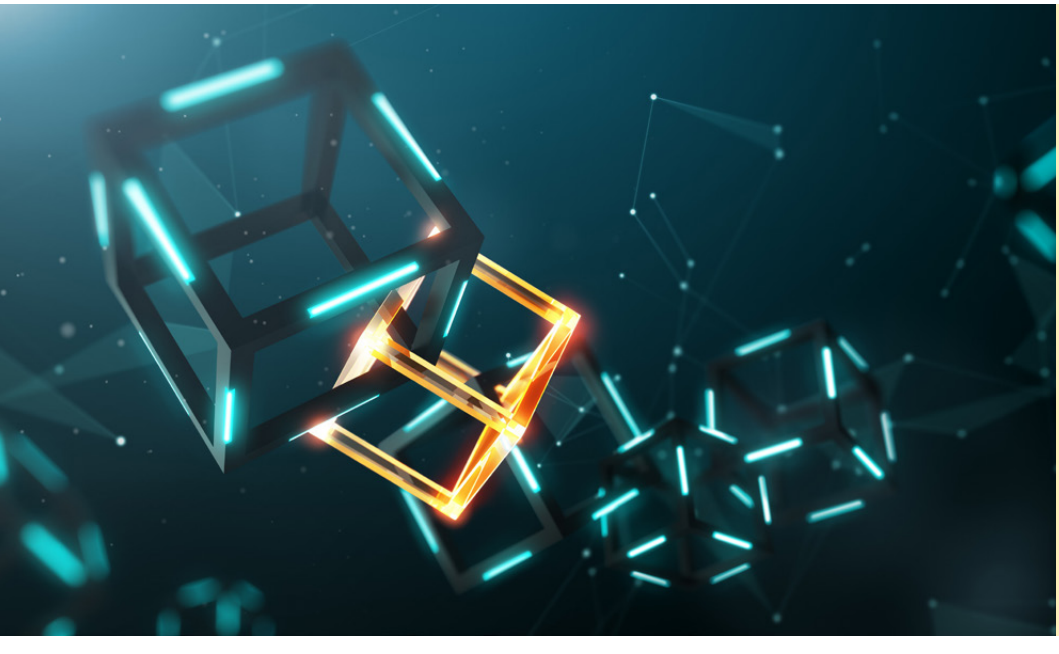
The process of achieving regulatory and legal compliance

Blockchain usually presents several implementation challenges for centralized entities.

Thus, the three broad considerations in implementing blockchain technology to support Government trade processes comprise architectural design, stakeholder coordination and regulatory compliance. Once a Government has determined that it needs a blockchain-based system for certain trade processes after undertaking a needs assessment and has ascertained the country's preparedness for the implementation of the technology through a readiness assessment, the Government's implementing body must make important decisions around technical considerations, options and trade-offs in relation to the system's design and architecture and the governance of the implementation process. Alongside this, a policy and regulatory environment that will support the implementation process must be built.

Technical design choices will largely consider trade-offs around sovereignty, security, performance, feasibility, reliability, value addition and sustainability. These technical choices may also influence some aspects of the policy and regulatory choices. Some of the key questions for the implementing body to consider include:

- What kind of blockchain should be used for trade facilitation applications? Should a public permissionless blockchain be used or should the Government deploy its own private, sovereign blockchain?
- What are the cost considerations of these design options?
- If the Government wishes to deploy its own private blockchain, would it be feasible, reliable and sustainable in the context of existing infrastructure and the regulatory and policy environment or would some adjustments be needed?
- What policy, regulatory and infrastructure adjustments or overhauls would be needed in the existing environment for the technology to function optimally?
- If the Government chooses to build trade facilitation applications on a public permissionless blockchain network, would the Government be prepared to give up sovereignty and control over certain trade data?
- What kind of public permissionless blockchain systems already exist that could be well-suited to the envisaged trade facilitation use-case, if any?



Technical design choices will largely consider trade-offs around sovereignty, security, performance, feasibility, reliability, value addition and sustainability.

These considerations are elaborated in table 3.

Table 3. Considerations for choosing the type of blockchain for trade processes

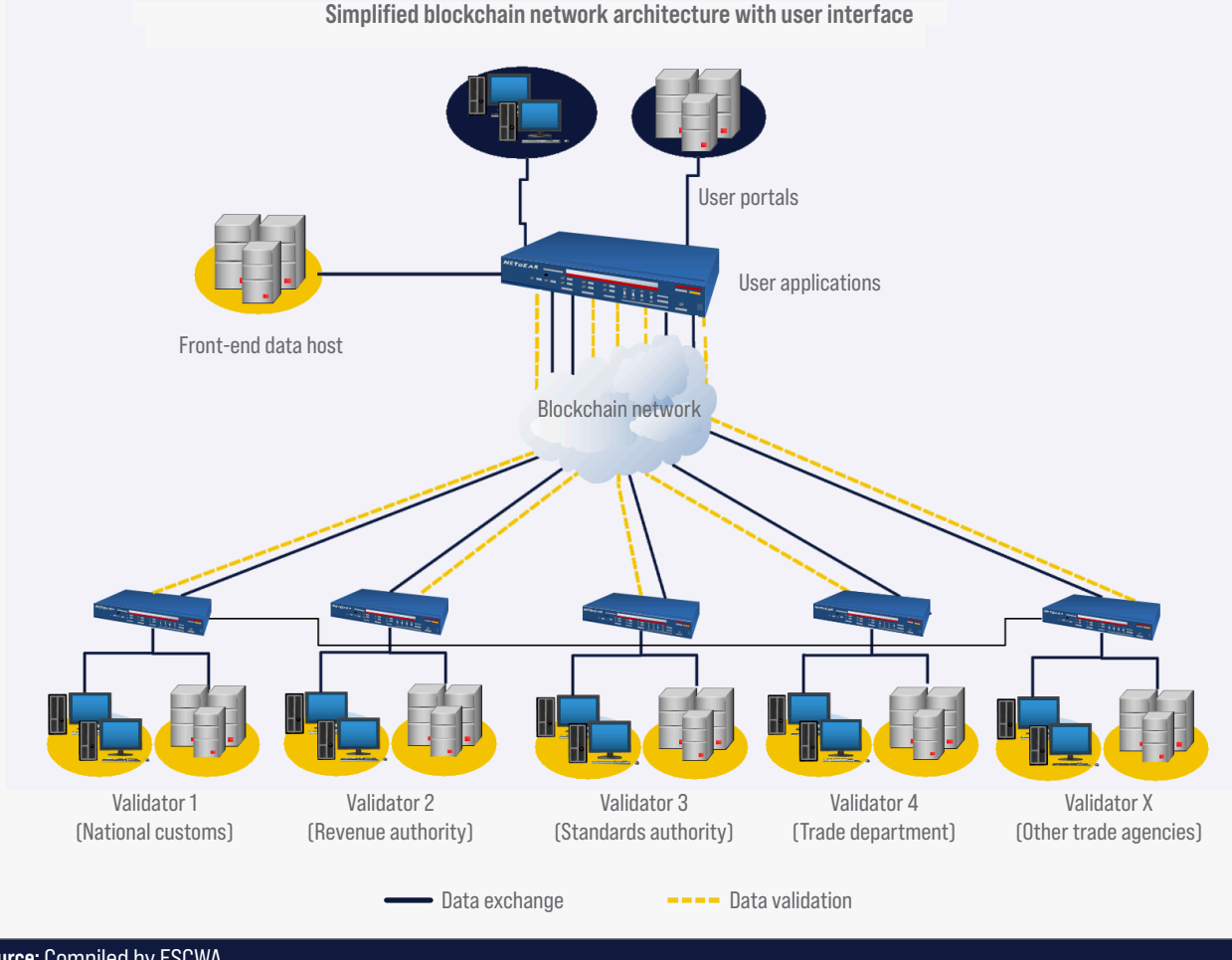
Considerations	Building on a public blockchain	Building on a shared permissioned blockchain/ consortium chain	Building on a private blockchain
Implementation	Involves building only the business logic and applications on top of an existing blockchain.	Involves building the business logic, applications and portals the Government may choose to support the infrastructure by building a server/node.	Involves building a full blockchain, as well as the business logic and the applications on top of the blockchain.
Cost	Involves costs for application and transaction costs for recording data on the blockchain.	Involves cost of hosting front-end data as well as operational development of business logic. Government may add cost of supporting the infrastructure with nodes/servers.	Involves infrastructure costs for maintaining servers/nodes and running the blockchain, as well as costs for the accompanying applications and portals.
Maintenance	Maintenance only required for the applications and business logic on top of the blockchain.	Maintenance may include applications and business logic as well as network infrastructure such as servers/nodes.	Maintenance and updates is required for the whole blockchain as well as for the process logic and applications.
Sovereignty	The implementing body would not have full sovereignty over the infrastructure.	The implementing body may has medium level of sovereignty over application logic and use-case but does not have full sovereignty over network infrastructure.	The implementing body controls the network and holds full sovereignty over the infrastructure, data and usage, depending on where the blockchain servers are hosted.
Security	Offers higher security due to global reach, permissionless systems and broad decentralization.	Offers a medium level of security. Not as secure as public permissionless blockchain but more secure than private blockchain networks	Offers lower security due to limited decentralization.
Flexibility	Offers limited flexibility on scaling, speed and adjustments.	Offers medium level of scalability, but not as flexible with scalability as private blockchain networks.	Offers total flexibility in choosing parameters and specifications based on users' needs.
Prerequisites	Requires a competent team and resources to implement applications and business logic.	Requires a team and resources to implement business logic and applications/portals, but the Government may also choose to commit resources to network infrastructure.	Requires infrastructure such as reliable electricity and internet connection, as well as the resources and expertise to implement the full blockchain and supporting solutions/ applications.
Suitability for trade facilitation	Less suitable for most trade facilitation purposes due to limited flexibility around key parameters.	Suitable for trade facilitation but reduced sovereignty and limited flexibility with scalability and parameters can be a disadvantage.	Flexibility to adjust specifications and parameters means higher suitability for trade facilitation purposes.

Source: Compiled by ESCWA.

Though potentially more cost-effective, public blockchain networks can bring both data sovereignty challenges as well as uncertainties around the transaction cost of recording data on the blockchain. Using a shared permissioned blockchain as in the case of regionally focused blockchain network, LACChain, also means full sovereignty over the network is not guaranteed even though cost of implementation could be minimal. This second option may require the Government to only design and operate a user-facing portal/applications on the shared consortium/regional blockchain together with regional counterparts. Lastly, if a Government builds a private blockchain, the Government will be required to run and maintain infrastructure to keep the network live at all times, in addition to bearing the associated operational and maintenance costs of the trade facilitation applications. This third option though could be costly, allows the Government great flexibility to choose the network features as may be suitable for its use in trade facilitation and beyond. Furthermore, this option, at the minimum, requires reliable electricity and internet connection to be secure and useful. Unfortunately, in most developing countries these two pre-existing conditions cannot be guaranteed.

Thus, while building a private blockchain requires developing and maintaining the entire architecture, which could comprise the components shown in figure 1, building on a public permissionless blockchain or on a shared permissioned blockchain may only require the Government to build and maintain the user portals, business logic and host front-end data.

Figure 1. Simplified blockchain network architecture with user interface



Source: Compiled by ESCWA.

Figure 2. The stages of the blockchain development and deployment process

Source: Compiled by ESCWA.

Thinking about the use-cases beforehand will help the Government choose the specific type of public or private blockchain required and make the right trade-offs around speed, security, reliability and sustainability.

In any case, it is critical that the Government adopts a process that will cause the least disruption to existing trade processes and that it implements the blockchain in a controlled environment before going into production. As shown in figure 2, the development and deployment process should be sequenced as follows: design, proof of concept, pilots, beta testing, limited user access and final deployment.

Based on user-specific login details and taking cues from the stakeholder credentials during login, the smart contracts could be designed to render different business logics to the user portal.

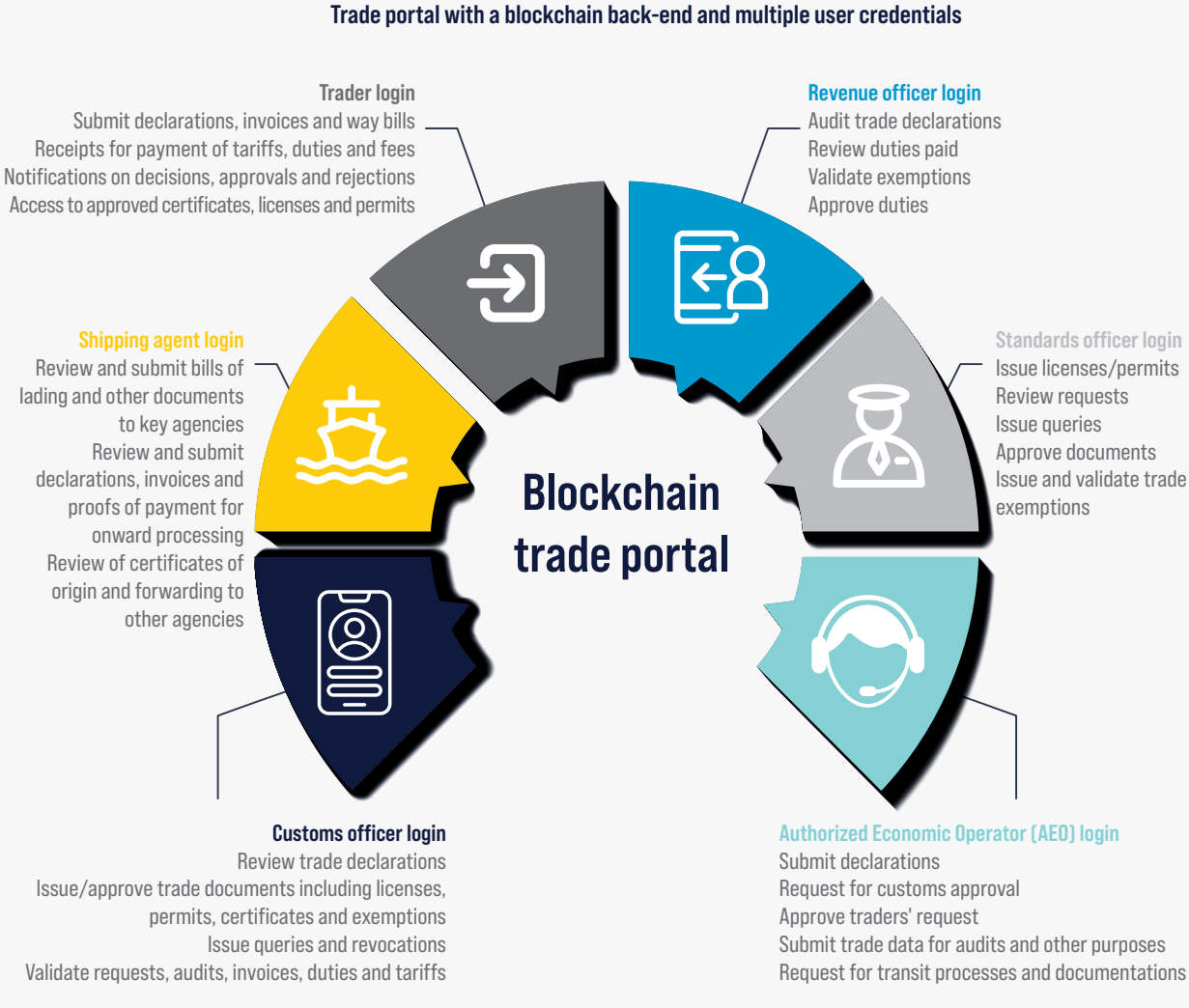
Lessons from each stage should be fully incorporated into the final product before full deployment, and each step should cover all the basic elements of a fully functioning and usable blockchain, including the application flow, the business logic and the middleware, as well as the user facing portals and interfaces that allow users to interact with the blockchain logic to deliver the intended trade facilitation processes, flows and user expectations.

Finally, user credentials can be created and entered at the portal level or business logic level with various rights and access controls. The business logic and middleware (in other words, the smart contracts stored on the blockchain) can be programmed to have different pathways depending on the credentials of the user that logs in. This should grant different levels of authorization, rights and privileges to the user and should allow for multiplicity of use and user interactions within the same portal, as well as the compartmentalization of various logics and access rights based on the user type, user needs and user demands. Based on user-specific login details and taking cues from the stakeholder credentials during login, the smart contracts could be designed to render different business logics to the user portal and grant

different user rights based on the stakeholder type, need and/or level of authority within the Government. This aspect, which is largely a policy, regulatory and compliance issue would be mainly informed by Government processes, stakeholder coordination mechanisms and leadership dynamics within the Government. Figure 3 demonstrates how multiple functionalities are possible using a multi-user interface or portal that could be built and supported by back-end blockchain. Such a set-up could give traders the opportunity to submit trade declarations while supporting customs officers to review, validate and approve the declarations.

Multiple functionalities are possible using a multi-user interface or portal that could be built and supported by back-end blockchain.

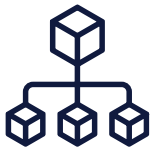
Figure 3. User interface of a blockchain-supported portal with multiple user functionalities



Source: Compiled by ESCWA.

Most Governments already use digital tools, applications and portals for trade processes. The implementation of blockchain should therefore consider three key user experience needs:

A



The implementation of the blockchain should, as far as possible, be done in the context of the existing infrastructure to allow for integration with existing legacy systems and future applications.

B

The implementation process should avoid disruption to the existing user experience within the various portals and interfaces and should instead aim to build efficiency, resilience and security into the existing business logics.

C

Where new portals or interfaces are created during the implementation process, they should enhance the average user's ability to undertake their daily operations with ease and minimize the possibility of human error.

Guidelines for assessing blockchain needs and readiness

CHAPTER 02

Blockchain is gaining the increasing attention of Governments and the private sector. As a general-purpose technology whose utility transcends trade processes, various debates have emerged on the technology's potential to streamline processes, enhance transparency and improve accountability within the context of international trade processes. Importantly, the implementation of blockchain technology is similar to the implementation of most digital technologies. However, certain peculiarities of blockchain make it both unique and susceptible to inefficiencies if implemented in an unprepared or needless environment. While blockchain can bring various value propositions to several areas in trade processing, it is not an all-encompassing panacea for all the trade facilitation needs of Governments. Thus, a blockchain needs assessment will help Governments establish the areas where the technology can bring potential efficiency gains within the country's trade landscape and ensure optimal use. Furthermore, by undertaking a readiness assessment, Governments will ensure that the appropriate legal and regulatory environment exists and that stakeholders are prepared to efficiently use the technology.

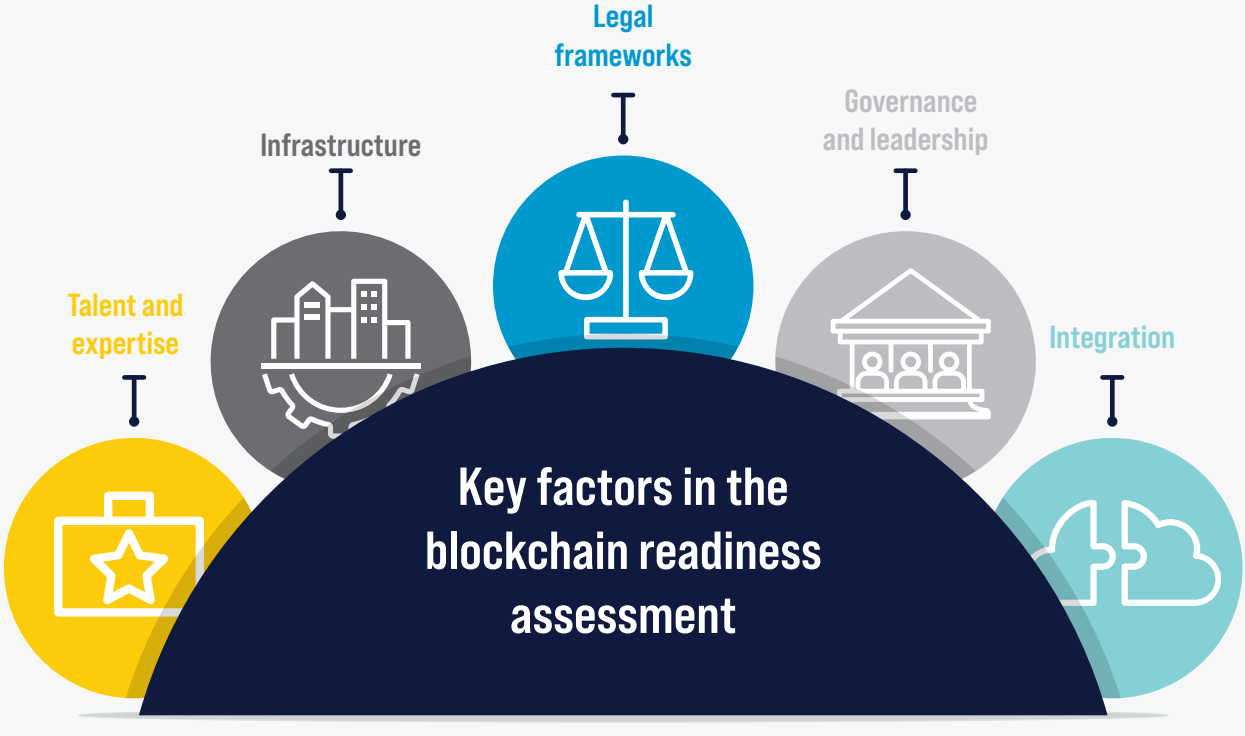
The present section outlines the processes and key factors to consider when undertaking blockchain needs and readiness assessments for Governments to successfully implement, sustainably manage and optimally use the technology for trade facilitation purposes. Undertaking these assessments will not only offer Governments the possibility to understand the trade facilitation problems that can be remediated by the technology but will also help Governments establish whether the required infrastructure, legacy systems and resources (both human and financial) exist to implement the technology. For most Governments today, the path to a successful and sustainable implementation of blockchain for trade facilitation remains unclear. Thus, before considering implementation, they need both a clear demonstration of the need for the technology and to ascertain the preparedness of their national environment in terms of resources, talent, expertise and regulatory frameworks that will support both the implementation and use of the technology.

A
Assessing preparedness for blockchain

In establishing a country's preparedness for the implementation of blockchain, a set of key indicators and technical factors focusing on regulation, infrastructure, resources, talent and expertise, as well as standards, are examined in the context of the broad requirements for blockchain implementation and use by the Government. These factors and indicators fall under five key dimensions, as shown in figure 4. It is imperative that the Government assesses its own readiness based on these key indicators and establishes any gaps that need to be filled in the technical, regulatory and policy environment before commencing the implementation process.

The five dimensions of readiness are further elaborated in the following sub-sections of this guide, beginning with the legal frameworks that would be needed to support a blockchain environment in trade facilitation. Addressing these dimensions will help Governments leverage the potential benefits of the technology while limiting the risks of failure and suboptimal use.

Figure 4. Key factors in the blockchain readiness assessment



Source: Compiled by ESCWA.

1. Legal frameworks

As a relatively new and fast-evolving technology, blockchain presents new legal, regulatory and compliance challenges to Governments. Most Governments, especially those of developing countries are still in the early stages of developing legal and regulatory frameworks for the broader digital economy. Thus, emerging technologies like blockchain present particularly significant challenges on issues around data management, data governance, digital identities, privacy protection and user safety. There are also challenges in relation to stakeholder knowledge of legalities and regulation. Any readiness assessment must therefore include a deep and broad overview of the suitability and applicability of existing laws in the country around new technical concepts such as digital signatures, digital identifiers, user privacy and data governance, as well as the legal gaps that need to be filled either with new laws or amendment to old laws. This will help close the divide between the required legal components of the technology and the technical capabilities of the technology for success. Furthermore, the readiness assessment must define the legal limits of the technology and a clear legal framework that outlines permissible use in order to curb abuse. The legal and regulatory component of the readiness assessment should also establish the legal basis for concepts such as data protection, intellectual property, smart contracts and user identities.

2. Technical infrastructure

Real-time applications of blockchain and its unique data management set-ups require two critical pieces of infrastructure to function reliably and efficiently in a country setting: reliable electricity and stable high-speed internet. While other infrastructure could be useful, these two are particularly necessary for the technology to work optimally. Unfortunately, most developing countries still have intermittent power cuts and unreliable internet systems, two phenomena that will lead to network halts, restarts and possible breakdowns of the blockchain network. While a readiness assessment will help ascertain the presence, reliability and preparedness or otherwise of electricity and internet infrastructure, as well as other supportive legacy systems, it will also encourage Governments take measures to overcome these challenges in the event that the environment is concluded to be unprepared. For example, a Government could decide to host the blockchain infrastructure within special infrastructure zones – domains that support critical Government infrastructure where internet and electricity are assured to be reliable enough – in order to protect the technology from frequent disruptions. Also, if a Government ascertains that it is unable to or lacks the reliable electricity and internet infrastructure to support a real-time database like those of blockchain, then other design options such as building on public permissionless blockchain may be explored as alternatives to the development and maintenance of a Government-owned fully functional private blockchain.

3. Talent and expertise

The availability and preparedness of the human resource that will implement the technology in the country is key to the success and sustainability of the implementation. The presence of both knowledgeable stakeholders and a talented workforce to ensure smooth implementation and optimal use of the tools of the blockchain infrastructure is crucial. Thus, a Government exploring the implementation of the technology must consider the availability of talent and expertise for implementing and maintaining the technology. Knowledge of the broader stakeholder base that will use the technology is also important in the assessment process. Governments need to ascertain their access to a pool of skilled professionals who can design, develop and maintain a blockchain-based system. Their expertise should cover areas such as cryptography,

distributed systems and cybersecurity. If talent and expertise gaps are identified in the assessment process, especially with regards to the implementation of a fully Government-owned blockchain, the Government could respond in one of two ways: either by finding an implementing partner within the private sector, industry, academia or by providing rigorous training to the workforce to undertake the implementation. Broader user and non-user stakeholder training will be key to ensuring optimal use of the technology post-implementation.

4. Technicalities of forward and backward integration

Once implemented, a blockchain will work in the context of a broader Government digital ecosystem for trade facilitation. This means standard applications and legacy systems such as cloud-based networks, conventional Web 2.0 applications running on traditional databases, and non-digital infrastructure that facilitate the Government's trade processes must work in tandem with the blockchain for a smooth trader experience. This will ensure that blockchain technology is used effectively and meets the needs of the different Government agencies. It requires both standardization of the interoperability processes as well as an understanding of the level of technical overhaul, restructuring and updates that will be needed. Establishing the Government's readiness to both transform the existing infrastructure that allows the integration of a blockchain ecosystem as well as prepare the environment for future infrastructure integration to meet future needs is important for the successful implementation of the technology.

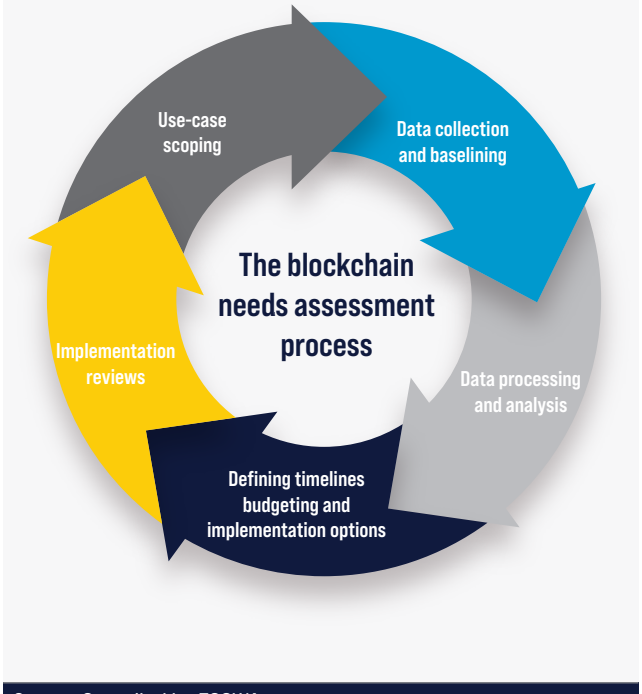
5. Governance, leadership and stakeholder preparedness

The leadership to oversee the adoption and use of blockchain technology as well as stakeholder preparedness to ensure optimal use of the technology are crucial for success. A high-level authority will be needed to oversee the implementation, and the day-to-day operational steps will require a knowledgeable, capacitated and well-educated middle-level workforce that is willing and able to support the implementation and use of the technology. This level of preparedness requires policies and guidelines, allocation of resources, authority and oversight to succeed. The arrival of new technologies may meet resistance to change by various types and levels of stakeholder groups. Leadership buy-in is thus crucial to resolve any resistance that the implementation process will meet.

B
Undertaking a blockchain needs assessment

There are several potential areas where Governments can use blockchain in their trade ecosystems to bring efficiency gains, help streamline daily operations and strengthen compliance. However, to deploy a blockchain-enabled trade environment, the use-case requirements should be considered. These will influence the design, architecture and process flows of the applications and solutions. The trade facilitation needs of Governments cannot all be met using blockchain, and some may be best fulfilled using other solutions. For example, the availability of information remains a key challenge in many trade environments.

Figure 5. Key steps in the blockchain needs assessment process



Source: Compiled by ESCWA.

In such cases, publishing information through conventional web portals and mobile applications could be the most resource-efficient approach to bringing transparency. A use-case of this kind does not need a blockchain. As shown in figure 5, key steps for assessing whether a trade facilitation use-case needs a blockchain include scoping the use-case scenario; collecting data and baselining the existing situation; processing and analysing the data collected to ascertain the likely efficiency gains; defining key timelines, the budget and implementation options; and finally, implementing process reviews which should be incorporated into any subsequent needs assessment for further use-cases, future scaling or adjustment purposes.

1. Scoping the use-case

Identifying and scoping the use-case(s) of the technology is the first step of the needs assessment. This helps to ascertain the envisaged intervention that will bring the most efficiency gains. While many trade facilitation needs, such as track and trace, trade audits, risk management and payment processing, could see significant improvements with the use of blockchain, some trade facilitation needs may be best implemented by non-blockchain solutions. Thus, defining those needs that can best be achieved with a blockchain to further ascertain the net efficiency gains that will be obtained from the intervention is key. This aspect of the needs assessment process will also help the Government to sharpen the technical, policy and regulatory objectives of the solutions that will be built on top of the blockchain. For example, if a Government has broader policy objectives of improving compliance, increasing trade competitiveness and improving revenue, use-case scoping should consider these policy objectives and how the implementation of blockchain will help meet them.

2. Data collection and baselining

The blockchain needs assessment involves understanding what exists, what works and what needs to change. Policy interventions can only succeed when the implementing body is fully aware of the existing landscape and therefore able to identify the changes required. This aspect of the needs assessment involves collecting both primary and secondary data through various methods such as policy reviews, interviews, surveys, focus groups and observations to ascertain the state of current trade processes and procedures and where the technology will bring the most value when implemented. It focuses on collecting data on the trade facilitation measures, establishing the desired future state of trade processes and focusing interventions on the gaps that need to be addressed to meet the discrepancies.

3. Processing and analysing data

Analysing data on existing trade facilitation measures helps with understanding links, patterns, themes and trends, in other words, the interrelationships between various components of the Government's trade facilitation needs. This

will allow individual and collective use-cases that require the technology to be aggregated. The analysis stage helps identify the most pressing trade facilitation issues and challenges that need to be prioritized in the implementation process. Furthermore, any discrepancies that may have been missed in the baselining step will be revealed in this aggregating stage and addressed accordingly.

4. Defining timelines, setting the budget and exploring alternative solutions

This stage of the needs assessment focuses on less technical, more practical considerations for successful and sustainable implementation. It also outlines the use-case challenges that may need to be addressed ahead of implementation. Setting feasible timelines, identifying resource requirements and stakeholder roles, and ensuring the cost-effectiveness of implementation options are crucial steps in the needs assessment process. Alternative solutions to address the identified trade facilitation needs, gaps or discrepancies should also be considered together with the cost considerations of each alternative technology. If trade audits can be cost-effectively implemented using cloud-based digital infrastructure and offer the same utility as a blockchain-based solution, why should the Government choose a blockchain? Furthermore, this step assesses the technical, policy and regulatory feasibility of alternative solutions in comparison to blockchain.

5. Implementation reviews

At this stage of the needs assessment process, trade facilitation measures that could benefit from blockchain have been ascertained and the implementation steps established. The process of implementation must be continuously reviewed to ensure that the technology is in continuous alignment with the trade facilitation needs of the Governments. This process could also assist the Government in expanding the technology to more use-cases, scaling it for more applications and adjusting it when necessary. Implemented solutions must be reviewed periodically to ensure that the trade facilitation needs of the country remain served by the technology. New trade facilitation needs that emerge along the way will require updates to the implemented applications. Thus, the solutions implemented will require continuous adjustments to ensure that they meet the identified trade facilitation needs and achieve desired outcomes.

Implemented solutions must be reviewed periodically to ensure that the trade facilitation needs of the country remain served by the technology. New trade facilitation needs that emerge along the way will require updates to the implemented applications.

Needs assessments help the implementing Government, the stakeholders and the technical workforce ensure that the design and architecture of the blockchain and its applications meet the needs of the user groups and resolve the expected trade facilitation challenges of the broader stakeholder base. A multi-stakeholder, multi-agency and multi-team approach will be required to undertake the process of identifying all the critical trade facilitation gaps and discrepancies ahead of implementing the technology. This will ensure that software, policy and regulation are designed with a clear understanding of these trade facilitation gaps.

Technical guidelines for implementation

CHAPTER 03

A
Getting the infrastructure right: 10 key technical steps

Blockchain can be implemented in many ways either for a single use-case or for multiple use-cases. While the implementation could take many approaches in respect of technical considerations and trade-offs, the standard procedures, processes and methods of design, development and deployment do not differ significantly in the context of best practice. The key technical steps of implementation include identifying the use-case, testing, integrating portals and user interfaces, integrating the blockchain with existing infrastructure, and security protocols. Figure 6 shows the ten key technical steps in more detail.

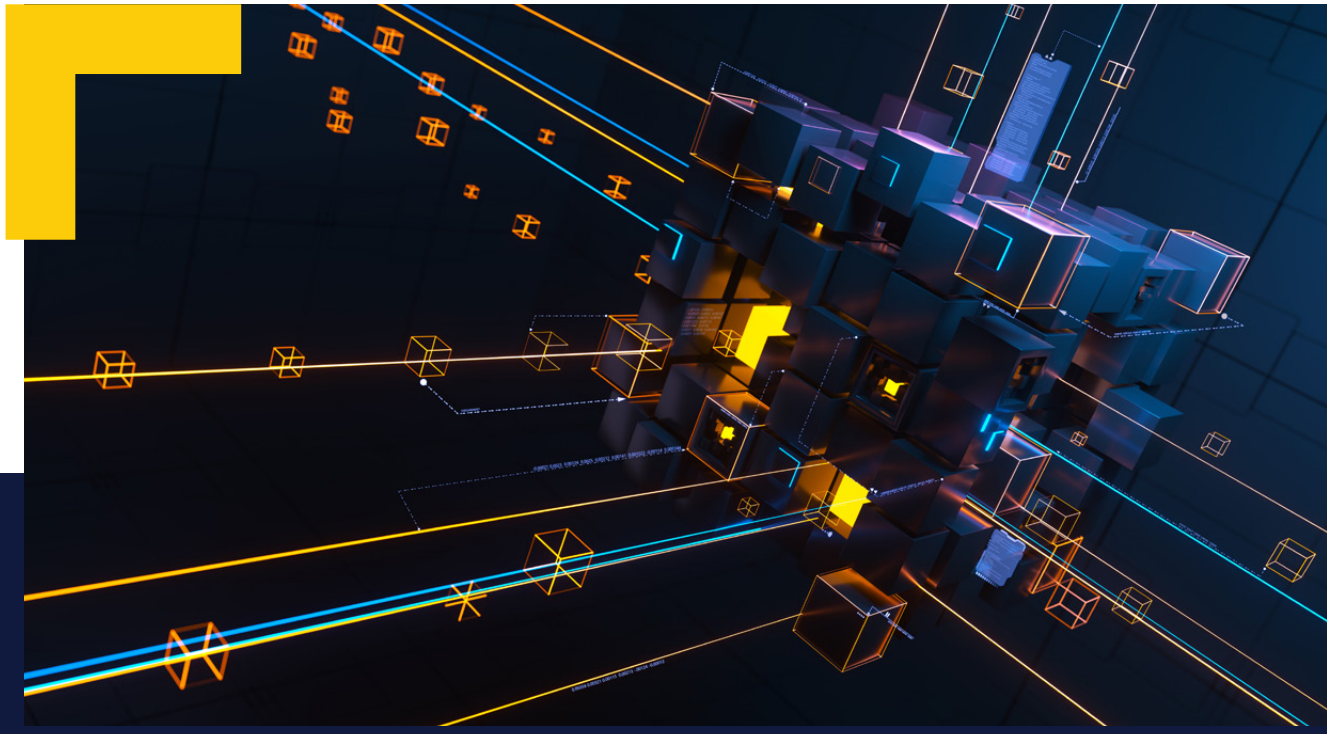
Figure 6. The 10 key technical steps for the blockchain implementation process

Source: Compiled by ESCWA.

1. Identify the needs, define the requirements and scope the use-case

To implement a blockchain for any purpose, defining the use-case based on the identified trade facilitation needs is the first and perhaps the most important step. Getting things right at this step will influence other subsequent steps such as the architectural design, and choices around speed and security as well as permissions and privileges of members. Identifying the specific problems that the blockchain is intended to solve and scoping the technical design accordingly will help the implementing body avoid difficulties later on in the implementation process.

A blockchain that is intended to process payments of duties, for example, may need high speed and high sovereignty at the core architecture in order to avoid delays and infiltration, while a blockchain for trade audits would require higher storage and data protection capabilities. Identifying the use-case for the blockchain and scoping the problem it aims to solve informs the architectural design, as well as, various aspects of the policy considerations. Identifying and defining the purpose of the technology within the trade environment is a foundational requirement for the subsequent technical steps in building the blockchain. In the end, this step will largely inform the degree of decentralization, security and speed of the network as well as the adopted architectural parameter and technical specifications of the protocol.



While a blockchain could be implemented to address multiple trade facilitation needs around trade audits, risk management, quality assurance, transparency and data validation, finding a balance between performance, security and sovereignty without major compromises is crucial.

2. Select the blockchain protocol and platform

The proliferation of different blockchain protocols over the years has brought to light the technical trade-offs that have to be made in deciding on the choice of protocol for a blockchain use-case. The chosen blockchain protocol necessarily influences the capabilities of the technology implemented, given the trade-offs to be made between speed, sovereignty and security. A well-distributed and largely decentralized blockchain protocol tends to be slow and lack speed but has high security. On the contrary, private/consortium blockchain networks tend to be fast in speed, high in storage, but lower in security and resilience. Furthermore, proof of work (POW) protocols such as that of Bitcoin, tend to be slower than proof of stake (POS) protocols such as those of Ethereum or Cosmos.[1] Thus, depending on the use-case envisaged and defined in step one, some protocols and architecture may be unfit for the use-cases in trade measures and others will be more suitable. Key technical considerations largely cover specifications around speed, quality assurance, data integrity, storage, resilience and security. Collaboration with the private sector, industry and academia will be useful in building the architectural details of the implementation process.

3. Design and implement the architecture

Designing the architecture of the blockchain is the first hands-on technical step of putting the network together that serves as the foundation of the technology. Once the use-case is known and the protocol is chosen, the technical design process entails a deeper and more detailed step of putting together the core of the blockchain network. The technical design step involves the network architecture, consensus mechanism, node configuration, levels of authority of network participants, emergency restoration and recovery processes, cryptographic functions, risk management procedures, digital signature protocols and other parameters. It is recommended that at this stage, private sector consultants and experts from industry collaborate with the Government in the execution process. Blockchain is relatively complex and requires skills in multiple fields to be implemented. Most Governments, especially those of developing countries, still lack the expertise and skills within their agencies to execute all the technical details. Given the lack of in-house expertise to execute the deeply technical aspects of blockchain technology, collaboration with the private sector and industry experts is advised for a successful implementation process.

4. Testing

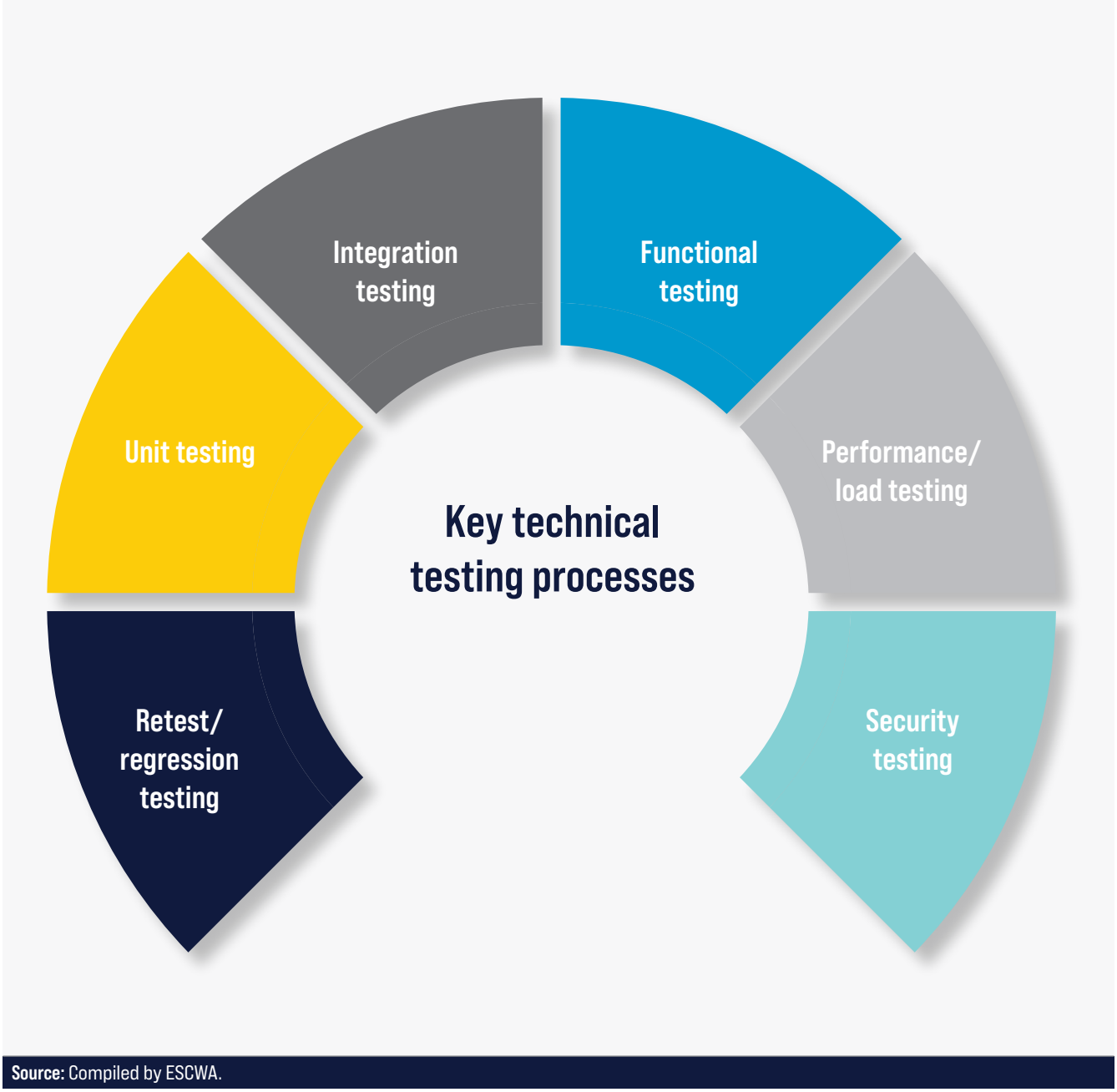
The complexity of blockchain brings with it significant chances of bugs, errors and code malfunctions. Hence, testing is a key step of the design, development and deployment process. This step usually entails unit and process assessments that allow for components as well as constituents of the code to be tested for risks, vulnerabilities and bugs. Testing is done within simulated environments in the form of testnets. It examines the network's functionality, security and stability, simulates real-world scenarios and ascertains that the blockchain will work as intended and without major flaws. During this phase, all major network issues are identified and fixed. Before implementing the technology for trade processes, customs, authorized economic operators (AEOs), traders and other agencies should be involved in the

1. More details about these protocols and how they differ from each other can be found in the Global Report on Blockchain and Implications for Trade Facilitation Performance, published by the United Nations Conference on Trade and Development in 2023.

key testing steps to ensure that the blockchain addresses all key user requirements and meets international standards. Testing allows the implementing body to identify major issues especially around security, compliance and interoperability and fix them ahead of deployment. This is an essential step in the development process of any blockchain and would usually entail key sub-processes as shown in figure 7 and detailed in box 1.

The complexity of blockchain brings with it significant chances of bugs, errors and code malfunctions.

Figure 7. Key components of testing in the blockchain deployment process



Source: Compiled by ESCWA.

Box 1. Seven key components of testing in the deployment process

Unit testing: involves testing individual components and modules of the blockchain network to ensure that they work as intended. At this stage of testing, automated testing frameworks and tools can be used to identify and fix issues in the early parts of the development process.

Integration testing: involves testing how different components of the blockchain interact with each other to ensure they do so as intended. This step ensures that the constituents of the program work as a whole and that there are no compatibility issues between different components.

Functional testing: involves testing features and key functionalities to ensure that they work in accordance with the original design and intent and that the key technical requirements specified in the design phase are achieved. This step tests the entire process and confirms that the blockchain performs as expected and can handle the technical workload that it is expected to handle.

Performance/load testing: examines whether the blockchain can handle the processing volume, workload, speed and multi-user interactions. This step investigates the computational strength of the blockchain and its ability to handle the expected user traffic in order to fix any performance issues that could affect user experience beforehand.

Security testing: checks for security vulnerabilities and bugs that could affect security functionalities and any other potential risks of unauthorized access, network disruption and insecurities. This step aims for the protection of the network's sensitive data.

User acceptance testing: involves testing the blockchain with real users to ensure that the design meets stakeholder expectations, delivers a good user experience and meets user capabilities. This step identifies usability bottlenecks that were not captured in the earlier testing phases but may be critical. The user feedback and stakeholder inputs help with designing a user-friendly blockchain protocol.

Retest/regression testing: involves retesting the blockchain's entire process after making changes and updates to fix vulnerabilities identified in the preceding testing phases. This step is taken to ensure that the updates and changes do not introduce new issues and vulnerabilities into the existing functionality.

5. Develop smart contracts

Smart contracts are self-executing codes, business logics and programs that are stored on the blockchain for specific logic and use-case purposes. While the blockchain itself is simply a distributed database with redundancies, smart contracts constitute the executive functionalities of the blockchain. They can serve as middleware between the blockchain database and the user-facing portal of the Government's trade facilitation portal, or they can simply be used to process logic between one or more functionalities. They could further serve as the process logic that provides access credentials, authorization, rights and privileges to users within a blockchain ecosystem. Smart contract design is a particularly important component of the blockchain design process. While a blockchain database could be a general purpose infrastructure for many use-cases, smart contracts allow for specific use-case designs and serve as compartmenting infrastructure to deploy individual

tasks and specific functionalities on the blockchain. For example, on a single blockchain, different smart contracts could be deployed to handle processes such as managing the digital identities of customs officers and AEOs, tracking and verifying trade document flows for audits, and automating authentication for the quality assurance of trade certificates and permits, all with the aim of meeting the Government's trade facilitation needs. As process-logic software used to define the rules of the network and automate processes, smart contracts are thus particularly useful in attributing and compartmentalizing user rights and privileges, levels of authority and user access controls, as well as conditions for the revocation of such user rights and privileges and undertaking risk mitigation mechanisms within the network.

6. Deploy the blockchain

Deploying the blockchain within a production environment is a stage when the network goes live, begins to process records, produces data pockets, creates data chunks (called blocks) and a digital history of the blockchain network. It usually involves a coordinated process of synchronization of computational units (servers/nodes) which are part of the network until a simple majority have been established on what can be considered as common agreement of the true state of the network records. Once the genesis block is up, running and producing further blocks, the network can be considered stable and safe and can then deliver the data reliability required in terms of meeting integrity requirements. This stage of the implementation processes comes with design and policy choices. For example, the implementing body could deploy the network on sovereignly owned physical computational infrastructure such as servers (usually called a bare metals approach) or opt for a cloud-based service provider like Microsoft Azure or Amazon Web Services. Choosing a cloud-based service means the implementing body doesn't own the infrastructure on which the network runs and thus gives up a level of sovereignty, although this choice may be cheaper. The implementing body may choose a third option where the blockchain is deployed using a Blockchain-as-a-Service (BaaS) platform such as the European Blockchain Services Infrastructure platform or the Blockchain-based Service Network in China, which allow any entity to deploy their own sovereign blockchain application without owning the digital infrastructure on which the blockchain runs. The implementing body gives up a level of autonomy and sovereignty with the use of these cloud-based option as well.

7. Design security protocols

The most significant value proposition of blockchain is data integrity. Thus, when a blockchain experiences unauthorized intrusion and data tampering, it causes numerous problems regarding re-establishing the true state of records on the blockchain and usually requires a network reorganization which can be resource intensive. Security breaches of

The implementing body gives up a level of autonomy and sovereignty with the use of cloud-based options.

blockchain that require network reorganization in order to clean the erroneous data from the network also mostly require special expertise, something most Governments may not readily have at hand. Implementing security protocols is thus critical for the overall network health, data integrity, as well as stability and reliability of the information that is stored on the blockchain. These security protocols include technical measures to prevent attacks and unauthorized access through data encryption, reliable private key protection mechanisms, access controls, risk prevention and mitigation protocols such as activity logs, procedures on emergency updates, code reviews, security patches, network halts and reorganization and restart procedures. These ensure network protection to prevent unauthorized tampering, access and attacks on data stored on the blockchain network.

8. Design and integrate portals and user interfaces

Although not technically part of the blockchain itself, user-facing portals and interfaces allow the average user to interact with the blockchain in a less technical manner. They also allow the business logic and process flow of the use-case applications of the blockchain to be experienced by the average user without deep technical expertise. Thus, they form the most critical part of the user experience and greatly influence the perceived user-friendliness, utility and value of the blockchain. As a complementary component of the business side of the blockchain, they are normally deployed as separate code with the sole function of ensuring that the user experience of the blockchain is optimal and efficient. This separate code can usually be designed by a separate team whose expertise lies in user interfaces and user experience but who, nevertheless, have good understanding of the technical primitives of blockchain and Web 3.0 in general. Implementation of these components can usually be done in a conventional Web 2.0 fashion.

9. Integrate with existing infrastructure

Implementing blockchain should not be done in isolation of the existing trade facilitation digital infrastructure. Doing this will create data silos and lead to suboptimal outcomes. Integration with existing infrastructure should be at the centre of the implementation process from the start. Given that most Governments already have existing trade facilitation solutions such as trade portals, trade reform trackers and single windows, a blockchain should only help improve specific trade facilitation measures that are not already handled well by other conventional legacy systems. Thus, the blockchain implementation process must be done in a manner that ensures integration with existing legacy infrastructure and allow for the possibility of future integrations. For successful integration with existing infrastructure, the implementing body should be guided by the steps set out in box 2 and shown in figure 8. There are also three key forms of integration, as shown in figure 9 and detailed in box 3, and these forms can be combined.

Given that most Governments already have existing trade facilitation solutions such as trade portals, trade reform trackers and single windows, a blockchain should only help improve specific trade facilitation measures that are not already handled well by other conventional legacy systems.

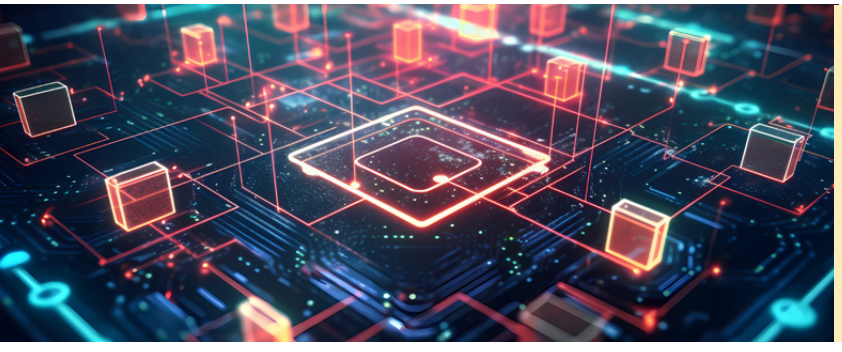
Box 2. Four key steps for successfully integrating blockchain with existing trade facilitation infrastructure

Define the purpose of integration: Defining the purpose of the integration will inform technical design choices around features and ensure proper alignment of the processes with the Government's overall trade facilitation goals. Depending on the targeted trade facilitation needs, the blockchain may be integrated in three possible ways: as a solely blockchain-backed utility, as a purely legacy digital system, or as a combination of legacy and blockchain back-ends where some application logics use a blockchain data back-end, while other logics lead to a conventional database back-end.

Design the technical requirements of integration: This includes the technical designs that will guide the design and implementation process of the integration. The design of technical specifications, connectivity systems and transport components that convey data to and from the blockchain environment and legacy infrastructure, as well as the overall architecture and user-facing portals, including the application programming interfaces (APIs) endpoints, data models and integration points, are put together at this stage. This step would usually involve multiple teams of the blockchain implementing body and the legacy technology groups to ensure that the integration is both technically feasible, functionally desirable and meets performance requirements.

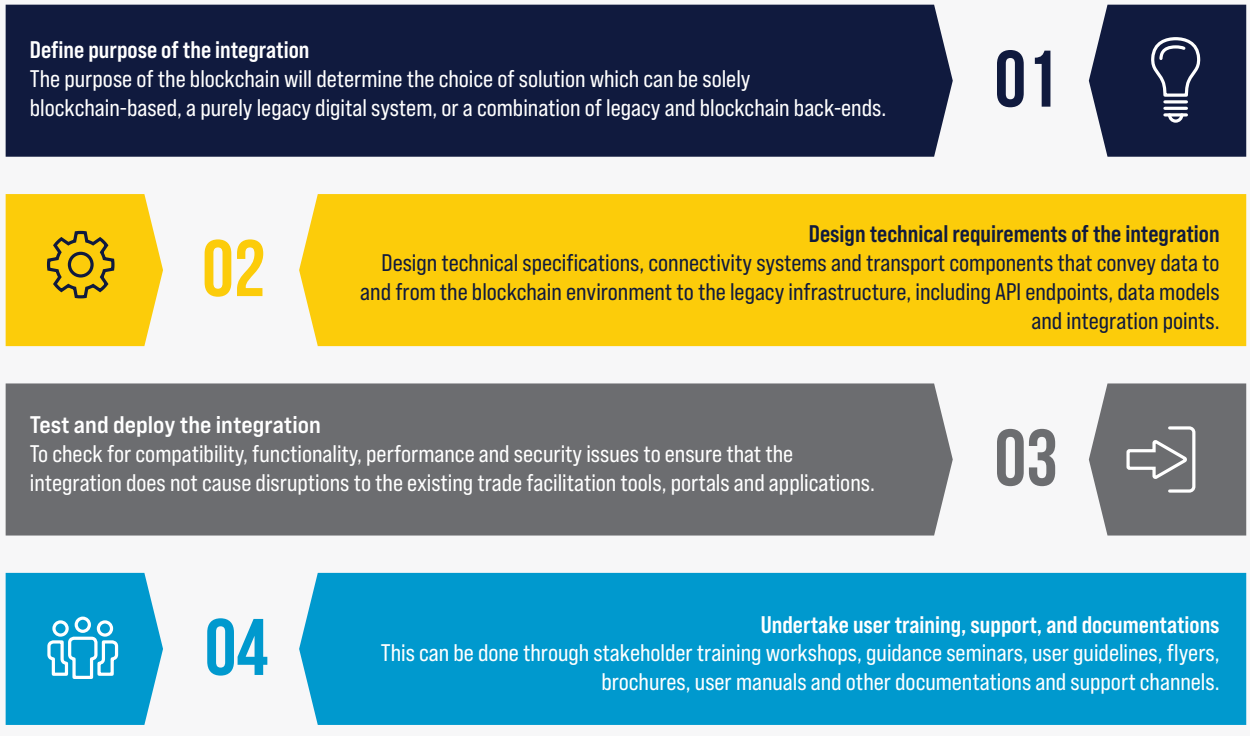
Test and deploy the integrated blockchain: As in all software development processes, the integration process of different infrastructures must be thoroughly tested and implemented after the architectural designs, requirements and feasibility are assessed. This generally involves testing code in a sandbox environment by the key teams in charge of the implementation for compatibility, functionality, performance and security to ensure that the integration will not cause any disruption to the existing trade facilitation tools, portals and applications. Once testing has gone smoothly, the integration can be deployed in a production environment and monitored closely for issues by tracking performance metrics, user feedback, event logs, security incidents and activity logs.

Provide user training, support and guidance documents: Once integration is complete, depending on the level of changes to the user-facing portals, interfaces and applications, user training and support for the new features will ensure smooth adoption and user acceptance. This step also becomes very important if new functionalities have been added to the existing application logic. Training and support can be provided in the form of stakeholder training workshops, guidance seminars, user guidelines, flyers, brochures, user manuals, other guidance documents and communication channels. Beyond continuous user support, the overall performance, functionality and security of the integrated infrastructure must be continuously monitored with regular reviews, upgrades and updates based on user feedback, evolving process requirements and emerging trade facilitation needs of the Government.



Implementing blockchain should not be done in isolation of the existing trade facilitation digital infrastructure.

Figure 8. The four key steps to get integration right



Source: Compiled by ESCWA.

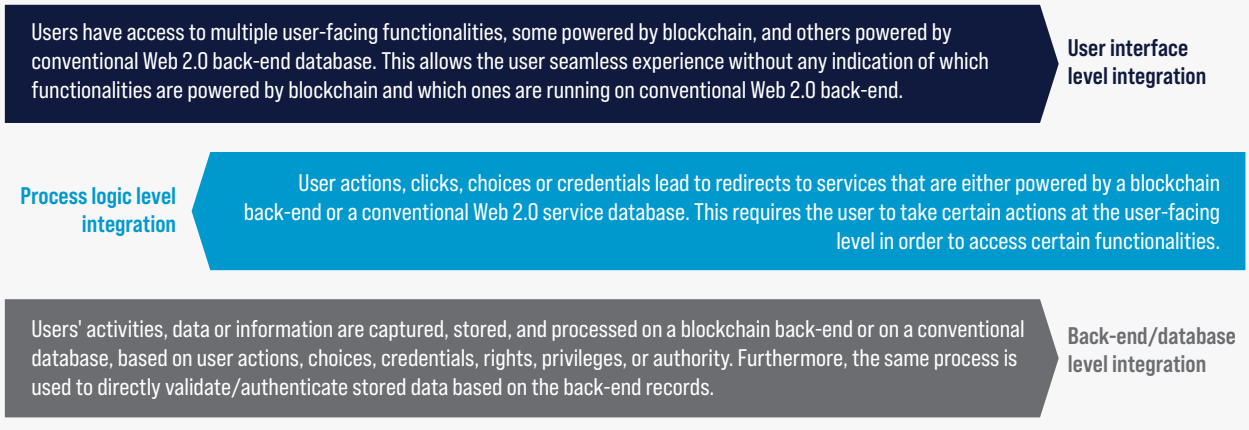
Box 3. Three key forms of integration

On a practical level, the way legacy systems and the blockchain ecosystem are integrated is worth addressing. Integration can take the form of various vertical and horizontal flows between the two ecosystems. For example, the blockchain back-end could also partly serve as the back-end of a conventional Web 2.0 application (a vertical flow), or both legacy systems and blockchain solutions could work in parallel for specific trade facilitation measures (a horizontal flow). The three key forms of integration are:

- Integration at the user-facing level: This is where users have access to multiple user-facing functionalities, some powered by blockchain, and others powered by a conventional Web 2.0 back-end. This provides the user with a seamless experience where they will not know which functionalities are supported by blockchain and which are powered by a Web 2.0 back-end. For example, a customs officer may use the same portal to approve the license of an AEO, a process recorded on a blockchain, as well as approve a trade declaration, which may be recorded on a conventional Web 2.0 database.
- At the process logic level: This is where, depending on the user actions, choices or credentials at the front-end, the user is directed to a particular service powered by a blockchain back-end or to a conventional Web 2.0 service. This option requires the user to take certain actions, make choices or enter certain credentials to be redirected to an application logic supported by a specific back-end.

- Integration at the back-end and database level: This is where, based on user actions, choices, credentials or privileges, the user's activities are captured, stored and processed on a blockchain back-end, or all processes happen on conventional database. For example, a trader may be allowed to use a blockchain-based Government service to independently authenticate the validity of a trade certificate issued by a Government agency in order to prevent fraudulent activities or to detect counterfeits. In this case by entering a certificate serial number or scanning a barcode/Quick Response (QR) code, the user gets validation from a blockchain-based records system or a legacy database. Furthermore, an AEO may be allowed to sign and store digital signatures on a blockchain network that allows for any future post-clearance audits to be able to trace activities to the AEO, and this will make quality controls easier for the Government and reduce trade risks. This could take place within a portal that supports both blockchain-based data and conventional database systems, with multiple process logics designed into it. Depending on the chosen purpose, the user would be directed accordingly to a blockchain back-end or to a conventional Web 2.0 back-end for validation and authentication of the information.

Figure 9. The key forms of integration for blockchain solutions and legacy systems



Source: Compiled by ESCWA.

10. Monitor, evaluate and maintain the blockchain and digital infrastructure

Once integration has been well-executed, regular monitoring and maintenance is required of the digital solutions of the blockchain, the complementary applications and the pre-existing digital infrastructure both in house and at the level of the network. The implementing body must cultivate a culture of regular evaluation and updates to resolve any functional, security and performance issues that emerge from time to time. Network health is critical for the continuous functionality and usage of the blockchain. Consequently, the implementing body must constantly assess activity logs to ensure that there are no network attacks or unauthorized access. The implementing body must also ensure that access controls are constantly improved to keep the network well-protected and its data integrity guaranteed. Monitoring the network for any issues and performing regular maintenance tasks, such as network upgrades and software updates can be done both as preventative measures but also as mitigative measures. Also, as the Government's trade facilitation needs evolve, new technical functionalities may be needed to meet the new needs. Stakeholders and users must also be constantly informed about digital hygiene and individual practices that keep data safe and protected. In table 4 the key technical implementation steps are summarised.

Table 4. Summary of key technical steps for implementing blockchain for trade facilitation

Key technical Step	Key deliverables
Identify needs, define requirements and scope the use-case	■ Needs assessment ■ Readiness assessment ■ Use-case scoping ■ Stakeholder coordination
Select blockchain protocol and platform	■ Defined use-case suitability, feasibility and performance requirements ■ Comparison of required specifications with existing design options ■ Choice of protocol design/architecture that meets design requirements or combination of various protocol features that meet the use-cases envisaged
Design and implement the architecture	■ Network architecture ■ Consensus mechanism ■ Node configuration ■ Participant authorizations ■ Emergency restoration and recovery processes ■ Risk management procedures ■ Digital signature handling procedures
Testing	■ Unit testing ■ Integration testing ■ Functional testing ■ Performance/load testing ■ Security testing ■ User acceptance testing ■ Retest/regression testing
Develop smart contracts	■ Middleware smart contracts ■ Process logic smart contracts ■ Access control smart contracts ■ User credentials, authorization, rights and privilege smart contracts
Deploy the blockchain	■ Decision on infrastructure set-up (cloud-based, platform-based or bare metals approach) ■ Launch main net ■ Get genesis consensus ■ Fully synchronize nodes and record production system
Design security protocols	■ Data encryption ■ Private key protection ■ Access controls ■ Application activity logs ■ Emergency update procedures ■ Procedures for network halts, reorganization and restarts
Design and integrate portals and user interfaces	■ User-facing portals, applications and solutions ■ Supportive technical procedures for digital signature processes and key handling
Integrate with existing infrastructure	■ Feasibility, functionality and performance assessments of the integration process ■ Technical specifications around connectivity, transport and architecture including APIs, endpoints, data models and integration points ■ Integration of legacy systems (trade portals, trade reform trackers and single windows)
Monitor, evaluate and maintain the blockchain and digital infrastructure	■ Regular maintenance ■ Network upgrades ■ Security updates ■ User digital hygiene ■ Data safety practices ■ New feature upgrades

Source: Compiled by ESCWA.

B
A work breakdown structure for the implementation process

It is important to break down the work into deliverables and tasks to be caried out by the implementing body in order to achieve the ten milestones elaborated above. This is considered the work breakdown structure (WBS) which is a technical decomposition of the implementation process into smaller, more manageable tasks.

It helps the implementing body properly scope the process, identify key requirements and organize resources efficiently. The technical breakdown of the design, development and adoption process of blockchain and its accompanying solutions are demonstrated as six broad steps in table 5 below.

Table 5. Technical work breakdown structure for blockchain implementation

Step	Implementation components
Commencement	■ Define the goals and objectives of the use-case. ■ Identify and define key technical and policy stakeholders. ■ Develop project implementation guidelines and other key documents. ■ Identify implementing partners.
Planning	■ Define the project scope of the use-case(s). ■ Identify functional, security and performance requirements. ■ Develop an implementation plan. ■ Design the implementation schedule with key timelines. ■ Create an implementation budget and resource limits. ■ Define project teams, roles and working relationships. ■ Pre-screen key implementing partners and service providers.
Design	■ Conduct user requirement analysis. ■ Define systems performance requirements. ■ Develop functional specifications. ■ Select the blockchain protocol. ■ Develop the network architecture. ■ Create design specifications for both the front-end and back-end. ■ Design the user interface and portal workflows. ■ Create a security protocol. ■ Develop code, including libraries, frameworks and modules. ■ Develop blockchain application-level modules.
Testing	■ Conduct testing, including unit testing, integration testing and systems testing, as well as security, functional, performance, user acceptance and regression testing
Deployment	■ Develop a full deployment plan that defines the order of execution. ■ Create a protocol for the network launch process. ■ Develop system requirements for foundational infrastructure. ■ Conduct stakeholder and user training. ■ Develop contingency plan for bottlenecks, halts and restarts. ■ Launch network and be prepared for unforeseen challenges.
Maintenance	■ Design a software maintenance plan. ■ Develop a procedure for updates, upgrades, halts and restarts. ■ Create a protocol for activity logs. ■ Carry out regular bug fixes. ■ Conduct regular updates and upgrades. ■ Undertake user support and training.

Source: Compiled by ESCWA.

Policy guidelines for implementation

CHAPTER 04

A
Policy considerations: towards a successful and sustainable stakeholder-centred approach

Technologies like blockchain need a supportive policy environment to succeed. In general, policy considerations have become a determining factor for the success and sustainability of digital solutions. This is particularly true for the multi-stakeholder and multi-agency space of trade processes and procedures. Thus, the policy considerations of blockchain implementation for trade facilitation purposes centre on stakeholder-dynamics, inter-agency coordination, user empowerment, public-private partnership (PPP) and users' digital hygiene, all of which are crucial for the long-term sustainability of the blockchain.

In the present section, issues of stakeholder empowerment, user support and inter-agency coordination, which are especially important for stakeholder ownership and support, are explored. Issues around data governance, user protection and standards are covered in the legal and regulatory section of the guide. The successful and sustainable implementation of blockchain for trade facilitation depends on implementation taking place in a multi-stakeholder manner, given that a combination of digital and physical infrastructure work in tandem in the trade environment and are managed by multiple agencies. Thus, a policy environment that will support critical trade infrastructure such as blockchain solutions necessarily requires a multi-stakeholder approach, a multi-structured set-up and a multi-user setting both within and across countries.

Furthermore, it is not only the trade policy environment that is multi-stakeholder in nature; the proper implementation of blockchain necessarily requires a multi-stakeholder architecture. The technology normally requires multiple entities to coordinate in keeping them resilient, secure and sustainable. Thus, in the design of any blockchain environment for the purpose of trade facilitation, stakeholder considerations should be at the centre of the policy and technical design. While blockchain is considered to hold potential for trade facilitation purposes, the areas of stakeholder interest, support and ownership, as well as the key policy area that largely determines the success and sustainability of trade infrastructure, have been given limited attention. The present section outlines the process and importance of having all relevant trade agencies involved in the implementation process as well as the need for appropriate individuals within the agencies who possess the required knowledge and authority to support and sustain the implementation process. Both inter-agency and intra-agency stakeholder coordination is critical in designing the blockchain policy environment. Effective engagement of key stakeholders in this regard is not only critical to the success of the blockchain implementation, but also presents the ultimate path to a sustainable digital infrastructure over the long term.

Both inter-agency and intra-agency stakeholder coordination is critical in designing the blockchain policy environment.

B

Key policy steps for successful stakeholder engagement

The steps to create an engaged stakeholder environment in the implementation process of blockchain for trade facilitation range from identifying and defining stakeholder roles to building their strength and knowledge in the implementation process. The success and sustainability of the blockchain implementation process will largely depend on how empowered and prepared the stakeholders are, both at the inter-agency level as well as at the intra-agency level. The process of getting stakeholder engagement right is laid out in the proceeding steps.

1. Identify key stakeholders and define key roles

The first step to set up the policy environment for a successful blockchain implementation is to identify the stakeholders who are critical to the implementation process and define their roles from start to finish. The identification and definition of stakeholder roles should take place within four key dimensions:

A

Sector-wide coordination. This encompasses broad Governmental stakeholder dimension. This is an all-of-sector broad level coordination where all agencies and key stakeholders of those agencies meet to decide the sector-wide direction of the technology and how the broad policy, regulatory and technical needs should be met. It will mostly be led by the ministry or department of trade within each country. At this level, regional and international collaboration may also be initiated for cross-border cooperation purposes.

B

Inter-agency coordination. This second dimension relates to the coordination mechanisms between key agencies in the implementation process, usually on a shared platform. This is where National Trade Facilitation Committees (NTFCs) will necessarily play a key role, for instance, by creating specialized subcommittees to address specific issues with regards to the implementation process.

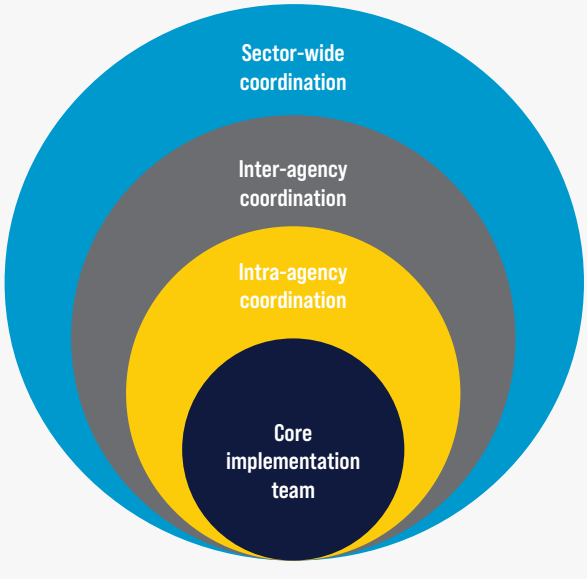
C

Intra-agency coordination. This third dimension relates to the level where key individuals within key agencies such as customs, ports or revenue authorities, internally coordinate among themselves and select key individuals for the implementation process. These key individuals are selected based on their relevant knowledge and level of authority for supporting the implementation process.

D

Core implementation body. This dimension relates to the core implementation team, where the coordination takes place directly at the functional and operational level among individuals of key agencies that undertake or oversee the actual implementation of solutions, technicalities and systems. The core team should include key institutions such as the customs, ports, standards and revenue authorities, with feedback loops across all key public and private sector stakeholder institutions. At this level, broad multi-stakeholder bodies such as NTFCs could also be useful in providing oversight and leadership.

Figure 10. Levels of stakeholder engagement for the implementation process



Source: Compiled by ESCWA.

All these four dimensions must include industry and private sector actors for the success of the stakeholder process. The various levels of stakeholder engagement are demonstrated in figure 10.

After the broad categorization and key stakeholders are identified, the definition of individual stakeholder roles that incorporate authority, domain and knowledge is important, especially when it comes to the constitution of the core implementing body. This process should be domain-dependent and reflect hierarchy. It would also necessarily vary from country to country. For example, while in some countries, customs will naturally form the core implementing body with a selected set of people from other agencies, in other countries the port authorities may constitute the core technical implementing body that undertake or oversee the actual implementation of the technology with the support of customs and other key agencies.

2. Understand stakeholder needs and communicate the benefits of the blockchain tools

Once stakeholders and their key roles have been identified and well defined, it is important to understand the trade facilitation needs, concerns and expectations of the stakeholders that can be addressed by the blockchain solutions. It is crucial to then tailor the stakeholder engagement towards addressing specific concerns and expectations by communicating to the stakeholders about the benefits of the technology and how it will help address those needs. For example, if private sector actors such as traders struggle with lack of transparency of Government processes, informing them about the unparalleled transparency, immutability and security of blockchain, as well as the empowerment of the private sector to independently verify and validate information using the blockchain solutions, could elicit their interest. Furthermore, certain Government agencies such as customs may struggle with the issue of quality assurance of declarations, under or over invoicing and revenue leakages due to inter-agency inefficiencies. Communicating to these stakeholders about the immutability, data integrity and security of blockchain and the technology's ability to prevent data tampering as well as drive inter-agency coordination efficiencies could secure their buy-in, interest and support in the implementation process. At this stage, undertaking a broad sectoral needs assessment for the technology will be appropriate.

Understanding the multi-user needs of the various key stakeholders also means considering the technical implementation processes of the blockchain for addressing these specific trade facilitation needs. While fully outlining and designing this would necessarily require the input of many agencies, it will be one of the most critical steps in the design process of the technical solutions. Understanding these user needs and outlining them ahead of the technical implementation process will be the key approach to ensuring that the blockchain solution meets the actual needs of the users and non-user stakeholders. Table 6 demonstrates some of the primary stakeholder user needs that may be incorporated into the design of the technical functionalities of a blockchain-supported user-facing application. It includes the user logic that would support key cross-border trade stakeholders adopted from the Global Report on Blockchain and its implications for trade facilitation performance.

Table 6. Key stakeholder needs that can be incorporated into blockchain design

Key stakeholders	Sector	Key technical design needs
National customs	Public	Interactive portal for: ■ Data authentication ■ Trade valuation ■ Payment processing ■ Issue and validation of Certificates of Origin ■ Notification alerts to/from other agencies
Agriculture authority	Public	Interactive portal for issuance and validation of sanitary and phytosanitary certification
Ministry of Trade/Trade Department	Public	A portal for approval/authentication of all trade documents, issuance of exemptions and preferential trade permits, and carrying out audits and sanctions
Health authority	Public	Interactive portal for issuance and validation of sanitary and phytosanitary certification
Standards authority	Public	A portal for the delivery of authorizations, classifications, and the issuance and revocation of licenses and permit
Revenue authority	Public	A portal for tariff lines, the receipt and processing of declarations and payments, and notifications/alerts to other agencies
Shipping agencies	Private	A portal for communicating and authenticating trader information, and for connecting/sharing such information with forwarders, bankers and Government agencies on documentation, declarations and transactions
Banking institutions	Private	A portal with integrated payment processing functionality, as well as communication functionalities to connect with traders, forwarders, shippers, customs and revenue authorities
Clearance/forwarding agencies	Private	A verification portal for trader-specific data, real-time trade flow, tracking of consignments, and the handling and forwarding of documentation, declarations and data to relevant Government agencies, shippers and banking institutions
Traders	Private	An all-encompassing portal for access to all service providers, payment processing, consignment tracking, self-declarations, certifications and credentials (especially of AEOs), and a notifications/alert system for approvals, sanctions and pending approvals

Source: Compiled by ESCWA.

3. Ascertain stakeholder readiness and preparedness for the technology

Once the stakeholder needs are understood and addressed with clear communication of the benefits of the technology and how it will address their needs, it is necessary to further assess the stakeholders' level of readiness and preparedness for the new technology. This involves understanding the concerns of the stakeholders regarding the implementation of blockchain technology in general, such as cost, complexity, user protection and security risks. Addressing these concerns is important to build trust and support for the implementation process. It also includes analysing the stakeholder's interests, expectations and level of influence on the overall implementation. Feedback mechanisms such as surveys and questionnaires that allow stakeholders to communicate their expectations and level of readiness for the new solutions will be particularly important for success. This will also inform the direction of focus of some of the subsequent steps to be taken in the implementation process such as nature of stakeholder training and education programmes, workshops and seminars. Furthermore, evaluating the stakeholder preparedness and contrasting that with the level of stakeholder interest in the technology will go a long way to support the implementation success and sustainability of the solutions. At this stage, undertaking a blockchain readiness assessment with the stakeholder inputs could help present a more complete picture of the level of preparedness of the various stakeholders.

4. Develop a stakeholder engagement implementation plan

Once the stakeholder needs and readiness are ascertained, it is important to put together a framework for stakeholder engagement. Developing a clear implementation plan that outlines the objectives, timelines, resources and expected outcomes for all stakeholder engagements will ensure success, efficiency and sustainability of the engagement efforts from the beginning to the end of the implementation process. The engagement plan must be reviewed on an ongoing basis to reflect the state of progress and emerging needs of the team and stakeholder groups that are engaged in the implementation process. This could also include a governance plan both for the application/use case and for the infrastructure. Furthermore, the plan should be continuously shared with all key stakeholders for input, feedback and to ensure that everyone is aligned and supportive of the implementation process. This engagement plan is best designed by an all-inclusive body like an NTFC. A basic template for the key components of the stakeholder engagement plan is presented in table 7. This can be adjusted according to each country's needs and based on the prevailing conditions of the implementing body.

Table 7. Key components of a stakeholder engagement plan

Key Sections	Constituents of the key sections of the stakeholder engagement plan
Objectives	■ To ensure effective communication, involvement and collaboration among all key stakeholders throughout the implementation process of the blockchain and accompanying solutions for trade facilitation purposes. ■ To address all stakeholder concerns, gather valuable inputs and achieve successful and sustainable adoption and utilization of blockchain technology in the trade facilitation efforts of the Government.
Timelines	Key timelines will include the following milestones and durations: ■ The pre-implementation phase (6 months): Identify stakeholders, attribute initial stakeholder roles, assess stakeholder needs and preparedness and design modalities of subsequent engagements. ■ Communication phase (3 months): Design channels of communication on major activities, meetings and workshops, define mechanisms and commence official meeting routines. ■ Training and capacity-building phase (6 months): Undertake training sessions, workshops and capacity-building events to address specific stakeholder challenges and concerns, and receive feedback and incorporate it in the implementation phase. ■ Implementation and evaluation phase (6 months): Monitor progress, evaluate engagement processes and efforts, and make necessary adjustments to reflect emerging needs.
Resources	■ Human resource: Set up a dedicated team responsible for stakeholder engagement constituting individuals with specialized knowledge in, communication, training and coordination. These individuals should be members of the NTFC. ■ Financial resources: Outline funding needs for communication, training materials, meetings, events, workshops and other engagement activities. ■ Communication systems: these should be channels of communication such as emails, newsletters, portals, social media accounts and surveys. ■ Training and support materials: Comprises user manuals, guides, tutorials, online courses and other training resources.
Expected outcomes	■ Increased stakeholder understanding of the benefits of blockchain technology. ■ Address concerns, mitigate resistance and build a sense of ownership and support for the technology among stakeholders. ■ Receive valuable inputs, suggestions and feedback throughout the implementation process for continuous improvement and alignment with stakeholder trade facilitation needs. ■ Stakeholders successfully adopt and utilize the technology, maximizing its potential benefits and minimizing risks. ■ Stakeholder groups that feel heard, valued and involved in the implementation process, resulting in a positive overall experience and increased satisfaction of all members.

Source: Compiled by ESCWA.

5. Organize key stakeholders before commencement of the implementation process

Once the stakeholder engagement plan is complete, key stakeholder involvement ahead of commencement of implementation is critical. Stakeholder coordination meetings, workshops and multi-agency engagement forums that bring every key agency and stakeholder group onboard will be crucial to the successful implementation and sustainability of blockchain infrastructure and solutions. This will lay the foundation for future engagement processes and will ensure the long-term health and use of the solutions. This process of organizing the stakeholders will also ensure that initial roles of the key stakeholders are well understood and that any needed adjustments will be executed ahead of the actual implementation of the project. This will further ensure that any initial conflations, gaps or overlaps of stakeholder roles are eliminated to establish clear lines of responsibility, duty and roles.

6. Training, education, research and support for stakeholders

Providing training and support to the stakeholders to ensure they are comfortable with the new technology and can use it effectively is one key component of the stakeholder organization process. This training can be geared towards multiple goals, such as helping stakeholders understand the key benefits and utility of the technology and helping increase their preparedness, ability and interest in the technology, and encouraging the maximum utilization of the solutions. Furthermore, undertaking periodic research towards improving the extent to which the technology meets stakeholder needs will be crucial. For example, if some stakeholders have high expected value of the technology based on their trade facilitation needs but have low knowledge of the technology and are thus less prepared, training efforts that are tailored towards empowering these stakeholders will be very useful. On the contrary, if certain stakeholders with high authority to support the implementation rather have low expectations on the technology's utility for their trade facilitation needs, education should be tailored towards the benefits, value proposition and efficiency gains of the technology for these concerned stakeholders and agencies. Empowering stakeholders through training, research and support is a key aspect of ensuring that the technology is well implemented and optimally used in a sustainable manner.

7. Implement stakeholder feedback loops, monitoring and evaluation

Continuous review of the stakeholder dynamics gives the overall implementation and utilization of the solutions an up-to-date perspective of stakeholder needs as well as expectations. It is important to constantly monitor and evaluate the implementation to identify areas for improvement and address any issues that arise. This will also help to ensure the success of the implementation and maintain stakeholder support. Also, evaluating the stakeholder engagement process to determine its effectiveness will allow for necessary adjustments in a timely fashion and will determine the sustainability of the project in a long term. Lastly, keeping stakeholders informed about the progress of the blockchain implementation process and its expected impact on existing trade facilitation infrastructure as well as the value of the new blockchain solutions is key.

In summary, getting the inter-agency vis-a-vis intra-agency coordination right is key for the overall implementation process. To get the above processes and steps right, some recommendations on the process of establishing the stakeholder ecosystem to support the implementation process are elaborated in table 8.

Table 8. Key recommendations for inter- and intra-agency coordination

Key Step	Recommendations
Selecting the lead implementing body/ agency	■ Choose a more technical agency that directly handles cross-border trade processes. This could be the customs, port or revenue authority. ■ The Ministry or Department of Trade will be a critical policy partner in providing leadership, oversight and resources for the lead implementing body's work.
Choosing the implementation team	■ The core implementation team will necessarily need to be made up of multiple stakeholders from core agencies that directly handle cross-border trade processing. ■ A technical team with appropriate knowledge and authority (middle-level management is most suitable) comprising customs, the ports and harbours authority, and the revenue authority will be best constituents of core implementing team.
Organizing the key stakeholders around infrastructure	■ Inter- and intra-agency coordination is best handled by a body like the NTFC with the collaboration of all key agencies and the private sector on issues around infrastructure design, user feedback on tools and user experience with the infrastructure.
Defining roles of key stakeholders	■ This should be done at the inter-agency and intra-agency levels. ■ At the inter-agency level, bodies such as NTFCs can coordinate and organize the dialogue on the key roles of each agency. ■ Once the roles of each key agency are defined, individual agencies will need to further select key individuals and their roles for proper coordination in the intra-agency context.
Sustaining stakeholder interest and participation	■ Once key stakeholders and their roles are well defined, sustaining the interest and continuous participation of the stakeholders in the implementation and sustainability of the ecosystem is key. ■ This will include constant communication, training, stakeholder support workshops and materials.

Source: Compiled by ESCWA.

A summary of the seven key steps of the stakeholder engagement process is presented in table 9.

Table 9. A summary of the seven key steps for building stakeholder engagement

Step	Process description
Identify key stakeholders and define key roles	Involves identifying stakeholders who will be critical to the implementation process and defining their roles at the four key levels (sectoral, inter-agency, intra-agency and core implementing team).
Understand stakeholder needs and communicate the benefits of the blockchain tools	Involves understanding the trade facilitation needs, concerns and expectations of the stakeholders and tailoring the engagement process so that it addresses these expectations, concerns and needs.
Ascertain stakeholder readiness and preparedness for the technology	Involves understanding the concerns of stakeholders regarding implementation, such as cost, complexity, user protection and security risks, and addressing these concerns in order to build trust and support for the implementation process.
Develop stakeholder engagement implementation plan	Developing a clear implementation plan that outlines the objectives, timelines, resources and expected outcomes for all stakeholder engagements will ensure the success, efficiency and sustainability of the engagement efforts from the beginning to the end of the implementation process.
Organize key stakeholders before commencing the implementation process	Stakeholder coordination meetings, workshops and multi-agency engagement forums that bring every key agency and stakeholder group onboard will be crucial to the successful implementation and sustainability of blockchain infrastructure and accompanying solutions.
Training, education, research and support for stakeholders	These should be geared towards multiple goals, such as helping stakeholders understand the key benefits and utility of the technology and helping increase their preparedness, ability and interest in the technology, while encouraging the maximum utilization of the solutions.
Implement stakeholder feedback loops, monitoring and evaluation	Continuous review of the stakeholder dynamics gives the overall implementation and utilization of the solutions an up-to-date perspective of stakeholder needs and expectations.

Source: Compiled by ESCWA.

C

Public-private partnerships as a key policy consideration

Establishing PPP is a standard approach for most physical and digital infrastructure development projects aimed at Government use. The approach holds many advantages that can support the success and sustainability of the infrastructure in question. PPPs not only leverage the strengths of both sectors but also bring optimal use of resources and expertise. Furthermore, given the crucial role of the private sector within the trade environment of most countries, the involvement of the private sector at the technical, policy and regulatory levels of the implementation process is the best way to guarantee an inclusive approach and ensure that the technology meets the needs of all key stakeholders. A PPP approach to the implementation process can thus bring many benefits to the implementing body, some of which are elaborated below:

1

Cost-effectiveness

By making use of private sector expertise, critical talent and delivery efficiencies, PPP can bring cost savings to the Government and ensure that limited financial resources bring high yields. Also, by enabling access to a wider range of such expertise, a larger talent pool and the additional capabilities across both the private and public sector, a PPP approach will likely benefit the blockchain implementation process and make it more cost-effective as a result of the multiple competencies, higher accountability standards, deeper stakeholder alignment and innovative performance mechanisms.

2

Collaborative innovation

Blending the technical know-how of the private sector with the policy endowments of the public sector can foster critical innovation for the benefits of the Government and the implementing body. While the private sector is known for its market-driven creativity, the public sector is known for its broad knowledge of societal needs. A combination of such domains in the blockchain implementation process can lead to significant innovation and successful collaboration towards the meeting of the trade facilitation needs of the Government.

3

Efficiency and risk management

A PPP approach to the implementation process can help mitigate the financial and operational risks that come with implementing significant physical and digital infrastructure. By allowing the implementation process to be a shared investment between the Government and the private sector, the process not only reduce the overall resource demands on the Government, but also presents the Government with the opportunity to share the challenges and potential operational hurdles with competent, efficient and innovative private sector partners. This reduces overall risks and drives efficiency for an optimal outcome in the implementation process.

The blockchain-based advance cargo information system of Egypt, which has become an integral part of the country's national single window and currently helps expedite shipment clearance, reduce cost and time for both sea and air freight, is an example of a PPP blockchain infrastructure implemented as a collaborative effort between CargoX and the Government-owned MTS.

4

Inclusive and impactful results

By involving both public and private sector partners and stakeholders, PPP can ensure a user-centric design approach, where key private sector stakeholders such as forwarders, shipping agents, clearing houses and other private sector AEOs provide critical user-experience inputs for the overall implementation process. Some of these private sector stakeholders can also become implementing partners leveraging their experience and expertise over the years to bring intuitive, user-friendly and well-aligned user benefits from the blockchain solutions. This will ensure the best long-term impact from the blockchain solution within the trade environment.

5

Capacity benefits

Partnerships between the public sector and the private sector usually promote knowledge transfer between these sectors. Thus, while the private sector can benefit significantly from the knowledge and processes of the public sector the opposite is also true. That is to say, the public sector can equally benefit from the technical expertise, efficiencies and innovation of the private sector to enhance their own practices. These insights can help improve other areas of the Government operations and improve the general processes of the public sector.

6

Long-term sustainability

The involvement of multiple parties in the implementation process through PPP can contribute to the long-term sustainability of the blockchain solution in the trade environment. This can be partly driven by the shared risk outlook between the two sectors but also enhanced by the maintenance culture of the private sector. Thus, by incorporating maintenance and support provisions in the partnership design, the expertise and talent of the private sector will be continuously leveraged for the long-term success and sustainability of the infrastructure even after the initial implementation phase.

A summary of the benefits of a PPP approach to the implementation process is presented in table 10.

Table 10. A summary of the benefits of a public-private partnership approach to the implementation process

PPP benefit	Description
Cost-effectiveness	By making use of private sector expertise, critical talent and delivery efficiencies, PPP can bring cost savings to the Government and ensure that limited financial resources bring high yields.
Collaborative innovation	The technical know-how of the private sector together with the policy endowments of the public sector can foster critical innovation for the benefit of the Government and the implementing body.
Efficiency and risk management	Allowing the implementation process to be a shared investment between the Government and the private sector not only reduces the overall resource demands on the Government but also presents the Government with the opportunity to share the challenges and potential operational hurdles with competent, efficient and innovative private sector partners.
Inclusive and impactful results	By involving both public and private sector partners and stakeholders, PPP can ensure a user-centric design approach, where key private sector stakeholders, such as forwarders, shipping agents, clearing houses and other private sector AEOs, provide critical user-experience inputs for the success of the overall implementation process.
Capacity benefits	Partnerships between the public sector and the private sector usually promote knowledge transfer between these sectors with the Government participants benefiting from the technical expertise, efficiencies and innovation of the private sector to enhance their practices within the public sector.
Long-term sustainability	Involvement of multiple parties in the implementation process through PPP can contribute to the long-term sustainability of the blockchain solution in the trade environment.

Source: Compiled by ESCWA.

D
Establishing public-private partnership for blockchain implementation

Establishing a PPP process for implementation involves multiple steps and a series of considerations to ensure successful collaboration, efficient performance and deep commitment from both sectors in the development, deployment and adoption of the blockchain infrastructure. While the technical development process can be easily undertaken with a simple partnership agreement, the stakeholder engagement processes can be complex and requires a significant level of process planning to be inclusive enough. Below are some of the key steps in establishing the PPP process for the implementation process. These can vary from one context to another, depending on the number of partners, governance system or the implementing body's mandate.

1. **Resource allocation:** Resource planning is a key component of the entire implementation process and is especially important when preparing a PPP approach, not just for determining these resources but also for apportioning them according to workload and responsibilities of the implementing

partners in a way that will ensure success. The allocation of the components of work is thus accompanied by the allocation of resources. Determining the financial, human and technical resources required for the overall implementation, identifying the sources of the resources and allocating these resources according to the components of the work commitments required from both the public and the private implementing partners is key.

2. **Defining implementing partner requirements:** Identifying the appropriate implementing partners will depend on key indicators defined by the implementing body. These indicators can include performance history, talent and expertise, resource capabilities and attestations of other relevant stakeholders. These will form the basis of selection of the public and private sector partners who are qualified to contribute to the partnership. Any institution that meets these requirements, such as Government agencies, software development firms, industry experts, research consultancy firms or academic institutions, can then be considered for the initial pool of potential partners for the implementation process.

3. **Design of legal and technical frameworks:** Developing the technical and legal frameworks that will govern the partnership will give clarity to potential partners on what to expect from the partnerships as well as what is expected of them in the partnership. For example, a technical/legal document that spells out the deliverables, and objectives of the solution as well as the timelines and resource commitments of the implementation process will give potential implementing partners a clear understanding of their eligibility by establishing the minimum requirements for expressing interest in joining the implementing process as a partner. The framework may take the form of a draft agreement, memorandum or draft contract that outlines the commitments, deliverables, responsibilities and expectations from potential partners.

4. **Seeking expressions of interest:** This is the stage where potential partners are requested to express interest in being implementing partners, usually through a request for proposals (RFP), where potential partners can apply either as individual implementing partner or as consortia. It is important to clearly define the project scope, obligations, evaluation criteria and timelines at the time of publishing the RFP. This ensures transparency, accountability and encourages broad-based participation by all qualified potential implementing partners.

5. **Evaluation and selection:** Received proposals are evaluated based on the predefined criteria set out at the technical frameworks stage and a selection is made based on the suitability and eligibility of the potential implementing partner or set of partners. Factors such as technical expertise, track record, financial viability and alignment with project objectives are key to consider.

6. **Partnership agreement:** After selection of a partner or set of partners, there is need to design and negotiate a partnership agreement that outlines the roles, responsibilities, rights and obligations of each partner in the implementation process. This stage is crucial for the overall success and sustainability of the blockchain project and its level of utility for the trade facilitation stakeholders. Most terms and conditions as well as technical and legal aspects in the partnership agreement will have direct consequences on the technical considerations of the infrastructure. The agreement should therefore address, among other things, the details of technical considerations, consensus mechanisms, architectural design, data governance, confidentiality, dispute resolution mechanisms and user-friendliness. As shown in figure 11, key areas to be considered within the partnership agreement include:

a. Development, deployment and maintenance: The partnership agreement should primarily consider architectural designs and other technical details of the development, deployment and maintenance process of the blockchain and its accompanying applications. It should clearly communicate technical design details on performance, security and sovereignty of the infrastructure and indicate key performance indicators to be met when the work is complete. The agreement should also establish mechanisms for ongoing maintenance, updates and support to ensure that the infrastructure and its accompanying solutions remain fully functional, meet user needs and perform optimally;

b. User evaluation and feedback mechanisms: The partnership, among other things, must include clear mechanisms for periodic evaluation, user feedback and regular inputs from key stakeholders to ensure that the solutions meet performance requirements, lead to user satisfaction and are improved in a timely manner whenever there are technical issues. The partnership must involve channels of feedback from end-users, stakeholders and Government agencies to identify areas for improvement, adjustments and iterations towards optimal use;

c. Knowledge sharing and capacity-building: The agreement should include mechanisms for knowledge sharing between the public and private sectors, facilitate skills transfer and promote capacity-building, especially for the public sector partner(s). This would help build expertise within the public sector and foster long-term sustainability of the blockchain and its usability. The agreement should specifically indicate channels for knowledge transfer and the legal means to address any failure to comply by this condition. It should also indicate which key public sector stakeholders the knowledge transfer process should be aimed at, ensuring that the knowledge benefits the Government the most;

d. Quality assurance, testing and audits: Another key component of the partnership agreement should be to ensure that the developed blockchain infrastructure, solutions and applications meet required quality standards, and that it is thoroughly tested for functionality, usability and security, with all codes audited through rigorous code reviews to identify and rectify any issues or bugs and ensure safety.

Figure 11. Select components of the partnership agreement for the implementation process

Source: Compiled by ESCWA.

The key steps for establishing a PPP approach are summarized in table 11.

Table 11. Summary of steps to establish a public-private partnership approach for the implementation process

Key step	Process description
Resource allocation	This involves determining the financial, human and technical resources required for the overall implementation, identifying the sources of the resources, and allocating these resources according to the components of the work commitments required from both the public and the private implementing partners.
Defining implementing partner requirements	This involves developing key indicators such as performance history, talent and expertise, resource capabilities, and the attestations of other relevant stakeholders to select partners such as Government agencies, software development firms, industry experts, research consultancy firms or academic institutions to join the implementation process.
Design of legal and technical frameworks	The outcome is a technical/legal document that spells out the deliverables, objectives of the solution, timelines and resource commitments of the implementation process, which will give potential implementing partners a clear understanding of their eligibility by establishing the minimum requirements for expressing interest in joining the implementing process as a partner.
Seeking expressions of interest	This usually takes the form of an RFP calling for potential partners to apply either as individual implementing partner or as consortia. In the RFP it is important to define the project scope, obligations, evaluation criteria and timelines at the time of publication to ensure transparency and accountability and to encourage broad-based participation by all qualified potential implementing partners.
Evaluation and selection	Received proposals are evaluated based on the predefined criteria set out at the stage of the technical frameworks and a selection is made based on the suitability and eligibility of the potential implementing partner or set of partners.
Partnership agreement	This step involves designing and negotiating a partnership agreement that outlines the roles, responsibilities, rights and obligations of each partner in the implementation process.

Source: Compiled by ESCWA.

Regulatory guidelines for implementation

CHAPTER 05

A
Regulatory considerations: compliance and meeting international standards

Blockchain technology is relatively new, but its reach has already become global. Governments have already attempted in several ways to build legal, regulatory and compliance systems aimed at ensuring that the technology works for the good of society. However, many Governments have not yet established robust legal systems within which the technology could function and thrive. Furthermore, blockchain for trade facilitation purposes has not yet reached mass use, and while many Governments are looking into this potential, many still struggle with the regulation and compliance components of the implementation process.

The present section outlines the foundational steps for building the regulatory environment and implementing blockchain technology in a compliant manner that incorporates such legal and compliance processes into the core design process of the technology. The implementation of blockchain solutions must consider compliance as an integral part of the development and adoption process. Hence, the present section focuses on processes that meet international legal frameworks and standards as well as the approach Governments should take to incorporate these standards into the blockchain implementation process. This section also considers the necessary steps to help stakeholders and user groups understand the nature, procedures and requirements of compliance mechanisms that can ensure safe use of the technology in cross-border trade.

B
Key steps to support regulation and compliance

The technical features of blockchain make compliance, quality assurance and controls particularly enforceable. For example, the use of digital signatures, which is a default feature of the technology, can easily guarantee the safety of the user, security of the systems and auditability of the user activities. This, together with other digital and technical features, can help assure the smooth implementation of compliance mechanisms, improved risk management and regulatory oversight. While blockchain solutions could help Governments meet trade compliance needs in risk management and the prevention of fraud, the technology also needs critical compliance measures for its proper use by stakeholders. Below are the key steps for ensuring a holistic regulatory

environment and a compliant implementation process for blockchain for trade facilitation.

1. **Defining the regulatory domain and legal gaps:** Before implementing any digital technology, blockchain included, it is imperative to define areas of regulatory weakness, legal gaps and compliance needs. This allows for the proper setting up of compliance systems to fill the regulatory gaps. As a relatively new technology, blockchain can usually work within existing compliance systems that regulate the broader digital economy, but it sometimes requires more than the existing regulations, especially for certain use-cases. For example, as a decentralized digital infrastructure, blockchain data is usually hosted in multiple systems with servers that are constantly synchronizing in real-time. This introduces new complexities on issues around data governance, privacy and user protection. This could sometimes require new legal structures that are different from the existing centralized data hosting systems. Furthermore, it could also require a new definition of data protection, data liability, user privacy and broader data governance issues around smart contracts and digital signatures before implementing the actual infrastructure.

2. **Identifying the regulatory requirements of expected use-cases:** Once the broader regulatory gaps have been identified, the next step is to determine sector-specific regulatory and compliance needs. While blockchain can be general-purpose technology, the use-case largely determines the compliance processes needed for the technology to function as intended. Thus, while a Government may have broader regulatory gaps for a new technology like blockchain, there can also be sector-specific regulatory ambiguities and discrepancies. Within trade facilitation, there are several trade-facilitation-specific regulatory and compliance processes to respect. Important trade regulations that would have to be considered at this stage could range from the data requirements of trade declarations to quality concerns about the declared goods. Defining sector-specific regulatory gaps would thus determine the specific regulatory processes that will be implemented at the technical level. Compliance with these sector-specific regulatory components can usually be implemented and achieved at the application level of the blockchain infrastructure. Furthermore, international standards on the specific sector could support the regulatory design process. For example, in trade facilitation, technical and legal standards such as the WCO SAFE Framework of Standards to Secure and Facilitate Global Trade, the International Convention on the Simplification and Harmonization of Customs Procedures, and the WCO Data Model are key guidance instruments that could assist the process. At this stage, it is important to involve industry stakeholders and private sector experts to undertake a broad review of existing regulations within the specific expected use-case area(s) and ascertain legal and compliance gaps, discrepancies and risks that could be mitigated by ensuring compliance.

3. **Designing a legal framework:** Once the regulatory gaps have been established at the national, sectorial and use-case levels, the next step is to build a relevant regulatory framework that fits the use-case, while adhering to the broader regulatory system. The regulatory framework must outline the compliance procedures and processes for both users and non-user stakeholders who engage with the blockchain system for all trade procedures. The rules and guidelines of engagement may include standards for data privacy, data governance, security and transparency, as well as guidelines for applications and smart contract development, as well as other aspects of the blockchain application layer. This level of the regulatory design is more specific and will necessarily involve the implementing stakeholder groups.

The design of regulatory frameworks would take place at more than one level:

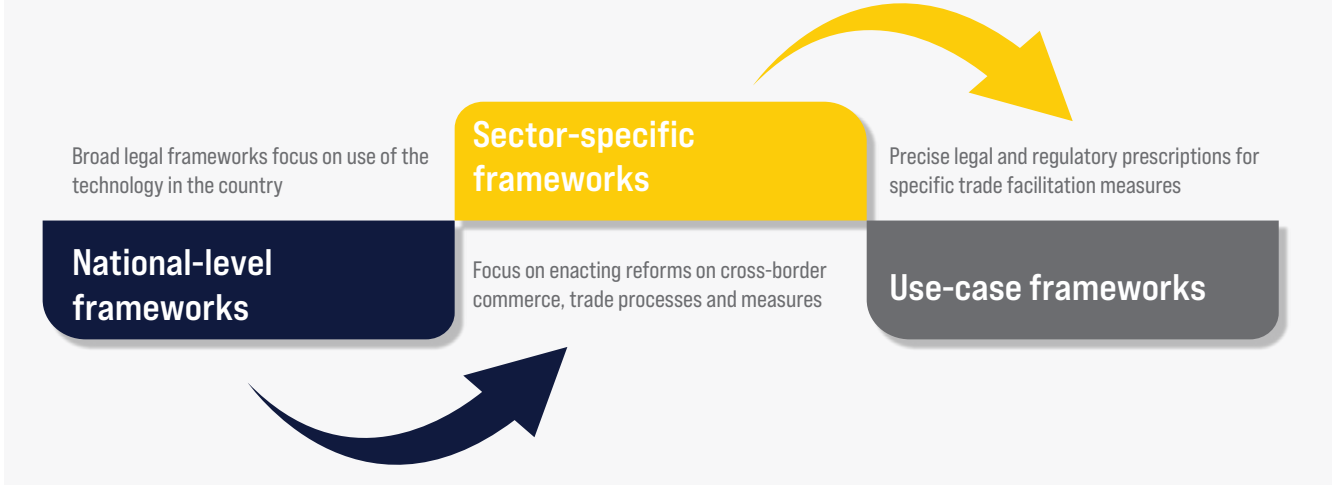
a. *National level frameworks.* This broad legal framework on use of the technology in the country can focus on a sector such as trade and commerce, or it can be a broad legal document on the use of the technology in general within the country. This framework will usually lack implementation precision but will convey strategic policy and regulatory directions that may take into consideration regional and international contexts of the use of the technology;

b. *Sector-specific frameworks.* These focus on exacting reforms on cross-border commerce, trade measures and driving trade facilitation efforts. Sector-specific frameworks focus on broader implementation guidelines that prescribe sector-wide reform strategies and will usually involve multiple stakeholders within the trade ecosystem;

c. *Use-case frameworks.* These regulatory frameworks give more targeted and precise legal and regulatory prescriptions on improving efficiency and driving value in relation to the precise trade facilitation needs of the Government. Such frameworks focus on the use-case of the blockchain solutions, such as in trade auditing, trade risk management, payment of duties, track and trace or fraud detection. The three levels of regulatory framework design are demonstrated in figure 12.

4. **Establishing compliance procedures:** Building a regulatory framework is important but establishing a compliance protocol is particularly relevant for important technologies like blockchain and for critical sectors like trade. Once a framework is in place, the next step will be to develop compliance procedures that help stakeholders meet regulatory requirements in the use of the blockchain solutions. Stakeholders need compliance mechanisms to ensure they successfully use the tools of the new technology and for general proper digital hygiene that reduces risks to users. Compliance procedures must also support system-wide digital health through regular inspections, audits and quality assurance of the systems. These compliance mechanisms should limit the regulatory burden on the user while ensuring that necessary standards are met. Preparing and documenting a protocol on compliance as a simple and understandable user guide can help stakeholders significantly.

Figure 12. The three levels of regulatory framework design



Source: Compiled by ESCWA.

5. **Informing and supporting user groups:** Educating stakeholder groups such as customs, clearing agents, revenue authorities, traders and ministries about the regulatory framework and compliance mechanisms is a key component of building the regulatory environment for any new technology. Once regulatory frameworks and the technical infrastructure are in place, stakeholder engagement that results in full familiarity with the technical and regulatory procedures is key to ensuring a successful and sustainable use of the blockchain environment. This can be done through stakeholder training, education and information and can take the form of training workshops, seminars, outreaches, flyers and booklets as well as user guides that communicate the user benefits, obligations and key dimensions of compliance.

6. **Enforcement:** While regulatory frameworks may give a particularly useful setting for the successful implementation of blockchain for trade facilitation, compliance is not guaranteed without proper systems of enforcement. Once training and education of the stakeholders is complete, the next step is enforcement that ensures compliance. Enforcement of the regulatory frameworks could take place through appropriate mechanisms such as fines or penalties for non-compliance, or revocation of licenses or certifications for breach of authority or abuse. Enforcement must be conducted fairly and transparently, with appropriate due process of protections for other stakeholders while deterring future non-compliance.

7. **Monitoring and improving the legal systems:** The legal, regulatory and compliance mechanisms should undergo continuous improvement. User feedback must be incorporated into further adjusting and refining the legal frameworks to meet emerging trade facilitation needs of stakeholders. The implementing agency must therefore continuously monitor and collect user feedback and improve the legal frameworks that govern the use of the technology. This allows for out-of-date laws to be changed or replaced as the technology evolves and helps ensure that the regulatory framework remains effective and relevant over time. The process may involve conducting regular legal reviews and assessments of the regulatory frameworks, regular legal updates that reflect changes in the technology, as well as other emerging trade facilitation issues that may impact or be impacted by the regulatory landscape over time.

A summary of these key steps is presented in table 12.

Table 12. Key steps in the legal and regulatory process

Key regulatory step	Description
Defining the regulatory domain and identifying legal gaps	This involves defining areas of regulatory weakness, legal gaps and compliance needs so that compliance systems can be set up to fill the identified regulatory gaps.
Identifying the regulatory requirements of expected use-cases	This step aims to address sector-specific regulatory ambiguities and discrepancies with regards to trade facilitation and compliance with trade measures.
Designing a legal framework	This involves outlining the compliance procedures and processes for both users and non-user stakeholders at the national, sectorial and use-case levels of the technology. The rules and guidelines of engagement may include standards for data privacy, data governance, security, transparency and smart contracts.
Establishing compliance procedures	A compliance protocol outlines measures for system-wide digital health through regular inspections, audits and quality assurance of all digital systems accompanying the blockchain.
Informing and supporting user groups	This involves building stakeholder familiarity with the technical and regulatory procedures for successful and sustainable use of the technology through training workshops, seminars, outreaches, flyers, booklets and guides that communicate user benefits, obligations and key dimensions of compliance.
Enforcement	This involves measures such as fines or penalties for non-compliance, or the revocation of licenses or certifications for breach of authority or abuse. Enforcement should be conducted fairly and transparently, with due process for protections and deterrence.
Monitoring and improving the legal systems	Stakeholder feedback is incorporated into further adjusting and refining the legal frameworks to meet emerging trade facilitation needs. This step involves conducting regular legal reviews and assessments of the regulatory frameworks to undertake regular legal updates that reflect changes in the technology.

Source: Compiled by ESCWA.

C

A work breakdown structure for the regulatory framework

A WBS is useful for breaking down complex legal and compliance processes into smaller, more manageable tasks. Table 13 shows a WBS for the regulatory, legal and compliance process when designing a blockchain ecosystem for trade facilitation purposes.

A work breakdown structure is useful for breaking down complex legal and compliance processes into smaller tasks.

Table 13. A work breakdown structure for the legal and regulatory framework

Steps	Implementation components
Initiation	■ Define regulatory and compliance objectives. ■ Identify implementing partners, experts and stakeholders. ■ Design a national, sector-specific and use-case-specific framework guidelines.
Planning	■ Define regulatory scope. ■ Identify compliance requirements. ■ Undertake legal reviews to establish legal and regulatory gaps. ■ Develop a compliance plan. ■ Create implementation schedules for compliance schemes. ■ Develop implementation budget. ■ Define core regulatory team for domain-specific regulations.
Analysis	■ Conduct a legal and regulatory analysis. ■ Identify compliance risks and enforcement challenges. ■ Develop compliance milestones, penalties and protocols.
Design	■ Design regulatory policies, procedures and protocols. ■ Develop a compliance training and support programme. ■ Design a legal monitoring system and compliance audit processes. ■ Define a process for reporting and investigating breaches. ■ Develop a data governance, privacy policy and information security programmes.
Implementation	■ Implement compliance policies and procedures and protocols. ■ Conduct compliance training for stakeholders. ■ Launch regulatory and compliance audit processes. ■ Implement data governance systems, privacy policies and information security programmes.
Monitoring and reviewing	■ Conduct continuous legal and regulatory audits. ■ Conduct periodic compliance risk assessments. ■ Undertake regular evaluations of regulatory systems to ascertain the effectiveness of compliance. ■ Conduct relevant regulatory reviews and legal updates. ■ Identify areas for improvement and implement changes.

Source: Compiled by ESCWA.

D
Coupling technical standards with regulation and compliance

In the use of blockchain tools, most regulation and compliance issues need a technical component to be reliably enforceable. Thus, Governments may have to establish various technical standards as well as comply with existing standards that will support the implementation of effective blockchain compliance systems. These standards help ensure that the technology is used in a manner that complies with regulations and reduces the risks of fraudulent or illegal activities. Some key compliance areas that will have to be ensured through technical implementation techniques and processes include the following:

1. **Privacy policy, security standards and data governance:** User privacy and security standards are essential for ensuring that personal data is protected from unauthorized access and misuse. Governments that build digital solutions with blockchain for trade facilitation purposes have a legal imperative to design the protocols and processes that appropriately handle the types of user data collected, where that user data is stored, and which users have the rights and authority to access such sensitive data. This may include alignments with already existing data management protocols and processes that are not specific to blockchain. Also, key compliance disclosures around user data handling including credentials such as usernames, contact details and IP addresses, must be clearly communicated. Technical standards around data encryption, secure storage and access control that ensure the protection of sensitive personal data must therefore be implemented both at the user portal level and on the database. Trade data can be sensitive or even proprietary and these kinds of data must be protected, encrypted and guarded by modern data management practices. From declarations to invoices, licences and certificates, data handling through the blockchain that are aimed at ensuring ease of information flow must also meet protection standards for purposes of regulation and compliance. For example, the blockchain-enabled advance cargo information system for the Egyptian Government was designed to be compliant with the provisions of the WCO SAFE Framework as well as the WCO Data Model and many other WCO instruments and items of guidance (Kotb and Igor, 2022).

2. **Interoperability standards:** For compliance, interoperability standards that ensure that critical information can be passed between one blockchain network and another or between a blockchain system and a legacy system must be properly designed, implemented and enforced. Ensuring safety and compliance in data storage is as important as ensuring compliance with the transfer and exchange of that data. Thus, interoperability standards should not only be aimed at the seamless transfer of data, but also the safety of the data while in transit. Governments implementing blockchain for trade facilitation purposes must establish technical standards that specify the protocols, formats and security requirements for data exchange between different digital domains. Technical standards around the encryption of data in transit, secure transfer and access controls must thus be implemented at the user-facing level as well as the back-end when possible.

3. **Smart contract standards:** Smart contract standards specify the technical requirements for developing and deploying smart contracts on blockchain networks. As tools for business logic between the blockchain and the user-facing portals, smart contracts play key roles such as defining user credentials, rights and privileges, as well as being used for automation purposes. Compliance standards on smart contracts should focus on data protection, safety, privacy and security. As digital vehicles that allow users to interact with the blockchain based on the use-case, smart contracts must meet minimum standards around data transfer, automation and communication. This compliance can be achieved by extensive design testing and auditing of the smart contracts.

4. **Consensus mechanism standards:** Consensus mechanism standards specify the rules and procedures for validating records and adding new information to the blockchain. This aspect of the technical design process forms the core of the blockchain infrastructure. Standards of regulation and compliance can be ensured by the technical specifications that are baked into the core of the consensus mechanism. Data requirements around the security, speed and resilience of the network influence the user experience and the compliance thereof. Specifications around the type of consensus, block size—the amount of data that can be stored in a single block of records— as well as the adopted cryptographic primitives, all

influence performance and user experience. But they also impact compliance. For example, a proof of authority consensus blockchain will naturally require that a hierarchy of authority be allocated to the network participants, which will grant some network participants higher compliance privileges compared to others. Governments must therefore establish technical standards that specify the requirements for consensus mechanisms, including performance, security, the degree of decentralization of the blockchain network and the dynamics of authority to ensure compliance.

5. **Identity standards for users:** Digital identities and user identifiers are default features of blockchain. The use of blockchain for a multi-user, multi-agency ecosystem like trade facilitation requires a distinct set of policy, regulatory and technical standards on user identity management and user identifiers. This will influence many aspects of the use of the blockchain solution, including the auditability of user activities, risk management, access controls and quality assurance. The standards and protocols on user identity management will also determine the level of user protection, user accountability and user privileges. Digital identity standards thus specify the technical requirements for verifying and managing digital identities on the blockchain network. To ensure compliance, bodies implementing blockchain for trade facilitation must create technical standards for digital identity verification, authentication and authorization that are in line with the established regulatory and policy environment.

6. **Auditing and quality control standards:** While ensuring compliance is an ongoing activity, the implementation procedures that ensure continuous compliance must be designed at the beginning. Auditability of user activities, data processes and security protocols must be at the centre of the design process. Audits and reporting standards specify the requirements for quality assurance of activities on the blockchain to ensure compliance with regulations. Technical standards that specify data elements, frequency and format for reporting blockchain records and activities will be necessary for ensuring compliance for most trade facilitation use-cases and for efficient and safe use of the technology in general.

A summary of technical standards for regulatory compliance is provided in table 14.

Table 14. Summary of technical standards for regulatory compliance

Standard	Description
Privacy policy, security standards and data governance	These are technical standards around data encryption, secure storage and access controls to protect sensitive personal data implemented both at the user interface levels and at the database levels.
Interoperability standards	These are technical standards that specify the protocols, formats and security requirements for data exchange between different digital domains comprising blockchain and non-blockchain legacy systems.
Smart contract standards	Standards on smart contracts focus on data protection, safety, privacy and security for compliance around data transfer, automation, communication and storage.
Consensus mechanism standards	These standards specify the requirements for consensus mechanisms, including performance, security and the degree of decentralization of the blockchain network, with compliance as a key consideration.
Identity standards for users	User identity management standards determine user protection, user accountability and user privileges. They specify technical requirements for verifying and managing digital identities on the blockchain network and grant rights around approvals, authentication and authorization.
Auditing and quality control standards	Auditing and reporting standards specify the requirements for quality assurance of data, the auditability of user activities and security protocols. The standards also specify data elements, as well as the frequency and format for reporting blockchain records and activities.

Source: Compiled by ESCWA.

Challenges and use-case overview

CHAPTER 06

The present section of the guide outlines the common challenges usually faced by implementing bodies both in industry and in Government and sets out a number of use-cases for the technology for trade facilitation purposes, as well as implementation considerations for each of those use-cases.

A
Common challenges in the implementation of blockchain

Implementing blockchain technology can be difficult and challenging. The technology's complexity and emergent nature makes it difficult to implement without running into talent shortages, resource constraints, as well as technical and regulatory limitations. Overcoming these challenges around talent and expertise, regulatory discrepancies, infrastructure incompatibilities as well as data governance issues is thus a necessary component of the implementation process. Some of the challenges that are commonly encountered by both Government and industry in the implementation process of the technology are outlined in figure 13. These range from regulatory frameworks to data protection, as well as resource constraints and a lack of talent and expertise.

Figure 13. Summary of common challenges in blockchain implementation

Source: Compiled by ESCWA.

These challenges are outlined in further detail below.

1

Regulatory and legal frameworks

Certain technical features and user-facing tools around blockchain technology necessitate new regulatory regimes and legal frameworks to support their use. For instance, digital signatures are a necessary and critical part of the technology. They allow the average user to interact with the blockchain. But most countries do not yet have laws that support the use or recognize digital signatures. Thus, Government agencies must find ways to navigate complex regulatory and legal frameworks or design new ones to ensure compliance with these new solutions in trade processes. New legal and regulatory frameworks for the use of blockchain technology must specifically address the use of smart contracts, digital signatures, privacy protection and data governance. But adapting existing regulations to accommodate the use of blockchain technology can be a significant challenge for most countries.

2

Incompatibilities with legacy infrastructure

Governments often operate multiple systems, databases and digital solutions for trade facilitation purposes. Thus, integrating blockchain solutions with this existing infrastructure to ensure seamless user experience can be complex or even impossible without disrupting the systems' existing operational dynamics. Furthermore, certain physical infrastructure may already be programmed to operate with specific automation software and applications and thus may not be able to interoperate with a new technology back-end such as a blockchain network. This can present a significant challenge for the implementing body, which is exacerbated by the fact that many Government agencies still rely on outdated legacy systems that have been in place for years for their trade processing. Integrating blockchain solutions with these legacy systems can be complex and may require significant modifications, overhauling, significant adjustments, major updates, data migration or complete restructuring with significant cost implications.

3

Capacity and scalability limitations

Blockchain networks, particularly public networks, face scalability limitations in terms of space, throughput and performance. Meanwhile trade facilitation processes often involve a large volume of records together with a wide user base. This makes the capacity and scalability limitations of blockchain particularly significant. A critical consideration is thus to assess the limitations of the various blockchain solutions, architectures and consensus designs, which can significantly influence storage capacity, throughput and performance of the final product.

4

Architecture and design difficulties

Determining the appropriate technical specifications, specifically around processes such as network governance and consensus mechanisms, can be challenging when it comes to Government use of blockchain. This is because many design choices exist today regarding the consensus mechanism and architectural specifications. While certain specifications could be suitable for certain trade facilitation needs, they may not be suitable for other use-cases. This makes the process of finding the right architectural balance for the multiple trade facilitation needs of the Government a difficult task. Deciding on technical specifications around speed, security, level of decentralization, consensus algorithms and governance structures thus requires careful consideration of factors such as efficiency, transparency, authority and accountability.

5

Data privacy and security concerns

Data governance has become a key component of digital policy. While blockchain provides inherent security features, ensuring the privacy and security of sensitive Government data can still present a challenge, especially in cases of low cyber hygiene by the users. Given that most trade documents and data are proprietary, confidential and non-public, blockchain features such as data encryption as a default functionality of the technology are timely and necessary. But user-facing tools may still present critical vulnerabilities in the protection of such data. Thus, finding a balance between transparency and data protection is essential, especially when dealing with personal information and proprietary data.

6

Talent and expertise deficits

The shortage of the talent and expertise required – in development, architecture, consensus mechanisms, distributed systems and cryptography – to implement and maintain blockchain ecosystems remains one of the most significant challenges in the implementation and adoption of blockchain both in Government and in industry, especially as blockchain technology is still relatively new. Overcoming this challenge requires the Government to collaborate with industry or invest in training programmes and initiatives to build a competent workforce capable of developing, managing and utilizing the technology effectively.

7

Adoption and user acceptance challenges

Government leaders, stakeholders, employees and citizens may have limited understanding or even misunderstanding of blockchain technology, which can hinder adoption and user acceptance. Working to reform perceptions and transform beliefs around a technology can be a significant challenge. If attitudes towards the technology are negative, creating a positive mindset about the value and benefits of the technology can take time. Effective communication and education initiatives are crucial to build trust, increase awareness and create the needed mindset on the benefits and potential value gains of blockchain in Government services such as trade processing.

8

Resource constraints and cost concerns

Unlike traditional Web 2.0 applications, implementing a fully functional private blockchain and supported solutions can still involve significant costs – for infrastructure development, system integration and ongoing maintenance, as well as training, stakeholder empowerment and user support. Governments must carefully assess the value for money of implementing blockchain in trade processes against the long-term benefits of the technology to justify these costs.

Addressing these challenges requires a strategic approach, a collaboration between Government agencies and industry, an engaged stakeholder community and the country's willingness to adapt new technologies together with an ever-evolving regulatory environment. Partnerships with the private sector, academic institutions and industry can be particularly crucial in the implementation of the solutions. The challenges discussed in this section are summarized in table 15.

Addressing these challenges requires a strategic approach, a collaboration between Government agencies and industry.

Table 15. Summary of key challenges in the blockchain implementation process

Challenge	Description
Regulatory and legal frameworks	Adapting existing regulations to accommodate blockchain technology and smart contracts can be a significant challenge. Sometimes new legal and regulatory frameworks may be needed to clarify the use of contracts, digital signatures, data protection, privacy and intellectual property.
Incompatibilities with legacy infrastructure	Integrating blockchain solutions with legacy systems can be complex and may require significant modifications, overhauling, data migration or complete restructuring, with significant cost implications.
Capacity and scalability limitations	The storage capacity, throughput and performance of most blockchain networks are still inadequate for most trade facilitation purposes.
Architecture and design difficulties	Deciding on technical specifications around speed, security, level of decentralization, consensus algorithms and governance structures that will drive efficiency, transparency, authority and accountability can be difficult when designing a blockchain for multiple trade facilitation needs.
Data privacy and security concerns	Trade documents and data are proprietary, confidential and non-public. This makes blockchain features such as data encryption very useful. But user-facing applications and smart contract logic can still present critical vulnerabilities in the protection of such data.
Talent and expertise deficits	The shortage of skilled professionals with expertise in development, architecture, consensus mechanisms, distributed systems and cryptography presents a key challenge for implementing and maintaining blockchain systems.
Adoption and user acceptance challenges	Limited understanding of blockchain as well as negative attitudes and high scepticism towards the technology can affect user acceptance.
Resource constraints and cost concerns	There are significant costs in relation to infrastructure development, system integration and ongoing maintenance, as well as stakeholder empowerment and user support.

Source: Compiled by ESCWA.

B
Overview of use-cases and implementation considerations

Blockchain is known to possess several features suitable for trade processing that could cut cost and time to trade, improve the trader's experience and expand the Government's revenue by helping solve issues of transparency, quality, fraud, risks and standards. However, when designing a blockchain-enabled environment for trade facilitation purposes, Governments need to consider a number of factors around use-case scoping, implementation modules and stakeholder preparedness. The present section of the guide describes a number of use-cases where the technology may be suitable and sets out the potential efficiency gains in these areas.

1. **Government revenue:** Revenue generation has long been an important aspect of the trade landscape of Governments especially in developing countries. Most developing country Governments derive a significant portion of their national revenue from duties, tariffs and fees. Hence, revenue leakages have been a policy hurdle for Governments around the world. Blockchain's technical superiority in terms of traceability, auditability and accountability can streamline, simplify and dematerialize stakeholder relations while building a resilient trade ecosystem that increases revenue to support needed development. For both agency-to-trader relations as well as agency-to-agency relations, disintermediating person-to-person contact can significantly reduce underhand dealings and corruption, a key channel for revenue leakage in most countries. Blockchain therefore presents a significant opportunity for Governments to increase their revenue and can bring other efficiency gains, such as:

   a. *Quality assurance.* Trade facilitation bottlenecks – which are generally caused by under or over invoicing, quality assurance issues with declarations, a lack of auditable trails of declarations, unreliable tools for audits and unreliable systems for enforcing compliance around permits and special trade arrangements – are an issue at most countries' borders. These can cause difficulties with valuation, charges and billing, causing Governments various forms of revenue leakages. This situation is often exacerbated by the lack of an underlying system to trace the activities of the authorizing bodies or stakeholders for key trade activities in a way that could ensure accountability. As a reliable digital database where information that passes through is unalterable, blockchain technology, offers significant quality gains;

   b. *Key documentation processes*. Allowing secure handling and transmission of declarations, documents and trader information to and from relevant agencies, offices and traders without a face-to-face encounters can significantly reduce the incentive for corruption and could be a critical step in the elimination of revenue leakages through informal and undocumented channels as well as underhand dealings;

   c. *Authorized economic operators and post-clearance audits.* Generally considered key actors in most cross-border trade processes, AEOs help ease the trading experience

for most traders, but there can be quality assurance issues with their certification, activities and document trails. Creating an AEO database and having certification processes locked on a blockchain will ensure auditability, accountability and compliance for numerous trade facilitation purposes. Furthermore, the use of the blockchain's unalterable database can enhance Government trade audits and risk management by making it impossible to falsify trade data, certifications and declarations. This includes the cross border data exchange between customs as specified in Mutual Recognition Arrangement of AEO programs in a blockchain which will also facilitate and secure trade.

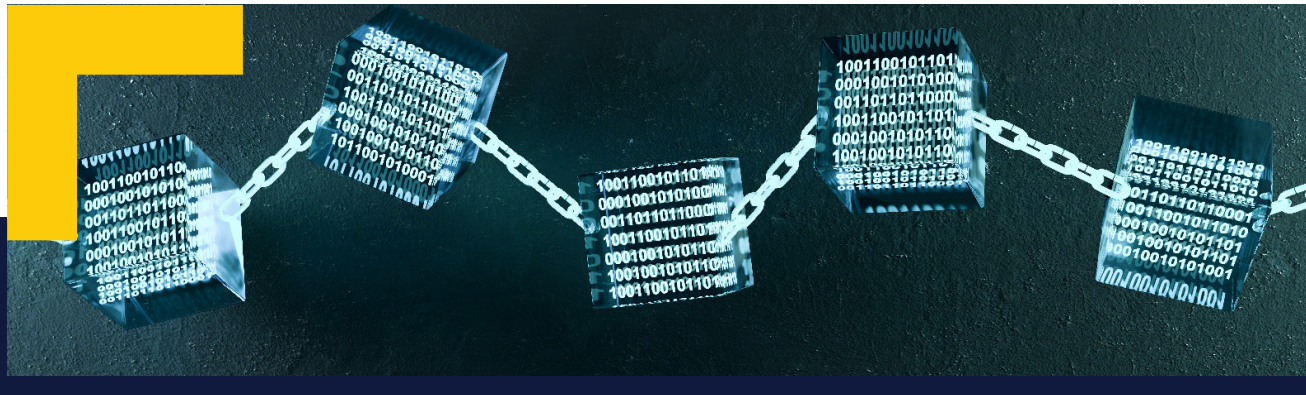
According to WCO, the advance cargo information system in Egypt, which is underpinned by blockchain, has helped the country go paperless in trade processing, enabled goods to be checked and cleared before they reach the country's ports, improved risk management and post-clearance audits, helped cut customs processing time by over 55 per cent, and increased trade revenue by 13 per cent (Kotb and Igor, 2022).

2. **Certification, verification and automation:** Crucial trade documents need to be certified and verified at several stages of the trade flow to avoid trade risks and prevent fraud. Certificates of origin for preferential trade regimes; validation of proofs of payments for fees, tariffs and duties; certification and validation of deeds; proofs of identity and validity of qualification for a preferential trade arrangement; proofs of integrity for products based on standard requirements (for example, for pharmaceutical products), are some of the documentation and standards requirements that need continuous verification to keep the trade ecosystem safe and devoid of fraud. A blockchain database that helps create, secures and stores these data can ensure both the auditability and validity of these data, prevent counterfeits of the documentations and products, and make this information instantly available to all concerned stakeholders in real time, without relying on human attestations. Furthermore, smart contracts could be useful for automating many verification processes to reduce the administrative burden on border officers, reduce time and improve the trader experience.

3. **Fraud detection and risk management:** The detection and prevention of fraud, tampering and alterations of trade documents such as trade certificates, declarations, payment invoices and receipts, or any other documents that ensure a safe and reliable trade environment, can be supported using features of blockchain technology such as cryptography. These features make trade fraud very difficult and help eliminate various trade risks associated with trade fraud. In 2020, the Moroccan customs authority launched a blockchain-based project in cooperation with DHL and the German International Cooperation Agency (GIZ Morocco) with aim of developing an ecosystem for the data of parties to all international transactions (traders, express mail service, customs and other agencies) to mitigate trade risks and improve the valuation of cargo (Moroccan Customs, 2020).

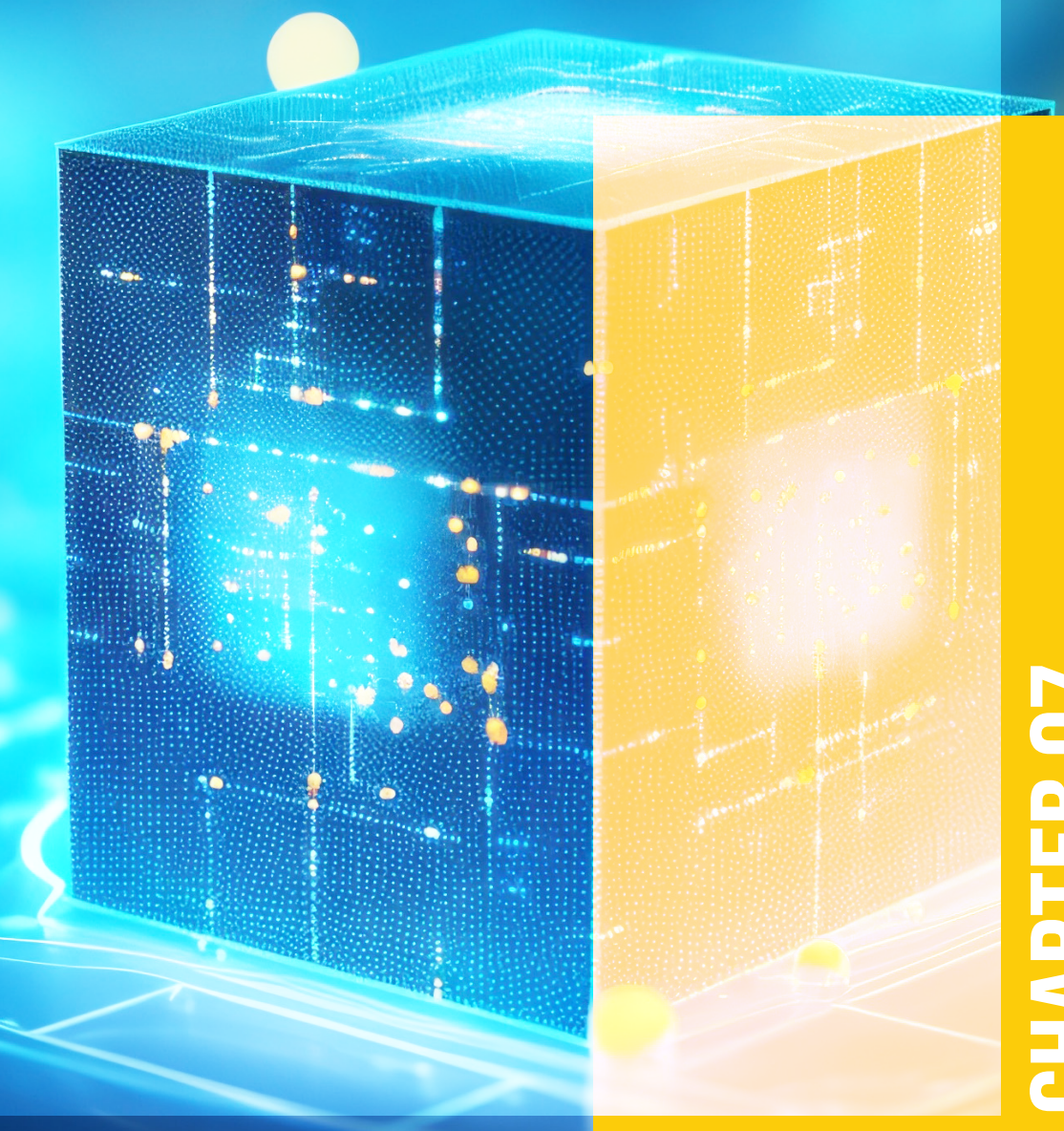
GIZ Morocco, DHL and the Moroccan customs authority joined efforts in 2020 for a blockchain project to cut time, speed up administrative processes, mitigate trade risks and enhance the accuracy of trade valuation (Moroccan Customs, 2020).

4. **Secure documents, transfers of information and data protection:** The transfer, entry and re-entry of data in trade processes in many countries accounts for a significant amount of time at the border and causes overall high cost and time to trade in these countries. Any digital tools that can ensure the secure and safe movement of critical electronic information and documents among key stakeholders without the risk of unauthorized changes are important for the simplification of trade processes in the country. As secure environments, blockchain networks can secure the exchange of mission-critical data and valuable documents both in storage and in transit. With the support of the Inter-American Development Bank, CADENA—a blockchain solution implemented by a group of Latin American customs authorities, including the Plurinational State of Bolivia, Chile, Colombia, Costa Rica, Ecuador, Guatemala, Mexico and Peru – has accelerated the processing of goods among beneficiary countries, streamlined information flow and improved the quality assurance of records and declarations, thus improving transparency (World Trade Organization (WTO) and World Customs Organization (WCO), 2022).



According to a 2022 joint publication by WTO and WCO, the CADENA Blockchain project implemented by a group of customs authorities comprising Chile, Colombia, Costa Rica, Guatemala, Ecuador, Mexico, the Plurinational State of Bolivia, and Peru brought noticeable reductions in time and cost to trade, improved quality assurance of both storage and transfer of data, and increased overall transparency in trade processes for the participating countries. (WTO and WCO, 2022)

Conclusion



CHAPTER 07

The emergence and use of blockchain technology in several domains today have triggered policy, regulatory and technical debates among Government stakeholders around the actual usefulness of the technology. Ongoing debate around the value of the technology has pushed certain Governments to ask important questions on whether and how the technology could help in areas such as trade facilitation in their countries. The present guide offers a succinct outline of key areas for consideration in the implementation process, including technical, policy and regulatory considerations. While the implementation of blockchain can be a daunting task for Governments, the potential efficiency gains from the technology within trade facilitation could be extensive.

Trade facilitation measures that may require a blockchain should be ascertained through a needs assessment, while a country's level of preparedness to adopt and use the technology should be established through a technical, regulatory and policy readiness assessment. This prepares countries to address gaps and discrepancies – whether legal, infrastructural, attitudinal or regulatory – in order to support a smooth and successful implementation of the technology.

While blockchain is suitable for most Government trade facilitation needs, the feasibility of implementing the technology in certain environments, especially in the context of developing countries can vary. Thus, it is necessary to ascertain whether prerequisite infrastructure such as electricity and internet connectivity are readily available to support the real-time data engines that come with blockchain networks. In the event that this prerequisite infrastructure is not well-established in the country, specific design choices may be required to overcome this challenge, such as the development of applications on a public blockchain network instead of a private blockchain, or the designation of special zones specifically designed to support Government critical infrastructure.

Blockchain may not be suitable for all Government trade facilitation needs. Some trade facilitation needs such as information availability for transparency could best be provided for through trade portals on a conventional web application or mobile application. Wherever possible, a conventional web application should be used because operating a fully functional private blockchain can be prohibitively costly and may not be efficient for some trade facilitation purposes.

The use of a multi-stakeholder approach in the implementation process is a key policy consideration. Blockchain is by default a multi-party digital infrastructure and trade facilitation measures usually require a multi-agency approach. Thus, taking a multi-stakeholder approach in both the implementation and utilization of the technology is the most crucial policy dimension of the process. This will ensure both the success of the implementation and the sustainability of the use for trade facilitation purposes. Furthermore, the use of public private partnerships (PPPs) in the implementation process can bring Governments a number of benefits such as cost savings, innovation, capacity-building benefits and risk management.

Governments and private sector actors still face numerous challenges today in implementing blockchain networks. These challenges can relate to cost, the availability of talent and expertise, stakeholder unpreparedness or regulatory and policy gaps. For the technology to work within the adopted environment, these challenges must be identified and resolved in time it to avoid implementation hurdles and suboptimal use of the technology.

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