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Report of the Joint Inspection Unit

Prepared by Petru Dumitriu

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Executive summary

Blockchain applications in the United Nations system: towards a state of readiness

Blockchain in the context of digital transformation

Blockchain is among the extending technologies whose fusion and interaction across the physical, digital and biological systems define the profile of the fourth industrial revolution. Even if the technology is still young, given its potential impact, weighing the trade-offs and determining regulatory action and operational frameworks should be a subject for multi-stakeholder dialogue, including in the United Nations system.

In its first years (2008–2013), blockchain was perceived as one of the most promising digital technologies, despite its relatively modest essence (a shared ledger of data). Blockchain has been proclaimed by some as the greatest innovation since the advent of the Internet, even though it builds on previously existing technologies (cryptographic techniques, peer-to-peer networking, consensus protocols) by combining them together in a very innovative way. The proponents of the technology claimed that it would disrupt every industry and would have a massive impact on the lives of individuals. The erosion of general trust in institutions generated in the aftermath of the 2008 financial crisis only added to the power of attraction of bitcoin as the first major use of blockchain.

The popularity of blockchain has seen a historic rise and a considerable fall, with little evidence of significant impact beyond the controversial history of bitcoin, the original blockchain application. The high rate of failures of start-ups proved that engaging in blockchain without careful consideration of the associated risks could be detrimental to the concrete objectives of private companies or public organizations. The emergence of new platforms after 2013, in particular Ethereum, opened new paths for blockchain applications, including smart contracts.

At present, the hype is over, and the time has come for blockchain to move towards business-ready solutions and proven results. The technology is still in its infancy but is gradually maturing. The evangelists of blockchain, who prevailed in the debate over blockchain in the early years of its development, have made way to providers of business solutions. The users and the theorists have come to realize that blockchain is neither an end in itself, nor a panacea for unsolved problems. Investments in the technology increase and so does the diversity of the blockchain landscape.

According to a recent study, while blockchain was once classified as a technology experiment, it has made the leap from the theoretical to the practical and is increasingly recognized as a true agent of change. More leaders now see blockchain as integral to organizational innovation. They are investing resources in blockchain as a strategic solution in more tangible ways (see, for example, "Deloitte's 2020 global blockchain survey: From promise to reality"). In the same vein, another study estimates that blockchain technology has the potential to boost global gross domestic product by $1.76 trillion over the next decade.[1]

The United Nations system organizations could not stand aside and watch developments in the industry. The 2030 Agenda for Sustainable Development and the strategic calls for innovation that have followed it, have prompted some organizations to take the lead and experiment with blockchain applications, mostly for operational activities. Some organizations are contemplating visionary ideas for very ambitious applications based on blockchain: a coronavirus disease (COVID-19) vaccination certification infrastructure (a partnership between the World Health Organization and the Government of Estonia), a

[1] PwC, "Time for trust: the trillion-dollar reasons to rethink blockchain" (October 2020).

unique United Nations ID (the United Nations Digital Solution Centre, founded by the Office of the United Nations High Commissioner for Refugees (UNHCR) and the World Food Programme (WFP) in collaboration with the United Nations International Computing Centre) and a draft governance framework for humanitarian assistance (issued by WFP and its partners in the "Building Blocks" project).

There is considerable work in progress in the United Nations system: standards are being developed, legal aspects examined and blockchain pilots carried out. Ten organizations use blockchain applications for different types of projects and operations, individually and in collaboration. The ongoing use cases, most of them at field level, include supply chain, digital payments, tracing of livestock, digital identity and land registration. Most organizations that are not using blockchain now, are considering a possible use in the future. Their interest will grow and mature as innovation in blockchain accelerates.

However, the resources used for blockchain are minimal and its history in the United Nations system is short: from 2017 to 2020. The Joint Inspection Unit (JIU) review was conducted with a view to looking to the future. The present report is intended to assist the participating organizations, in particular those willing to implement blockchain applications but not yet having the means, the knowledge or clear objectives to do so. In a nutshell, the main purpose of the report is to assemble information and a package of recommendations leading to a state of readiness of United Nations system organizations for making good use of the technology.

The main dilemmas faced by JIU in its attempt to take a balanced approach to blockchain were, by and large, the following:

(a) Using a language accessible to readers who are non-technical, including senior managers, while being accurate enough for the United Nations staff involved directly in the promotion or practical use of blockchains;

(b) Moving the focus on recommendations from a traditional compliance perspective to a prospective focus and from too prescriptive a standpoint to a more flexible scenario-based approach, without prejudice to the specificity of the United Nations system;

(c) Arguing for a fundamental change of attitude towards innovation, from a wait-and-see approach (let us see what the technology would let us do) to a proactive one (let us see what technology could do for us);

(d) Keeping as much as possible the balance between highlighting the potential benefits of blockchain (without promoting unconditional adoption of the technology) on the one hand and the risks and challenges involved (without discouraging innovation) on the other hand;

(e) Trying to propose a specific United Nations decision-making approach to using blockchain, whose original concept was born with the clear underlying intention of circumventing central control. Such an approach is not likely to be cognizant of the values of the United Nations and its vocation to deliver public goods;

(f) Demystifying the aura that surrounded the technology when it was being hyped and conveying the message that adopting blockchain is less a technological decision than a pragmatic, business-serving decision.

The report contains both arguments and caveats as presented by the participating organizations, while the recommendations and the elements for a decision-making matrix are all proposed by them.

The report is also intended as a contribution to the collective efforts triggered by recent overarching strategies on new technologies and the future of work, which address the issue of innovation and the use of digital technologies by the United Nations system in an action-oriented approach. The use of blockchain is viewed in the context of the achievement of the Sustainable Development Goals, in support of the vision contained in the report of United Nations Secretary-General's High-level Panel on Digital Cooperation.

Objectives

The specific objectives of the JIU review of blockchain applications were to:

(a) Map the current use of blockchain applications in the United Nations system;

(b) Compile lessons learned during this phase of incipient development and identify good practices;

(c) Identify main challenges and risks related to the use of blockchain;

(d) Explore the potential use of blockchain to facilitate greater inter-agency cooperation and efficiency;

(e) Provide inputs for developing guidance, standards and frameworks for the future use of blockchain applications.

In chapter V and recommendation 4 below, JIU proposes a decision-making matrix, developed in full consideration of the specificity of the United Nations, for the rigorous determination of the use cases for which blockchain is really the best option compared to traditional alternatives. The sequence that is recommended describes a simple but comprehensive decision-making process, in several layers, that includes a minimalistic decision tree for the adoption of a blockchain solution, passing through the choice of a specific blockchain platform and the optimization of blockchain architecture to its compatibility with the Sustainable Development Goals and the safeguards of United Nations values. The decision-making matrix is an attempt to offer some initial system-wide guidance as a response to the needs formulated by many United Nations system organizations.

Main findings

There is an **increasing interest** in the United Nations system in the use of blockchain applications, including among organizations that are not contemplating an immediate adoption of the technology. Several organizations took the lead in experimenting with blockchain projects and can provide the system with valuable lessons learned and some promising practices. The caution, where it exists, is fueled by a number of different issues, including a lack of knowledge of the technology, a lack of resources to engage in pilot projects and a lack of awareness of the specific problems to be solved using blockchain.

The ongoing blockchain applications do not offer a critical mass, quantitatively and qualitatively, to demonstrate the usability and relevance of blockchain in its specific core features. Some assumptions are not confirmed yet; characteristics such as immutability and decentralization need more testing. The **experience accumulated so far is still inconclusive** as to a possible massive use beyond financial services.

Some of the core features of blockchain, such as anonymity, as present in some cases of blockchain applications, or the individual control of private keys, appear to be incompatible with some of the areas of interest for United Nations system organizations, in particular in the humanitarian domain. Awareness among current and potential users of the new risks brought about by blockchain is increasing and **compromise solutions are being sought,** possibly contradicting popular assumptions about blockchain.

While rigid regulation of blockchain at too early a stage may still be counterproductive, **minimum policies and standards** are expected by both users and solution providers in order to reduce legal uncertainty and encourage innovation.

The views on the **need of in-house technical expertise** may diverge, but most participating organizations consider that building such expertise is useful and realistic. The creative use of open-source blockchain solutions is feasible and can reduce vendor lock-in and other forms of excessive dependence on the market.

Blockchain, by virtue of its network vocation, carries **unprecedented opportunities for inter-agency collaboration**, while working in silos will be a recipe for a waste of resources, duplication, lack of coherence and blind dependence on commercial terms.

Partnerships with other stakeholders **can take new forms**, but the trust and reputation aspects need to stick to the existing rules.

Blockchain implies a need for **culture change** at the level of inter-agency collaboration: for example, acceptance of the role of leading organizations or coalitions of the willing as a driving force in **innovation** efforts; encouraging collective engagements in using blockchain in support of the Sustainable Development Goals; joint investment in **blockchain** projects; and incentivizing cooperation. Member States do not promote inter-agency cooperation enough in practical terms and continue to fund individual projects in individual organizations with similar objectives, rather than conditioning such findings on collective work.

Against that background, one of the most optimistic findings of the present review is that the first years of blockchain practice in the United Nations system confirm already **a healthy emerging tendency towards inter-agency cooperation**. The most significant ongoing projects are already being undertaken by two or more organizations and are open to other willing organizations, while standards with a system-wide potential are developed with multiple inputs. Even pilot projects developed at country level have an in-built vocation of openness and inclusion, as illustrated in the present report.

The report is an attempt to encourage a new silo-breaking and collaborative approach that blockchain technology allows and **supports**. **A real state of readiness in using blockchains, if and when needed, should be irreversibly built on inter-agency cooperation**.

* * *

Recommendations

The report includes eight formal recommendations in which JIU proposes guidance for future action aimed at solving the problems identified during the review, including on the integration of blockchain use into the overall innovation strategies and policies; knowledge sharing and capacity building; system-wide action and role playing; risk management. Another key recommendation describes a decision-making matrix for the determination of an adequate business case.

The recommendations are addressed to the governing bodies of the United Nations system organizations (2), the Secretary-General of the United Nations (1), and the executive heads of the United Nations system organizations (5).

Recommendation 1

The governing bodies of the United Nations system organizations should ensure that, when applicable, the use of blockchain applications will be integrated, together with other digital technologies, into the innovation strategies and policies adopted by their respective organizations.

Recommendation 2

The executive heads of the United Nations system organizations should make sure that the examination of possible blockchain use cases will be based on assessments of project risks, including with respect to relevant organizational policies and regulations on privileges and immunities, data protection, confidentiality, cybersecurity, system integrity, and reputation.

Recommendation 3

The executive heads of the United Nations system organizations, if they have not already done so, should endorse the Principles for Digital Development by the end of 2022, as a first step to ensuring a general common understanding of digital transformation at the organizational level, including the possible use of blockchains.

Recommendation 4

The executive heads of the United Nations system organizations should ensure that any decision on using blockchain should be based on an appropriate determination of the business case and of the most suitable solution, using as guidance a decision-making matrix (as described in the present report, as well as any enhancements and/or adaptations).

Recommendation 5

The Secretary-General, in consultation with the executive heads of the United Nations system organizations, with support from the International Telecommunication Union, should assign, by the end of 2021, to a United Nations representative in charge of digital technologies and related issues, the task of following the development of blockchain interoperability standards and open-source projects aimed at blockchain interoperability, as part of an overall consideration of the policy implications of the technology, and to work with all organizations accordingly.

Recommendation 6

The governing bodies of the United Nations system organizations should encourage Member States to engage with the United Nations Commission on International Trade Law in its exploratory and preparatory work on legal issues that relate to blockchain in the broader context of the digital economy and digital trade, including on dispute resolution, which is aimed at reducing legal insecurity in that field.

Recommendation 7

The executive heads of the United Nations system organizations that have developed blockchain applications - in line with the call by the Secretary-General in his Roadmap for Digital Cooperation for the United Nations to deploy digital public goods – should follow, whenever possible, open-source principles when they develop software, and make available the codes to other United Nations organizations.

Recommendation 8

The executive heads of the United Nations system organizations, through the relevant coordination mechanisms, including with support from the United Nations International Computing Centre, should consider the adoption of a non-binding inter-agency blockchain governance framework for use by interested organizations, with a view to ensuring coherent and consistent blockchain approaches across the system by the end of 2022, including for projects that may involve multiple United Nations organizations.

The report also contains nine soft recommendations. Most of the soft recommendations are meant to disseminate good practices and improve blockchain knowledge-sharing at the system level.

- The “Building Blocks” governance framework, if and when adopted, should be examined for its relevance for similar undertakings (para. 78);
- ITU should regularly inform all organizations about the standards developed for digital technologies, including distributed ledger technologies, such as blockchain (para. 256);
- A library of information should be established on the concrete blockchain applications in use in the United Nations system and the progress made in their implementation (para. 140);
- The organizations should cooperate with the UNCITRAL secretariat by providing documentation on their experience, the lessons learned from their use of blockchain-

supported applications and on their prospective needs from a legal standpoint (para. 268);

- A roster of external providers of blockchain solutions, accessible to all interested organizations, should be established (para. 277);
- The creation of a United Nations digital identity should be supported (para. 298).

Two further soft recommendations concern the need for blockchain solutions to be fully transparent and clear as to the exact roles and responsibilities of the participants (para. 73) and be assessed in terms of efficiency, not in isolation but by the inclusion of management and maintenance costs on a longer perspective (para. 89). Finally, one soft recommendation invites organizations to consider the inclusion in the organizational learning curricula, where appropriate and necessary, of basic training on how blockchains and other digital technologies work (para. 288).

Contents

Annexes

Abbreviations and acronyms

CEB	United Nations System Chief Executives Board for Coordination
ERP	Enterprise Resource Planning
FAO	Food and Agriculture Organization of the United Nations
ICAO	International Civil Aviation Organization
ICT	Information and communications technology
IFC	International Finance Corporation
ILO	International Labour Organization
IMO	International Maritime Organization
ISO	International Organization for Standardization
ITU	International Telecommunication Union
JIU	Joint Inspection Unit
NGO	Non-governmental organization
UNCITRAL	United Nations Commission on International Trade Law
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNDSC	United Nations Digital Solutions Centre
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFPA	United Nations Population Fund
UN-Habitat	United Nations Human Settlements Programme
UNHCR	Office of the United Nations High Commissioner for Refugees
UNICC	United Nations International Computing Centre
UNICEF	United Nations Children's Fund
UNIDO	United Nations Industrial Development Organization
UNIN	United Nations Innovation Network
UNJSPF	United Nations Joint Staff Pension Fund
UNODC	United Nations Office on Drugs and Crime
UNRWA	United Nations Relief and Works Agency for Palestine Refugees in the Near East
UN-Women	United Nations Entity for Gender Equality and the Empowerment of Women
UPU	Universal Postal Union
WFP	World Food Programme
WHO	World Health Organization
WIPO	World Intellectual Property Organization
WMO	World Meteorological Organization

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I. Introduction

A. Background

1. The Joint Inspection Unit (JIU) of the United Nations system included a review of blockchain applications in its programme of work for 2020.

2. Based on a proposal by a JIU Inspector, the intention is to respond to the increasing interest of United Nations organizations, at the strategic and operational levels, in leveraging the efficiency gains that are attributable to a dynamic and promising digital technology: blockchain.

3. In doing so, JIU joins the collective efforts triggered by recent overarching strategies on new technologies and the future of work that address the issue of innovation and the use of digital technologies by the United Nations system in an action-oriented approach.[2]

4. The use of blockchain should also be viewed in the context of the achievement of the Sustainable Development Goals. The Secretary-General's High-level Panel on Digital Cooperation recognized that digital technologies are expected to bring a significant contribution to the realization of the 2030 Agenda for Sustainable Development and to cut across international boundaries, policy silos and professional domains.[3]

5. The preliminary research conducted before the start of the present review, showed that, despite the growing interest in this technology, there is a need for more guidance available to the United Nations system organizations, including frameworks or methodologies on how and when they should consider using blockchain applications. As the blockchain industry is in its infancy, as is the awareness in the public sector of the opportunities and challenges related to such technologies, the United Nations system cannot just wait and see or engage its resources randomly.

6. The present review gives the Inspector the opportunity to emphasize the increasing importance of, and need for engagement in, a strategic oversight that is not limited to reviewing present practices, but also attempts to anticipate, prevent and mitigate risks and foster efficient use of resources in the future, while encouraging innovation.

B. Context

7. "The Fourth Industrial Revolution creates a world in which virtual and physical systems of manufacturing cooperate with each other in a flexible way at the global level."[4] As stated by the coiners of the concept, the fourth industrial revolution is not only about smart and connected machines and systems. It is the fusion of these technologies and their interaction across the physical, digital and biological domains. Blockchain is an extending technology that can reform the physical world, alter the human being and integrate the environment, together with artificial intelligence and robotics, the Internet of things, quantum computing, virtual and augmented realities and others.

8. Blockchain is a digital distributed ledger which has an immutable characteristic. A ledger is a database of transactional records (data). In contrast to traditional transactional systems controlled by centralized authorities, such as a bank or service provider, blockchain technology enables the distribution of responsibility among all participating computers (called nodes), which share the same information, use a consensus process to validate transactions and monitor records collectively. Once the nodes reach a consensus on the validation, the transaction is written into a block, which becomes very difficult to modify or delete.

[2] See "UN Secretary-General's strategy on new technologies" (September 2018) and ILO Global Commission on the Future of Work, *Work for a Brighter Future* (2019).

[3] High-level Panel on Digital Cooperation, "The age of digital interdependence" (2019).

[4] Klaus Schwab, *The Fourth Industrial Revolution*, 2016.

9. There are different types of blockchains, notably two main groups: public, permissionless blockchains; and private, permissioned blockchains. In a public blockchain, anyone who wishes can participate in the network, help maintain the ledger and see all the transactions that are taking place. In a private, permissioned blockchain, both the information and the maintenance of the network are restricted to a selected group of members.

10. The key intrinsic features attributed to blockchain are its decentralized structure, immutability and security. In principle, those features create trust among the parties to the blockchain, foster cooperation, make transactions safe and secure and enhance transparency, among other things. On the downside, the use of blockchain technology may raise concerns in terms of its environmental footprint, data privacy, cybersecurity and potential misuse for illegal purposes.

11. Besides the prominent and controversial case of bitcoin, there are various other use cases of blockchain technology, which include supply chain tracking, digital payments, transfer of assets, digital identity and land registration. Smart contracts can be used in streamlining internal processes, such as invoice management, vendor payments, asset transfers and dispute resolution. However, smart contracts will have to be integrated into the existing legal framework. The current focus of blockchain users and developers is on the identification of use cases where blockchain can make a difference.

12. The international financial institutions are also examining, in an increasingly systematic and action-oriented manner, the potential uses of blockchain applications. In 2017, the World Bank established a blockchain lab as an innovation hub for poverty reduction projects, including the development of opportunities to use blockchain and other disruptive technologies in areas such as land administration, supply chain management, health, education, cross-border payments, and carbon market trading. The International Finance Corporation (IFC) worked with key influencers and experts to examine the potential and perils of blockchain. An initial report was published in October 2017. In a more recent report, IFC observed that since then, additional in-depth notes had been added to broaden and deepen the understanding of this burgeoning technology, its enormous potential, and its many challenges.[5]

13. According to the information collected by JIU, governments at the national or local level also use blockchain applications, while others have adopted specific blockchain regulations. The common denominator of those regulations and other institutional measures is that they consider blockchain applications not only from a technological or cost angle, but also from governance and social perspectives, given the inherently decentralized structure of blockchain.

14. Blockchain is a strategic topic of considerable potential and the United Nations should do more to understand it and identify efficient uses enabled by this technology. Blockchain applications can help organizations to reduce transaction costs, enhance efficiency and effectiveness, lower the risk of fraud, control financial risk and protect data. They may also help to address operational and programmatic challenges. On the other hand, in view of some of its characteristics (decentralized consensus mechanisms, possible anonymity of users, energy imprint), some of the main features of blockchain can raise ethical problems, ecological concerns and legal issues.

15. In the 2030 Agenda for Sustainable Development, the General Assembly emphasized the need to discuss "technology and innovation cooperation around thematic areas for the implementation of the Sustainable Development Goals, congregating all relevant stakeholders to actively contribute in their area of expertise".[6] That cooperation implies not

[5] See, for example, IFC, *Blockchain: Opportunities for Private Enterprises in Emerging Markets* (January 2019) in which IFC provides an examination of blockchain implementation in financial services and global supply chains; a regional analysis of blockchain developments in emerging markets; and a new focus on the ability of blockchain to facilitate low-carbon energy solutions, as well as a discussion of the legal and governance issues associated with adoption of the technology.

[6] United Nations, General Assembly, Resolution 70/1 "Transforming our world: the 2030 Agenda for Sustainable Development".

only inter-agency cooperation and partnerships, but also efficient use of technologies. Blockchain, by its nature as a distributed technology, may be the catalyst for more system-wide coordination and convergence, and an enabler of a more efficient use of resources.

16. While the advantages of using blockchain technologies in United Nations operational activities are assumed to be inherent and embedded in such technologies, the evidence that the theoretical benefits are confirmed in practice is not always available. In addition, some of the core characteristics of blockchain, among which are trust and immutability, have been challenged. In addition, some features that are valorized in the private sector may not fit the purpose, values and responsibilities of the United Nations system. While opening the door to innovation, an understanding of the potential implications of blockchain must therefore be continuously updated and deepened. United Nations staff, from Headquarters to the country level, should understand how such technologies are impacting their areas of work and test, in a responsible way, how blockchain can be leveraged to better deliver on their respective mandates.

C. Purpose, objectives and scope

17. In line with its mandate, the purpose of this JIU review is to inform and make recommendations to decision makers (governing bodies and executive heads) on the characteristics of blockchain technology from a cross-cutting perspective and bearing in mind the potential benefits and risks. It is expected that the assessment and analysis will help to bridge the knowledge gap between the decision makers in the United Nations system and the promoters of blockchain on the market, as well as increase awareness of and accountability in using blockchain technologies.

18. The objectives of the review are to:

(i) Map the current use of blockchain applications in the United Nations system;

(ii) Compile lessons learned during this phase of incipient development and identify good practices;

(iii) Identify the main challenges and risks related to the use of blockchain;

(iv) Explore the potential use of blockchain features that may facilitate greater inter-agency cooperation and efficiency;

(v) Provide inputs for developing guidance, standards and frameworks for the use of blockchain applications.

19. The present review was undertaken on a system-wide basis and included all 28 JIU participating organizations and the United Nations International Computing Centre (UNICC).

20. In the review, JIU explored: (a) blockchain applications that are currently and effectively used; (b) blockchain-related projects recently launched or under consideration; and (c) desirable potential uses of blockchain in the future.

21. In the review, JIU also explores what use cases relevant to the 2030 Agenda for Sustainable Development could be supported and facilitated by blockchain applications. The use of blockchain for the creation of cryptocurrencies as such was not, a priori, intended as a focus of the review. However, some aspects related to potential uses of blockchain in financing United Nations mandates or in operational activities at field level, were considered and examined.

D. Key terms and definitions

22. During the review, the technical literature consulted by the JIU team, offered a plethora of blockchain-related concepts used by practitioners and theorists of blockchain. While those concepts may differ more in language than in substance, the JIU team opted for the technical specifications produced in the United Nations system by the International

Telecommunication Union.[7] The list below is not exhaustive; it only includes concepts used throughout the report:

- **Blockchain**: a type of distributed ledger which is composed of digitally recorded data arranged as a successive growing chain of blocks, with each block cryptographically linked and hardened against tampering and revision.
- **Block**: an individual data unit of a blockchain, composed of a collection of transactions and a block header.
- **Block header**: a data structure that includes a cryptographic link to the previous block.
- **Consensus**: agreement that a set of transactions is valid.
- **Decentralized application**: an application that runs in a distributed and decentralized computing environment.
- **Decentralized system**: a distributed system wherein control is distributed among the persons or organizations participating in the operation of the system.
- **Distributed ledger**: a type of ledger that is shared, replicated and synchronized in a distributed and decentralized manner.
- **Immutable**: the property of blockchain and distributed ledger systems that ledger records can only be added, but not removed or modified, and are designed not to allow changes to historical data over time.
- **Ledger**: an information store that keeps final and definitive (immutable) records of transactions.
- **Node**: a device or process that participates in a distributed ledger network.
- **Permissioned**: requiring authorization to perform a particular activity or activities.
- **Permissionless**: not requiring authorization to perform any particular activity.
- **Permissioned distributed ledger system**: a distributed ledger system in which permissions are required to maintain and operate a node.
- **Permissionless distributed ledger system**: a distributed ledger system in which permissions are not required to maintain and operate a node.
- **Public distributed ledger system**: a distributed ledger system which is accessible to the public for use.
- **Private distributed** ledger **system**: a distributed ledger system which is accessible for use only to a limited number of users.
- **Smart contract**: a program written on the distributed ledger system which encodes the rules for specific types of distributed ledger system transactions in a way that can be validated and triggered by specific conditions.
- **Token**: a digital representation of value on a shared distributed ledger that is owned and secured using cryptography to ensure its authenticity and prevent modification or tampering without the owner's consent.
- **Transaction**: the whole of the exchange of information between nodes.
- **Wallet**: software and/or hardware used to generate, manage and store both private and public keys and addresses, which enable distributed ledger technology users to carry out transactions. Some wallets may interact with smart contracts and allow single and/or multi-signature.

Note: blockchain is a distributed ledger technology, but there are other distributed ledger systems that are not blockchain. While the definitions above cover distributed ledger systems in general,

[7] International Telecommunication Union, ITU-T Technical Specification ITU-T Focus Group on Application of Distributed Ledger Technology (FG DLT), "Technical specification FG DLT D1.1 - distributed ledger technology terms and definitions" (1 August 2019).

they are fully valid for blockchains. In other words, *distributed ledger technology* reads also, in the selection of terms and definitions, as *blockchain*.

E. Methodology

23. The inclusion of the topic in the JIU programme of work was preceded by preliminary research and preparatory activities, such as the "Special dialogue on how can blockchain technology help us to finance the SDGs" (3–4 April 2018), as part of an international conference, organized by JIU in follow-up to a report on partnerships with the private sector, and the Conference on "Blockchain for impact", co-organized by JIU and Geneva Macro Labs (Geneva, 26–27 September 2019), both with multi-stakeholder participation.

24. To explore the interest of participating organizations at the operational level, the Inspector also attended meetings organized by other United Nations entities (SDG Lab, the United Nations Institute for Training and Research) and diplomatic missions (Canada and Switzerland) in 2018 and 2019. He also attended meetings under global auspices, such as the second Geneva Blockchain Congress and the World Economic Forum in Davos (2020). The available preliminary documentation included a report focused on the United Nations, produced for JIU by a Capstone research team from the Geneva Graduate Institute of International and Development Studies.

25. The review was undertaken between February and November 2020 on a system-wide basis. In accordance with JIU norms, standards and guidelines and its internal working procedures, the methodology followed in preparing the report included an extensive literature review, an in-depth desk review and analysis of existing policies and practices related to the use of blockchain technology, a corporate questionnaire and interviews. Data collection and analysis relied on both qualitative and quantitative methods.

26. Data collection instruments included:

(a) Questionnaires to all JIU participating organizations and the International Computing Centre;

(b) Structured and semi-structured interviews with officials in the United Nations system;

(c) Ad hoc brainstorming sessions and participation in meetings of blockchain practitioners;

(d) Consultations with representatives of the industry and government authorities that have adopted specific legislation with respect to blockchain;

(e) Dialogue and consultations with other international organizations;

(f) Use of open sources for information and learning on blockchain, including online courses on the LinkedIn, edX and Coorpacademy platforms.

27. The questionnaires were drafted as two options, in order to collect the views of both organizations that currently use blockchain and the expectations of those that do not. All JIU participating organizations and UNICC responded to the corporate questionnaire and other requests for information. In addition, 56 interviews with approximately 116 individuals were conducted before and during the review. In-person meetings were held with individuals from organizations headquartered in Geneva, where possible. Online interviews were conducted in cases where on-site meetings were not possible, due to COVID-19.

28. The team interviewed members of staff of and benefited from presentations by the International Organization for Standardization (ISO), the World Economic Forum and the World Bank, as well as from legal experts and blockchain solution providers from governmental authorities, start-ups, networks and platforms, including the Office for Financial Market Innovation of the Principality of Liechtenstein and Crypto Valley Venture Capital (CV VC), Zimt, the Swiss Blockchain Federation, Bitcoin Suisse AG, Nägele Rechtsanwälte GmbH, Digital Assets Legal Advisors (DALAW), Old School GmbH, Tezos Foundation, the Geneva Internet Platform, the Swiss Blockchain Institute and Geneva Macro Labs.

29. In its assessment, JIU was also guided, as appropriate, by the principles of a SWOT[8] analysis to identify strengths, weaknesses, opportunities and threats related to the efficient use of blockchain applications in the context of the United Nations system.

30. At the time of the preparation of the present report, only a limited number of entities had implemented or experimented with blockchain applications. Existing practices do not therefore represent a statistically significant quantity or a timeline long enough for a rigorous SWOT analysis. However, an analysis of the current blockchain applications offers valuable lessons learned and indicates areas of work that can be, in principle, supported by the technology. The other organizations indicated a keen interest in exploring the potential of blockchain. In the report, JIU attempts to offer guidance, raise awareness of blockchain in a balanced and realistic way, provide information about standardization and regulatory activities that are relevant in this area and, more importantly, anticipate the need for inter-agency cooperation.

31. An internal peer review procedure was used to solicit comments from all JIU Inspectors ("collective wisdom") before the report was finalized. The draft report was also circulated to JIU participating organizations for correction of factual errors and for comments on its findings, conclusions and recommendations.

32. To facilitate the handling of the report, the implementation of its recommendations and monitoring thereof, annex IV contains a table indicating whether the report is submitted to the legislative bodies and executive heads of the organizations reviewed for action or for information.

33. The Inspector wishes to express his sincere appreciation to all representatives of the United Nations system organizations and representatives of other organizations and entities who assisted in the preparation of the present report, and in particular to those who participated in the interviews and questionnaires and so willingly shared their knowledge and expertise.

[8] S.W.O.T. is an acronym of the four parameters of analysis: Strengths, Weaknesses, Opportunities, Threats.

II. Mapping blockchain applications in the United Nations system

A. Interest in blockchain increases cautiously

34. United Nations system organizations are at an early stage of blockchain implementation. The existing applications are used in different forms and ways and for different types of projects, programmes and activities.

35. At the time of the preparation of the present report, 10 organizations were using blockchain, individually or in collaboration, and had a dedicated blockchain infrastructure in place. Those organizations include World Food Programme (WFP)/United Nations Entity for Gender Equality and the Empowerment of Women (UN-Women), the Food and Agriculture Organization (FAO)/International Telecommunication Unit (ITU), the International Computing Centre (UNICC)/United Nations Joint Staff Pension Fund (UNJSPF), the United Nations Human Settlements Programme (UN-Habitat)/United Nations Office of Information and Communications Technology (UN-OICT) (all engaged in joint projects), the United Nations Children's Fund (UNICEF) and a number of country offices of the United Nations Development Programme (UNDP). Use cases include supply chain, digital payments, tracing of livestock, digital identity and land registration.

36. Other organizations are considering the possible use of blockchain applications in the future, including the United Nations Population Fund (UNFPA), the United Nations Relief and Works Agency for Palestine Refugees in the Near East (UNRWA), the International Labour Organization (ILO), the World Health Organization (WHO) and the United Nations Secretariat. Several organizations are engaged in research and other activities, such as capacity-building projects, in relation to their core area of work and mandate and in support of their stakeholders. Among them are the United Nations Industrial Development Organization (UNIDO), the World Intellectual Property Organization (WIPO), the United Nations Conference on Trade and Development (UNCTAD), the World Meteorological Organization (WMO), the International Maritime Organization (IMO) and the International Civil Aviation Organization (ICAO). They have all started to consider possible uses of blockchain and they are all interested in understanding and knowing more about the potential benefits and related challenges that the technology could bring.

37. A specific role is played by ITU, whose focus group on the application of distributed ledger technology has developed several standards and specifications of high importance for a coherent use of blockchain by ITU members and United Nations system organizations.[9]

38. At a system-wide level, blockchain is also being looked at by the United Nations Innovation Network, a collaborative platform on which various agencies can share knowledge and advance discussions on innovation. The International Computing Centre offers operational assistance to concrete blockchain projects and a recently created United Nations Digital Solutions Centre proposes testing and implementing cutting-edge technology pilots, including blockchain-based pilots, that can be scaled up for use by multiple organizations.

39. Annex I to the report provides an overview of the United Nations system organizations that are currently using blockchain applications. Annex II lists areas of interest for potential blockchain applications in the future.

B. Pioneering organizations take the lead, inter-agency cooperation is emerging

40. Several organizations have been early implementers of blockchain. They are using ongoing blockchain applications at different stages of maturity. In doing so, they have paved the way for other organizations to use innovative technology, as their experiences –

[9] See www.itu.int/en/ITU-T/focusgroups/dlt/Pages/default.aspx.

achievements, but also challenges and lessons learned – will help to build a knowledge base and a set of fertile practices for the use of blockchain by United Nations system organizations.

41. The **WFP** "Building Blocks" is a major blockchain project in the humanitarian sector. Building Blocks leverages blockchain to make cash transfers faster, cheaper and more secure. It also creates a neutral space, 100 per cent co-owned and co-operated by its members, which allows various humanitarian organizations to coordinate the determination and delivery of assistance under common identifiers. The project currently serves 822,000 Syrian and Rohingya refugees in Jordan and Bangladesh. Since its launch in May 2017, Building Blocks has transferred $150 million through 8 million transactions. In November 2020, Building Blocks was also launched in Lebanon for inter-agency coordination of assistance in support of the emergency response to the Beirut blast in August 2020.

42. **UN-Women** joined the Building Blocks platform through a pilot in June 2019 for a cash transfer system in the Za'atari and Azraq refugee camps for women in Jordan. UN-Women also has a project testing blockchain-based cash transfers in the Kakuma refugee camp in Kenya.

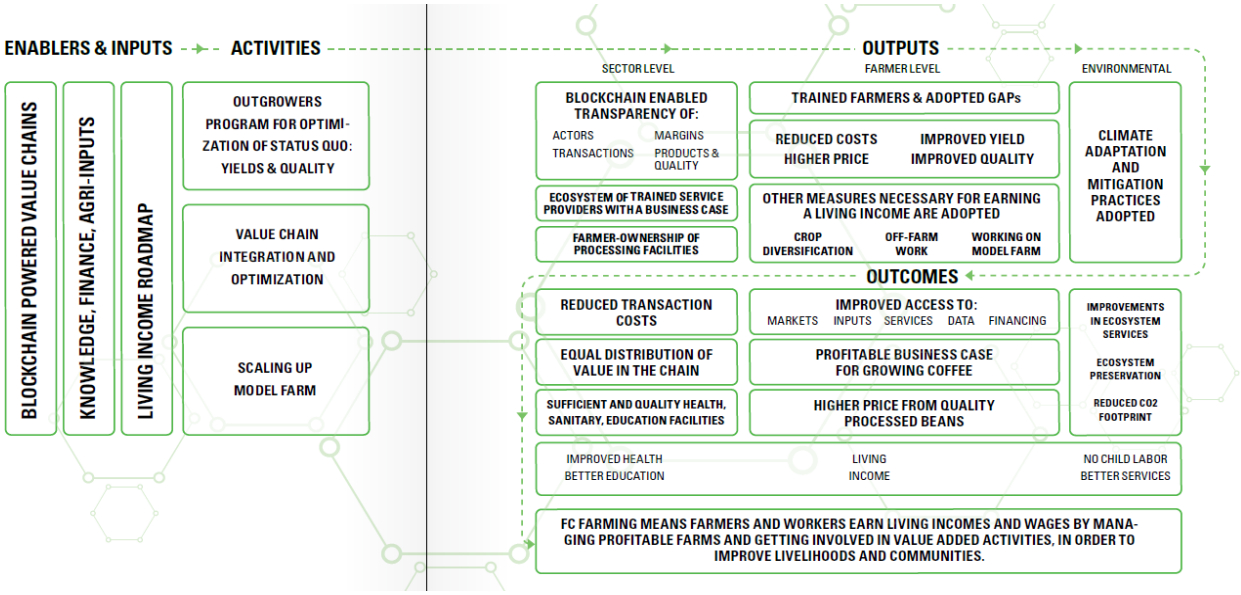
43. **WFP** also runs the "Blocks for Transport" project, which aims to improve the timely availability of shipping documents using blockchain technology for the supply chain and logistics. The project started at the procurement and transport stage of a supply chain corridor in Djibouti and Ethiopia. The full implementation of this project is expected for 2021. The long-term vision is to establish a blockchain-powered, modular supply chain platform for the humanitarian community.

44. **UNDP** has piloted blockchain use cases in several different areas, including cryptocurrencies for crowdfunding. It also has several blockchain pilots ongoing in some of its country offices, using blockchain for supply chain tracking, the generation/allocation of digital tokens and for tracking food donations. The most developed relate to improving traceability in sustainable supply chains.

45. The UNDP country office in Ecuador has used blockchain to track commodities (cocoa), from the point of origin to sale in the form of chocolate bars. It has also created a digital token for the chocolate bar with monetary value attached. Each token can be redeemed for a discount on the consumer's next purchase or returned to the original farmer for reinvestment in the production process.

46. Figure I provides a graphic depiction of the envisioned impact of the blockchain project implemented by the UNDP Ecuador country office. Most data are captured on the blockchain, but not all. For example, invoices that are captured as attachments are not stored on the blockchain. "Off-chain" data is stored in a separate database, which can be kept at the client level or hosted with a third-party facilitator.

Figure I
UNDP Ecuador blockchain project

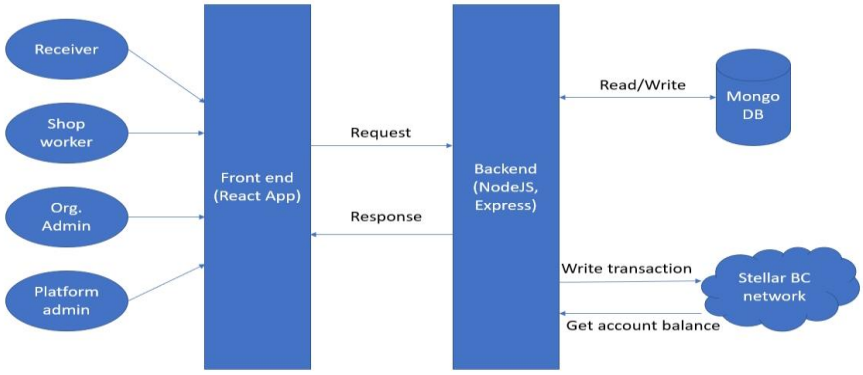


Source: UNDP Ecuador and FairChain Change Management.

47. The UNDP country office in Serbia has developed blockchain-based tracking of food donations from retailers (e.g., supermarkets) to a recipient non-governmental organization. The intention is to extend the tracking to the full donation process: farm production, delivery to supermarkets, collection by food banks and donation to individuals. Other blockchain pilot projects in UNDP country offices (Mongolia, Republic of Moldova, India) have been discontinued for circumstantial reasons, other than technology.

48. The flow chart in figure II illustrates the structure and process of the UNDP Serbia blockchain project on food donations. Every participant in the platform has its own blockchain account (combinations of private and public keys) and every donation or transaction between entities is recorded in the blockchain. In the local database there is information on donation details, donors and receivers. Tokens based on the weight of food donation are generated. Once the project is fully up and running, other retailers could be enabled to join.

Figure II
UNDP Serbia blockchain project



Source: UNDP.

49. The Serbia project uses a public blockchain as an infrastructure layer on which to build a custom-designed, private application for use by selected participants in the food donation chain. Using an existing public blockchain has reduced development time, the

investment needed and the maintenance needs of the project. For the very practical purpose of designing and understanding blockchain-based applications in the United Nations system, the Inspector found the approach adopted by UNDP Serbia interesting. Indeed, since the emergence of the original blockchain (Bitcoin), the underlying technology and its applications have continued to evolve, resulting in more capable, but also more complex, systems. From the technical perspective, it may be possible to dissect the modern blockchain networks into multiple layers. For the very practical purpose of designing and understanding blockchain-based applications in the United Nations system, the Inspector found it useful to describe a functional perspective, based on two layers, which may reduce the cost and complexity of the project (see box 1).

50. **FAO** runs a project with **ITU** for pig farmers in Papua New Guinea, using blockchain technology for livestock traceability. It allows consumers to buy in confidence by verifying the history of their products. Before the system was implemented, consumers had no means of verifying such information. The implementation of the new tracking system is vital for establishing consumer trust and enabling farmers to expand their markets and earn a fair return on their investments.[10]

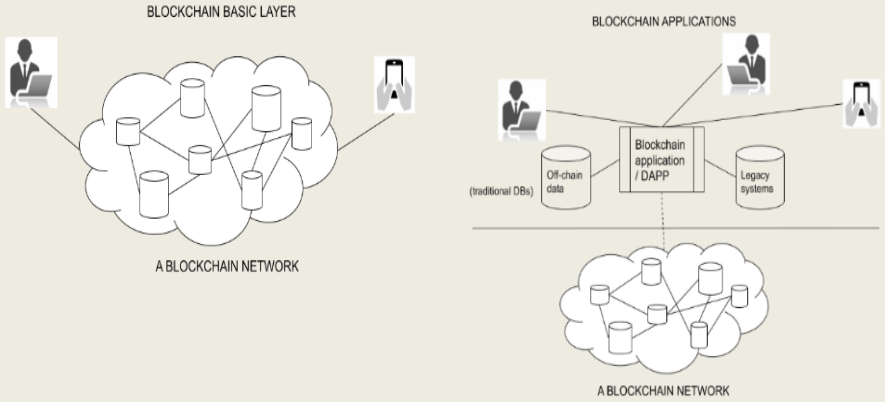
51. **UNICC/UNJSPF**: The United Nations International Computing Centre is supporting the United Nations Joint Staff Pension Fund in the technical implementation of a "digital certificate of entitlement", using blockchain and machine-learning technology. In the business pilot, approximately 280 WFP retirees living in 70 countries are involved in testing the full solution. The full use of blockchain technology could be exploited in the next phase, which is to provide a digital ID for the entire United Nations workforce and not just for retirees.

Box 1
Blockchain layers

The blockchain basic layer

This is the basic blockchain network, consisting of server nodes, connected through Internet, maintaining and serving a distributed ledger to the blockchain participants. Depending on the design of the blockchain, this layer provides the basic capability of verifying and recording transactions and achieving consensus among the many instances of the distributed ledger.

Public blockchains may typically also have a cryptocurrency associated with their use, but this does not have to be a primary function of a blockchain. Many blockchains today also provide smart contract functionality or other extended and sometimes specialized functions. Users can interact directly with the basic blockchain layer using digital wallets as end-point applications. For example, users could send or receive funds using only a simple smartphone application acting as a digital wallet.



[10] See www.fao.org/in-action/pig-farmers-in-papua-new-guinea/en/.

The blockchain application layer

Blockchain platforms also offer ways to connect to external systems through predefined protocols and interfaces. Many modern blockchain platforms also support some form of programmable functionality that is stored and executed by the basic platform layer.[11] In practical terms this means that it is possible to build sophisticated applications outside or on top of the underlying blockchain platform that connect to and use blockchain networks as a kind of infrastructure layer. Such applications can create and deliver completely new functionalities that are not limited by the functionality provided by the basic layer.

For example, an application that can only be used by selected registered users can be built on top of a public blockchain that allows anonymous users to use its basic functionality. In such cases, the basic blockchain platform serves as a public infrastructure, similar to the way the Internet is used as a public infrastructure for creating sophisticated web applications. One such case is the UNDP Serbia project, which uses the Stellar public network for a "private" application. *(Source: JIU)*

52. **UN-Habitat/UN-OICT**: In Afghanistan, blockchain is being used to track the ownership of parcels of land. As part of the "City for All" initiative, UN-Habitat and UN-OICT are working together to build a digital registry. By leveraging blockchain technology, an immutable version of land records is created, which can then serve as the basis for other government services, such as urban planning, citizen engagement and revenue generation.

53. The UNICEF Digicus project, a proof of concept, leveraged blockchain to digitize the agreements that UNICEF has with its implementing partners (Governments, NGOs, academia) in one country office (Kazakhstan) as smart contracts. The goal of the prototype was to develop a platform to streamline cash transfers in order to improve the transparency and accountability of partnerships. The platform enables streamlined verification of the results achieved by the partners and – by means of blockchain-based smart contracts – automatic release of payments, after verification and authorization. It allows all parties to have a common understanding of the actual stage of the project and which goals have been achieved and showcases how smart contracts can be used to expedite the processing of paperwork and payment. UNICEF is also exploring the scalability of the concept. In support of the blockchain activities, UNICEF has established a venture fund and a cryptocurrency fund (see subsequent sections).

54. **The Inspector welcomes the effort of the front-runners in the exploration of possible uses of blockchain applications in the United Nations system and the diversity of modalities in which innovative approaches have been taken (focus on a niche area, inclusion in innovation policies or multiple-use cases piloted at country levels). The Inspector also welcomes the inter-agency initiatives. Inter-agency collaboration not only valorises the vocation of blockchain to build action-oriented networks, but may also stimulate a new culture of cooperation, the avoidance of duplication, increased coherence and breaking silos in the use of blockchain applications in support of the 2030 Agenda for Sustainable Development.**

C. Preliminary research and exploration of blockchain is taking place

55. In the **United Nations Secretariat**, the Office of Information and Communications Technology has produced a white paper and prototypes of potential applications of blockchain. As a focal point within the Economic and Social Council for trade facilitation recommendations and electronic business standards, the United Nations Centre for Trade Facilitation and Electronic Business produced a white paper overview of blockchain for trade and a white paper on the technical application of blockchain to deliverables for the Centre.

[11] Ethereum was the first blockchain to introduce significant support for this in 2014 through "smart contracts" (a concept that was previously known in computer science, but which had not been applied to blockchain technology).

UNCTAD has addressed the topic of cryptocurrencies and blockchain in several of its reports, publications and conferences. The work of UNCITRAL is described in section VI below.

56. **WHO** is working on a global strategy for digital health to establish a more systematic way of leveraging digital technologies, which includes blockchain. The immutable nature of blockchain records provides an important data integrity characteristic that can be used in supply chain management for medical goods to fight counterfeit medications and other forms of medical fraud. In October 2020, WHO also initiated a landmark project based on blockchain: a COVID-19 vaccination certification infrastructure, as a partnership with the Government of Estonia. **UNIDO** has developed a methodological framework to assess the readiness of a commodity value chain to adopt blockchain, to be piloted for cocoa in Ghana.

57. **FAO** has issued several publications addressing, among others, blockchain for agriculture and has examined the issue of farmers' digital identity and data ownership on blockchain. **UNEP** has published papers on blockchain applications in the climate change and sustainability areas. As part of the "Climate warehouse" project, a prototype for carbon emission accounting undertaken in collaboration with the World Bank, research shows how blockchain can create peer-to-peer system designs.

58. **WIPO** is exploring with its Member States the potential uses of the technology in the ecosystem of intellectual property and established a blockchain task force in 2018. The World Tourism Organization (**UNWTO)** is also raising awareness among its members of the possible use of blockchain for digital identity, travellers' records and the traceability of sensitive information combined with the assurance of privacy.

59. The **ICAO** Assembly urged its Member States with experience of facilitating the introduction of innovation into civil aviation to share their experience with other States.[12] One such example is the blockchain summit, co-hosted by ICAO in 2019, to explore innovations in blockchain technology that have the potential to support the development of civil aviation systems. **UN-Habitat** is exploring the potential uses of blockchain for sustainable urban development.

60. **ITU** has produced, inter alia, definitions of key terms, descriptions of blockchain applications, use cases and processes, as well as a methodology to assess distributed ledger technology systems.

D. Blockchain partnerships pose new challenges

61. The decentralized nature of blockchain and the fact that its operation requires a network of participants create specific challenges that need to be addressed. In view of the multitude and diversity of the participants in the blockchain network, there is a need for clarity as to their different roles and responsibilities. While the use of blockchain can foster, in principle, partnerships and collaboration, a clear governance framework and arrangements are necessary to ensure mutual benefits and incentives for members, implementing partners, users and beneficiaries of the blockchain, adapted to the portfolio of specific projects. The following examples illustrate the complexity of some blockchain projects.

62. The Inspector noted the relatively precise and completed illustration of partnerships and roles in the WFP Building Blocks project, the FAO livestock traceability project, the UNICC/UNJSPF digital certificate of entitlement and in several UNDP country projects he examined. An example of the distribution of roles in a blockchain application, is outlined in box 2.

[12] ICAO Assembly, resolution A 40-27, 2019.

Box 2
Distribution of roles in the FAO/ITU livestock traceability project in Papua New Guinea

- **FAO**: Project conceptualization, technical and expertise support, coordination with agricultural stakeholders, financial support, development of the application.
- **ITU**: Project conceptualization, technical and expertise support, financial support, development of the application.
- **Department of Agriculture and Livestock**: Identification of the pilot, support for the pilot, technical contribution, human resources and expertise.
- **Department of Communications, Information Technology and Energy and the National Information and Communications Technology Authority**: training, technical support, connectivity, project management support, financial support.
- **Provincial government** (Jiwaka): problem identification, interaction with the community, financial incentives to farmers, project management support.
- **Switch Maven**: contractor of software developers.

63. The **Building Blocks** project includes different providers and users of registration, biometrics, beneficiary management, assistance delivery and reconciliation systems. Each member of the Building Blocks network is 100 per cent equal to every other. The underlying architecture of the Building Blocks can easily be adapted to other use cases such as digital identity and supply chain management. Its entire codebase and know-how are available for free to other members.

64. Both **WFP** and **UN-Women** manage their back-end infrastructure separately**.** Transactions initiated are validated by both WFP and UN-Women nodes on the blockchain network. Web application, the back-end system and smart contracts are managed separately by the two organizations on their own Amazon Web Services cloud hosting infrastructure. **UNHCR** provides its identity management system/biometric service to authenticate the valid identity of beneficiaries living in refugee camps. A summary illustration of the complex blockchain infrastructure of Building Blocks is presented in box 3.

Box 3
WFP Building Blocks blockchain infrastructure

Parity Technologies:[13] blockchain and smart contract components.

Baltic Data Science:[14] infrastructure, back-end, front-end and mobile applications.

- Application development and support to both WFP and UN-Women.
- Development of the solution on Ethereum-based smart contracts.
- Upgrade of cloud infrastructure.
- Upgrade and maintenance of Ethereum.

ConsenSys:[15] governance framework.

- WFP keeps oversight of change requests and system upgrade.
- Enhancements are first approved by the governance framework body and implemented by UN-Women/WFP separately.

[13] www.parity.io/fighting-hunger-with-blockchain/.
[14] http://balticdatascience.com/tag/building-blocks/.
[15] www.consensys.net.

IrisGuard:[16] biometric solution (retina scanner) at point-of-sale in the supermarket to identify beneficiaries who are authorized and entitled to the "cash for work" programme.

Amazon Web Services: cloud hosting services. UN-Women and WFP manage their own Amazon Web Services infrastructure separately.

UNHCR: beneficiary information (including biometric data).

Source: WFP

65. The UNDP blockchain projects involve a variety of partners across their respective value chains, including technology providers (Fairchain, KrypC, Stellar Network, Convergence); producers and suppliers (farmers, herders, supermarkets); sustainability certifiers (Sustainable Fibre Alliance); and end consumers (chocolate bar purchasers, clothing manufacturers, food donation recipients).

66. In its country pilot projects, UNDP deals directly with producers/farmers and leads the overall concept development and project management. Typically, UNDP has partnered with technology companies to serve as vendor for technical implementation. **One notable exception is the "tech cell" team in UNDP Serbia, the in-house expertise resource that has developed and will run its blockchain project.**

67. An example of a less complex structure of a blockchain project is the UNJSPF/UNICC project. For the technical implementation of the 'digital certificate of entitlement', UNICC is the technology provider, acting as the system integrator in the project. The users of the full-technology solution are retirees from the United Nations system (served by the UNJSPF). The system has two parties in the chain at present. The success of the project may allow that, in the future, all United Nations agencies, programmes, and offices to participate in the creation of a United Nations unique digital ID. **The Inspector takes note with interest of the inbuilt vocation of inclusiveness and expansion of the project for broader United Nations participation and recommends that all steps in the development of the project take into account such perspectives** (see also paragraphs 296 and 297 below).

68. For the **UNICEF** "Digicus" project, UNICEF Kazakhstan determined the original need for the platform and is the primary user. A vendor was contracted to build the platform prototype, which was tested by UNICEF Kazakhstan, the vendor and partners. The infrastructure is managed by the UNICEF Information and Communications Technology Division in conjunction with UNICEF Kazakhstan, the vendor and the UNICEF Venture Fund.[17]

69. Organizations have engaged external service providers/vendors for the technical aspects of their blockchain projects and to manage the blockchain infrastructure. One notable exception is the "tech cell" in Serbia, as noted above. Another exception is UNICC, as it hosts nodes on its own servers. Blockchain nodes are on servers and computers hosted in the UNICC data centres – under United Nations privileges and immunities.

70. Against this background the Inspector notes that partners in and parties to blockchain applications include outside entities in both the private and public sectors. **Multi-stakeholder blockchain governance needs to take into consideration both the blockchain validation and consensus specificities and the applicable standards, rules and practices that generally apply to any agreements, contractual relationships and other types of cooperation between United Nations organizations and outside entities, be they private or public.**

[16] www.irisguard.com/where-we-work/humanitarian-assistance/refugee-cash-assistance/.

[17] The UNICEF Venture Fund is a pooled fund investing in early-stage, open-source, emerging technology with the potential to impact children on a global scale. It also provides product and technical assistance, support for business growth and access to a network of experts and partners. It is complemented by the UNICEF Cryptocurrency Fund, a vehicle whereby UNICEF can receive, hold and disburse donations of cryptocurrencies, such as ether and bitcoin. For further information, see annex II.

71. Similarly, the Inspector notes that not all the main features of blockchain fit into the United Nations working environment. A governance framework for blockchain applications and networks needs to be compatible with other applicable rules, regulations and practices of the United Nations system organizations (e.g., in terms of protecting privacy, confidentiality, etc.).

72. The information provided by participating organizations indicates that, besides the blockchain applications, other existing databases and cloud services not based on blockchain, including front-end, back-end and web-based applications, are used.

73. While noting that the limited experience that exists in the United Nations system does not allow for a rigorous picture of the use of blockchain and other databases, **the Inspector recommends that blockchain solutions should be fully transparent and clear as to the exact roles and responsibilities of the participants with regard to blockchain applications and/or other existing databases**.

Building Blocks project governance framework: a vision for inter-agency collaboration on blockchain

74. In view of the multi-stakeholder format of such undertakings, the Inspector emphasizes the importance of a clear definition of roles and responsibilities in a blockchain application, with all parties to and partners in the application agreeing on an adequate governance framework. From this perspective, the most complex illustration is the draft governance framework of the Building Blocks project.

75. In addition to its solitary presence in the United Nations blockchain landscape and its complexity, the projected governance framework of the Building Blocks project is an ambitious attempt to be robust, neutral, decentralized, flexible and attractive for inter-agency collaboration. If it is taken up by both WFP and UN-Women, the governance framework will have an inbuilt vocation to make Building Blocks a multi-organization, multi-modality, equally owned and jointly operated network for humanitarian operations.

76. The Building Blocks draft governance framework is also an attempt to reflect a modular approach, where specialized systems (registration, biometrics, entitlements, delivery, reconciliation, reporting and analytics) are integrated into a collective whole.

77. The framework is intended to formalize aspects, such as membership criteria, onboarding or offboarding of members, data protection and privacy, network maintenance and dispute resolution. Its main provisions are set out in the following sections, which may have general relevance for other complex projects:

- **Core principles**
- **Organizational structure** (membership, governance committee, technical committee, product team)
- **On-chain governance** (consensus algorithm, nodes, members, network maintenance, security and risk management, technical standards)
- **Off-chain governance** (ownership, voting rights and procedures, dispute resolution, member eligibility criteria).

78. **The Inspector recommends that the interested participating organizations examine the governance framework of the Building Blocks project, if and when adopted, and its relevance for similar undertakings, in view of its openness to new members joining the blockchain project and scaling it up** (see also para. 298).

E. Multi-stakeholder blockchain projects can attract multiple financing sources

79. Adequate funding of blockchain projects needs to be available throughout the life cycle of the project. Only basic information on funding has been available for the present review. That is not surprising as blockchain use is very recent and the management and maintenance costs for blockchain projects are difficult to assess at this stage.

80. While the data collected is neither comprehensive nor exclusive, as the volume of actual blockchain-based projects is still low, the Inspector was able to outline the main sources of funds, which reflect the diversity of projects and their participants. Two patterns became apparent: (a) blockchain projects are funded from multiple sources, including external parties and (b) seed funding and other support may come from innovation units or similar.

81. Blockchain projects are funded from different sources, including: (a) the regular budget, both from internal sources for regular programme activities and seed funding from special units, such as innovation units; (b) public-private partnerships; (c) other donors; and (d) international institutions. In many cases, there are multiple funding sources and several pilots are jointly funded by two or more entities.

82. Funding sources may differ, depending on the stage of the blockchain project: for example, testing and development would be supported by special funds, such as innovation units, while implementation and roll-out would be funded from programme resources.

83. For instance, for the Building Blocks project, UN-Women used seed funding from an Innovation Norway grant, with co-financing from the budget of a UN-Women country office, while staff time was made available by internal units. For WFP, funding came from its Innovation Accelerator and regular internal resources.

84. The blockchain initiatives taken by UNICEF have been financed from its Venture Fund, which was created to quickly assess, fund and grow open-source solutions that have been developed in programme countries. Donors include private sources, such as companies and foundations, public (governmental) sources and the resources of country offices.

85. At FAO, blockchain projects are currently financed through regular programme resources, seed money and extrabudgetary funds from the European Union. The ITU/FAO project in Papua New Guinea is an example where the national partner was part of the project and contributed financially.

86. In the case of UNDP, some of its blockchain projects have received internal **resources**, such as from the UNDP country investment facilities (for example, Ecuador), while others have relied on private sector partnerships (e.g., the Serbia example is 86 per cent funded by the private sector supermarket partner and 14 per cent by UNDP Serbia).

87. **The Inspector believes that the use of seed money from innovation units to fund pilot projects (WFP, UNIDO, UNICEF, UN-Women) is a good practice, not only because they can provide support to country-level initiatives, but also for assuring the coherence and synergy of all such initiatives.**

88. The Inspector recalls that funding is to be considered as a whole, to ensure the coherence of the entire life cycle of the project. There may be specific needs for preliminary investment (or seed funding) for development, piloting and testing. In that respect, the role of internal innovation units, where they exist, is important in collecting evidence on how the blockchain technology has led or not to positive results, including cost-efficiency and increased effectiveness. **The Inspector notes that assessments of the financial sustainability of pilot projects should go beyond the projects themselves and examine the perspective of scalability**.

89. The participating organizations could not provide JIU with enough data and benchmarks to assess the direct and post-contract costs of the management and maintenance of blockchain projects as a distinct category. **The Inspector recommends that the efficiency of blockchain applications should not be assessed in isolation but include management and maintenance costs, as well as other resource implications, on a longer perspective.**

90. In theory, blockchain is attributed considerable potential for supporting innovative financing. The views of participating organizations in this respect were also sought by the review team. Not surprisingly the feedback was rather limited. Only three organizations (UNDP, UNICEF, UN-Women) provided specific examples on how blockchain technology has the potential to support innovative financing mechanisms, although several other organizations expressed an interest in such possibilities.

91. The Inspector took note of the two main ways the organizations envisage supporting innovative mechanisms for financing for development: (a) crowdfunding using cryptocurrency and (b) through establishing a fund that allows acceptance and disbursement of cryptocurrency.

92. The UNICEF Cryptocurrency Fund is one such example. UNICEF reported that by accepting and disbursing cryptocurrency, transactions are not only transparent, but they happen faster with fewer intermediaries and at a low cost.

93. Another example is UN-Women, which referred to the Blockchain Charity Foundation (Binance) that had mobilized $1.4 million in cryptocurrency donations for victims of the floods in western Japan in 2018.

94. UNDP cited two early-stage examples (whose results were inconclusive at the time of the preparation of the present report):

(a) UNDP Lebanon proposed the "cedar coin", a digital asset that has been used to support cedar tree reforestation in Lebanon. For each tree planted, a cedar coin would be distributed to its investors and to the communities hosting the trees;

(b) UNDP Moldova plans to experiment with the use of a "solar coin" to install solar panels on a large hospital. Investors would use solar coins to purchase cells in the panels and they could then lease these cells to local businesses to recoup the costs of equipment, installation and maintenance.

95. UNIDO underlines the opportunity that blockchain brings to crowdfunding, when conventional financial mechanisms are combined with the new technical capacities brought by blockchain. It noted the example of the World Bank that issued the first bond created, allocated, transferred and managed using blockchain technology.[18]

96. The examples set out above show that blockchain offers opportunities for complementing existing funding sources through crowdfunding or by accepting cryptocurrency donations. Besides the technical challenges, any such resource mobilization activities need to be in line with the resource mobilization policies and financial rules and regulations of the entity in question. One aspect to which due attention should be paid is the possible anonymity of blockchain, which needs to be appropriately addressed to ensure compliance with the financial rules and regulations of an organization. In addition, innovation efforts could also support the applicability of new technologies and/or new business models, as reported by WFP in relation to its Innovation Accelerator.

Conclusions

97. The diverse experiences accumulated by the participating organizations have already yielded a set of lessons learned and important aspects to consider when using blockchain. They will be covered in the following sections.

98. The mapping of the blockchain landscape and its various uses shows that, despite its novelty, this technology does not create a new world. Blockchain adoption should not be seen in isolation from the existing policies and strategies that are followed by United Nations system organizations. One first conclusion is that the use of blockchain requires that not only aspects intrinsic to the technology itself are addressed, but also implies change management. As highlighted by several officials during interviews, the technical challenges are a lesser problem in implementing blockchain than the changes and reform efforts that come with blockchain or other vectors of digital transformation. The use of blockchain technology should be also seen in the context of innovation, reform and digitalization.

99. Several organizations have developed and issued strategies on new technologies and innovation in order to provide a corporate and strategic framework for implementing them, including by outlining the key principles, objectives and goals. One such example is the United Nations Secretary-General's strategy on new technologies, in which he notes: "The goal of this internal strategy is to define how the United Nations system will support the use

[18] See www.worldbank.org/en/news/press-release/2019/08/16/world-bank-issues-second-tranche-of-blockchain-bond-via-bond-i.

of these technologies to accelerate the achievement of the 2030 Sustainable Development Agenda and to facilitate their alignment with the values enshrined in the UN Charter, the Universal Declaration of Human Rights, and the norms and standards of international law."[19]

100. Ensuring a corporate, strategic and coherent approach aligned to the business needs and means of an organization requires an overall coherence in the implementation of all new technologies that allow innovation. In the same vein, existing information and communications technology (ICT) capacity, as well as infrastructure and human resources, have consequences for the adoption of blockchain.

101. The implementation of the following recommendation will strengthen coherence at both the strategic and operational levels.

Recommendation 1

The governing bodies of the United Nations system organizations should ensure that, when applicable, the use of blockchain applications will be integrated, together with other digital technologies, into the innovation strategies and policies adopted by their respective organizations.

[19] "UN Secretary-General's strategy on new technologies" (September 2018), executive summary.

III. A critical analysis of blockchain promises

A. Theoretical strengths and benefits of blockchain are not self-fulfilling

Strengths and potential benefits

102. In theory, there are several inherent features of blockchain which make it attractive for use by United Nations system organizations and which are perceived as providing competitive advantages over alternative solutions. As the power of attraction of the new technology is considerable - blockchain has been acclaimed as the Internet of the future – the review team questioned the participating organizations about what benefits they expected from it.

103. Those benefits could be categorized in two groups: (a) traits or features intrinsically (and theoretically) attributable to blockchain technology, such as immutability and transparency, and (b) indirect benefits that stem from the use of blockchain technology – owing to its distributed nature – that generally encourage and enable increased collaboration among stakeholders.

104. Potential benefits intrinsically engendered by the original nature of blockchain include:

- Creating a single source of **common information** between multiple parties;
- Creating **trust** between parties who traditionally would not trust one another;
- **Avoiding** intermediaries;
- **Decentralizing** governance;
- Enabling **immutability** of information;
- Increasing the **resiliency of** information because it is distributed across multiple nodes;
- Increasing the **transparency** of information and therefore holding associated parties **accountable**;
- Neutrality, **robustness** and the **flexibility** to accommodate various use cases with the same architecture;
- Reducing coordination/reconciliation **costs** between multiple parties;
- Enabling the **fast** transfer of assets around the world;
- Streamlining processes using the automated logic of **smart contracts**;
- Possibility of **"tokenization"**;
- **Scalability** and the possibility of expanding the network to new nodes and users.

105. The Inspector notes that the above paragraph summarizes the benefits of blockchain, as qualified by the participating organizations in their responses to the questionnaire. They are neither exhaustive, nor necessarily demonstrated in practice, compared with the theoretical benefits invoked by blockchain promoters.

106. The same goes for the indirect benefits of blockchain, which include: (a) encouraging and enabling increased collaboration among stakeholders and (b) creating opportunities for new ways of delivering services, disbursing funds, using automation and cutting out middle layers and intermediaries, which can lead to cost and time savings.

107. The most frequently mentioned strengths of blockchain, according to the responses collected by JIU, are transparency and traceability. These two features could solve the conventional problem of distrust in different application scenarios, such as funding, supply chain tracing, and digital identity. It therefore has the potential to change the fundamental relationships of stakeholders.

108. FAO highlighted transparency and traceability as two core benefits to its livestock traceability system supported by blockchain. ITU, its partner in the implementation of the project, argues that blockchain allows farmers to make a business case on a large scale.

109. UNDP also found that traceability was the key benefit of blockchains that had been delivered in its multiple country-level projects. For instance, the Mongolia country office was able to track cashmere from the time it was collected throughout the remainder of the value chain. Local herders found that blockchain added intangible benefits to products such as a "sense of pride".[20] Similarly, the Ecuador country office has been able to demonstrate to consumers the provenance of their chocolate bars.

110. UN-Women considers that blockchain can change the fundamental relationships of stakeholders along the value chain and enable them to increase collaboration by creating new ways of delivering services, new channels for fund disbursement and smart contract modules to automate activities, and by cutting out the middle layers in terms of cost and time saving.

111. UNICC labels trust-building as the biggest strength, as it provides a "bridge" between agencies for exchanging employee information. The previous generation of computing means, application programming interfaces (API) for multiple software applications to interact with one another and public key infrastructure (PKI) for security, proved to be very cumbersome to implement and maintain. With the "distributed" nature of the blockchain, both functions have improved.

112. Other participating organizations list the key strengths of blockchain in a general manner, without attributing or linking it to a specific ongoing blockchain project. For example, UNICEF noted that blockchain creates trust between parties who would traditionally not trust one another, enabled by immutable information, decentralized governance and holding associated parties accountable. It also reduces coordination costs and enhances the fast transfer of assets by streamlining processes using smart contracts.

113. UN-OICT indicates that the distributed nature and immutability can create trust and accountability, and WFP mentions neutrality, robustness and flexibility as the key strengths of blockchain.

Reasons for using blockchain

114. As stated by UNICEF, when looking at a business case, there are questions that need to be considered: (a) whether blockchain is the right fit for the problem and (b) if so, which type of blockchain to use. The areas for consideration of whether blockchain would be a good choice include: is there value in the information being public, can the information be publicly shared, is there an element of mistrust among parties, is there a need for central control of the information, do multiple parties require access to the same set of data, do all parties require the same level of access, would the parties trust a third party, and what is the level of required throughput of the system? These questions are part of a more complex package that should be asked to determine the real need for blockchain solutions. Such questions will be examined in detail in section V below.

115. The organizations cite different reasons to explain the search for blockchain solutions over other alternative solutions (for example, web-based solutions without blockchain, databases, traditional paper-based processes and cloud-hosted solutions). They do indeed correspond to the inherent strengths and opportunities that blockchain technology offers in principle, notably: data integrity, transparency, the potential ability to accommodate multiple participants or scalability, traceability, immutability, a decentralized structure and a reduction in the need for intermediaries.

116. UNDP noted that no other technology could provide the same level of trust in data integrity or the ability to grow a pilot into a full-scale solution, such as adding more partners and adding peer-to-peer value transfer and payment mechanisms.

[20] The project had to be abandoned, not because of technological choice, but because of the collapse of the market provoked by the COVID-19 crisis.

117. Other aspects as to why blockchain applications were chosen included the maturity of the codebase or platform, the availability of fit-for-purpose platforms, the possibility of smart contracts and the capability to generate tokens. Some organizations estimated that no other technology could provide the same level of trust in data integrity or the ability to grow a pilot into a full-scale solution, such as adding more partners, adding peer-to-peer value transfer and payment mechanisms. Others, on the contrary, believe that scalability is problematic.

118. Other reasons or assumptions play a role as well, such as cost efficiency, automation and an easier to operate system. These are not traits intrinsically linked to blockchain; they could also be achieved through alternative means. As noted by UNICEF concerning its Digicus application, the traditional database that was in place for UNICEF Kazakhstan was a costly and laborious paper-based system. The country office worked on the hypothesis that using blockchain would make the process cheaper, more transparent, easier to operate and more efficient and could be automated.

119. According to UNICC, there are always several alternative technologies available, including other distributed ledger technologies that are under development (for example, cloud-based immutable databases, such as AWS Quantum Ledger) and traditional database solutions. All of them require the development of applications, running on top of the database. The single database solution approach is attractive from a cost and ownership point of view. The costs are likely to be lower because the development is easier, especially when developed and deployed in a cloud-computing context. The data ownership management is simpler, because there is only one owner and this is a key feature that blockchain claims to overcome.

120. **The Inspector notes that the potential strengths and benefits of blockchain should not be assessed in the abstract. Every potential business case is different and requires different technical solutions. A process of assessing and analysing various options against rigorous criteria or performance indicators and a cost-benefit analysis is needed. Section V below deals with the determination of potential use cases.**

B. Proving potential benefits: a long way to go

121. According to the responses received from nine participating organizations, the effectiveness, efficiency and other gains depend on, and are different for, the varying uses and business cases. They are linked to the goals, objectives, results or impact intended to be achieved by the project for which blockchain solutions are used.

122. In most cases, blockchain uses concern external parties and beneficiaries. In only two cases reported on, they aimed at internal administrative and management processes: UNICEF (Digicus) and UNDP (the Serbia project). In UNICEF, a Digicus pilot project is being implemented where the use of a blockchain-based platform in place of the traditional paper-based system has increased transparency and is expected to reduce processing time and costs and demonstrate that payments could be automated. The UNDP project expects efficiency gains, with blockchain helping to eliminate the manual, spreadsheet-based tracking of donations that is currently in use. By enhancing tracking, the developers of the project believe they can reduce waste and increase the amount of donated food. In both cases, it is too early to assess whether the benefits have been confirmed.

123. In one case it was clearly stated that the effectiveness, efficiency and other gains were not necessarily a result of the use of blockchain applications. WFP reported that in Jordan, the Building Blocks project reduced banking fees by 98 per cent, resulting in savings of $1.5 million to date. However, these savings were from business process re-engineering and not attributable to blockchain (i.e., they could have been achieved without blockchain). However, WFP estimated that blockchain did present the potential for effectiveness, efficiency, cost reduction, transparency, inclusion and inter-organizational collaboration in the longer term.

124. In relation to the project implemented by its Ecuador country office, UNDP noted:

> “although some projects are still in pilot phase, the evidence so far is promising. In Ecuador, for example, blockchain has meant transparency in over 17,000 chocolate bars sold to date. By incentivizing consumers to purchase sustainable products, it meant 50 per cent of the product’s production value could remain in Ecuador (vs. 7

per cent from typical chocolate bars), and farmers on-the-ground received two-times higher wages. Furthermore, 90 per cent of consumers chose to reinvest their blockchain token in planting more cocoa trees (vs. discounting a future purchase), strengthening the bond between consumer and producer."

125. UN-Women reports benefits related to:

(a) **Reduced costs:** UN-Women no longer needs to manage cash disbursements in person or send cash to a bank as an intermediary;

(b) **Change of** governance **model:** the role of banks and other intermediaries changed in this pilot. In addition, the data from UNHCR, WFP and UN-Women could be reconciled for service delivery;

(c) **Inclusion:** UN-Women developed the pilot in a gender-responsive manner, assuming that electronic payments would improve the physical safety of women.

126. FAO mentioned its livestock project in Papua New Guinea as an example of value created through transparency and traceability. ITU noted that the pilot did highlight the volume of data available to farmers and gave stakeholders access to a repository of information that was not available in previous historical records. However, the farmers still lacked the basic skills and knowledge (digital literacy) to fully utilize the information collected and entered to improve the current situation. While it was too early to draw conclusions about the level of efficiency achieved, the project attracted interest from farmers and stakeholders and built capacity.

127. FAO further referred to another project in Côte d'Ivoire for which the "proof of concept"[21] report stated that:

- Blockchain has the potential to help build traceability systems that are more transparent, efficient and reliable;
- The issue of cost (private blockchain) and complexity must be carefully studied to justify the use of such technology;
- Blockchain is only a tool that will in no way help to solve the core issues;
- Efforts to review and enhance the workflow, procedures and practices should be made first.

128. The UNICC/UNJSPF project has two main effectiveness/efficiency gains as a goal. The immediate one is (a) the digital identity management needed by UNJSPF. The longer-term benefit is (b) the use of digital identity for other administrative processes:

(a) Digital identity management for the UNJSPF: in the current business process, the Fund processes the files of 72,000 retirees in over 195 countries using a paper-based form. That implies using 195 different postal services, leading to delays, the suspension of pension payments, etc. The blockchain platform is meant to be part of a bigger digital transformation and to be used as a tool to ensure that the new processes are secure and auditable;

(b) The extension use case of a United Nations digital ID is expected to foster inter-agency cooperation and to bring efficiency gains by allowing faster movement of staff between agencies and increasing the interoperability of the existing management systems of United Nations system organizations.

129. The Inspector notes that while blockchain has the potential to help build traceability systems that are more transparent, efficient and reliable, to demonstrate progress, the issue of costs and complexity must be carefully studied to justify the use of such a technology rather than other existing ones. The traditional efforts to improve processes, procedures, business flows, etc. need to be done anyway and cannot be replaced by blockchain (or any other technology) per se.

[21] Proof of concept is a realization of a certain method or idea in order to demonstrate its feasibility, or a demonstration in principle with the aim of verifying that a concept or theory has practical potential.

130. The Inspector also notes that proof of concept processes are often led by interested third parties and conducted always in controlled environments.[22] Caution should therefore accompany innovation endeavours.

C. Not all assumptions are confirmed

131. Most organizations indicated that the advantages of their blockchain applications had been confirmed, while not always fully. At the same time, some concerns needed to be resolved. However, there was little evidence that the assumptions made were the result of assessments conducted in comparison with alternative means. As stated by ITU, it is too early to draw any definitive conclusions.

132. UNICEF noted that further testing was needed to confirm the decrease in transaction costs. The Digicus prototype confirmed an increase in transparency of information, improved efficiency in dealing with implementing partners, a reduction in unnecessary intermediaries, a shorter time spent on spot checks and also enabled the possibility of immediate and automatic payment. However, further testing was needed as the prototype used test data on a test network.

133. In regard to the blockchain project implemented by its country offices, UNDP indicated that scaling had proved difficult for various reasons, including limited capacity. One lesson learned was the need for a train-the-trainers model to build capacity.

134. WFP noted that neutrality, robustness and flexibility were proven in practice in the Building Blocks project. UN-Women stated that blockchain limited the need for intermediaries and that disbursements to beneficiaries were more direct, transparent and secure. Without the need of a trusted authority to validate transactions, the blockchain solution allowed actors to interact without third parties verifying transactions, by providing a single, agreed-upon source of truth.

135. In the case of the FAO blockchain experience, the assumptions related to transparency and traceability were confirmed. In terms of persisting challenges, regulation and standardization of frameworks needed to be resolved to ensure the mainstreaming of solutions. Interoperability remained a key concern and the traditional issues with data governance (collection, storage, ownership, etc.) were still bottlenecks. They would have to be sorted out to extract the full benefits of blockchain implementation.

136. UNICC emphasized that since they were using a fit-for-purpose platform, all their assumptions and requirements had been met. At the same time, one key aspect - moving the user wallet into a mobile application - was still a work in progress and hence no conclusion could yet be drawn.

137. The Inspector agrees that the early stage of blockchain use in the United Nations system has not yet produced enough data to be statistically relevant and provide authoritative conclusions. While a few organizations claimed that some of the assumptions of benefits (notably neutrality, robustness, flexibility, traceability and elimination of intermediaries) were confirmed, others noted that further testing would be needed.

138. The Inspector notes that attention should be paid to the prerequisite that the blockchain fits the intended use. As rightly highlighted (for example by UNICEF), no one should opt for blockchain only because of the hype associated with it, but for proven benefits (such as savings or higher productivity). In cases where a private blockchain application is chosen, it may have many similarities to a database. A private blockchain should therefore be designed in such a way that it takes advantage of the decentralized and distributed nature of blockchain, i.e., having nodes in various locations or regions and being hosted on various cloud providers.

139. The Inspector notes that it is essential in any experiment or choice of blockchain applications to compare the potential benefits and cost with the opportunities offered by existing alternatives. **Blockchain is not an end in itself: it is a new tool whose use should**

[22] World Economic Forum, “Building value with blockchain technology: how to evaluate blockchain’s benefits”, White paper (July 2019).

be based on solid business cases and analyses. In view of the common values and interests of the United Nations system, it is important that the results of the use of blockchain by the United Nations system organizations is systematically shared among them in order for them to learn collectively and respond coherently to the needs of Member States.

140. **The Inspector recommends that the United Nations Innovation Network establish a library of information on the concrete blockchain applications in use in the United Nations system and the progress made in their implementation, as well as lessons learned, and that it systematically inform all United Nations system organizations about new developments.**

D. Immutability can backfire, decentralization needs more testing

Immutability implications

141. In principle, immutability is considered a fundamental characteristic of blockchain. Technically, a record on a blockchain remains immutable or unchangeable after it has been created. To create and record a transaction, participants or nodes running the blockchain protocol must come to a consensus on the validity of the transaction. After a valid transaction is recorded in the ledger, no participant can tamper with it. The immutability of the information serves as resilience and irreversibility, providing the security and integrity of the data. Since the data is replicated across many different locations or nodes, any attempt to change it in one location or node raises suspicion and is interpreted as fraudulent activity or as an attack on the integrity of the blockchain by other participants.[23]

142. Immutability was cited by respondents in United Nations organizations as the main reason or desirable feature for adopting blockchain applications. In their view, immutability supports transparency and accountability and builds trust among the parties and users of the blockchain.

143. For UNDP, immutability is a critical feature in building trust in the underlying data among consumers and monitoring agencies. ITU and FAO noted the same in respect of their joint blockchain project on tracing pig livestock in Papua New Guinea.

144. UN-Women reported that the Building Blocks project (aimed at making cash transfer efficient, secure and transparent, while protecting beneficiary data and controlling financial risk) demonstrated how immutability was realized in practice on a private blockchain. Ledgers used in the solution ensured that the full history of and information on the application was available at any time.

145. In relation to its Digicus prototype, UNICEF noted that the immutability of data increased the level of transparency as to how funds were spent. Similarly, for the start-ups funded by the Venture Fund, immutability allowed a new level of accountability and was a source of trust between multiple parties and a trigger of smart contracts. The Cryptocurrency Fund is meant to leverage the inherent immutability of blockchain to create a new level of transparency and accountability in donations.

146. However, immutability should be considered with care because possible mistakes cannot be fixed easily, if at all. WFP, for example, highlighted that extreme diligence and testing is needed before code release and no sensitive information, such as names, dates of birth, and biometrics, should be put on the blockchain.

147. UNHCR cautioned that immutability would only be guaranteed if the nodes were properly distributed among multiple entities, each undertaking periodic independent audits to ensure proper and secure operation in line with their respective data protection and information security policies. If all nodes are essentially under the control of a few individuals, that would create concern and would essentially contradict the core security and immutability characteristics of blockchains.

[23] There are scenarios, such as a 51 per cent attack, whereby a change to the data is forced through gaining control of the majority of the nodes. Such an attack is very difficult and costly, especially on a large network of public blockchains.

148. The Inspector would like to point out that some of the main attributes that make blockchain so relevant, including immutability, are the very things that also pose a major challenge, in particular in the United Nations environment. The immutability of information on a blockchain contradicts the right to be forgotten. The transparency of personally identifiable information could put users at risk.[24] **The Inspector invites interested organizations to consider that challenge in the design and optimization of blockchain solutions, taking into consideration the decision-making matrix proposed in section V**.

Implications of blockchain decentralization

149. The experience that exists so far in the United Nations on the benefits of decentralization as another fundamental feature of blockchain is inconclusive.

150. UNDP reported on how the balance between the desire for decentralization and its inherent complexity and the cost burden was considered in real cases. For instance, the Fairchain Node Network, as an external technical provider, manages the underlying infrastructure for the Ecuador project. Currently, they run five nodes, of which three are located outside Fairchain, ensuring that no single actor can modify the data. In contrast, in the case of the blockchain application run by the Mongolia country office, the administrators ultimately decided to forego some decentralization, given the nature of the transactions being tracked (no direct financial value was associated with them), in order to keep things simple and come up with more stable hosting/operating costs that could be split between participants in the network.

151. FAO explained that in the case of the Papua New Guinea livestock project, decentralization gave the community a better grasp of tracking and trading in a commodity that was considered important. At the same time, FAO stated that the issue of cost and complexity must be carefully studied to justify the use of such an alternative.

152. UN-Women stated that the Building Blocks project was a private blockchain solution that was mostly centralized in nature, but still achieved decentralization in terms of the architecture of the distributed ledger technology. Both WFP and UN-Women have separate cloud servers, which host Ethereum nodes and smart contracts, making them independent from each other. WFP noted that action had been taken to improve the robustness of the solution, including by deploying nodes in additional cloud providers. There is no technological solution for handling issues, such as disputes, during daily transactions. The Inspector notes that this lacuna is expected to be covered by the future Building Blocks governance framework.

153. UNICC pointed out a major benefit of decentralization as a feature in the UNJSPF blockchain-based project, namely that other interested organizations would join the network. The decentralized nature of the project would make it possible to publish different types of "identity information" and allow that information to be consumed by other parties without having to focus too much on data standardization.

154. **The Inspector believes that trade-offs between the desired attributes of blockchain for given applications are possible and necessary, which will result in different blockchain solutions, optimized for the needs of different organizations.**

E. Adequate digital infrastructure remains a challenge

155. "Blockchain is a technology in search of a problem to solve" is one of the maxims that circulate in the online literature and was noted in one response to the JIU questionnaire. That statement has more meanings but, by and large, most participating organizations admit that blockchains are available and the technology is improving: the right choice of use case and an adequate solution are the real challenge. Most organizations use one of the two major existing blockchain platforms, which are described in box 4.

[24] See Carla LaPointe and Laura Fishbane, "The blockchain ethical design framework", *Innovations: Technology, Governance, Globalization*, vol. 12, No 3-4 (winter-spring 2019).

Box 4
Blockchain platforms

Ethereum is a decentralized open-source blockchain platform, featuring smart contract functionality. It provides a decentralized, replicated, virtual machine that can execute scripts using an international network of public nodes. It is used to create and run decentralized digital applications that enable users to make agreements and conduct transactions directly with each other without intermediaries. Ethereum also supports multiple programming languages, enabling developers to build and publish smart contracts and distributed applications. In 2017, the Enterprise Ethereum Alliance was created, which now includes among its members partners of the United Nations organizations such as Mastercard, Accenture, Deloitte, Cisco Systems and ConsenSys. (*Source: investopedia.com*)

Hyperledger is an umbrella project of open source blockchains and related tools, started in 2015 by the Linux Foundation, with contributions from IBM, Intel and SAP Ariba, to support the collaborative development of blockchain-based distributed ledgers. The objective of the project is to advance cross-industry collaboration by developing blockchains, with a particular focus on improving the performance and reliability of such systems. The project will integrate independent open protocols and standards by means of a framework for use-specific modules, including blockchains with their own consensus and storage routines, as well as services for identity, access control and smart contracts. (S*ource: Wikipedia*)

156. Organizations used the Ethereum or Hyperledger blockchain technology, and in one case (the UNDP application in Serbia) a Stellar protocol was used. Annex I provides more details for each organization.

157. While the applications were mostly permissioned and private blockchain, in some cases they were public or a combination of the two. In most cases the organizations engaged vendors and service suppliers to develop and build the platform, while they acted as the technology partner and service provider.

158. For example, the WFP Building Blocks project runs on a private, permissioned blockchain using the Parity Ethereum client with a proof-of-authority consensus algorithm.[25] The UNICC/UNJSPF project also uses a permissioned, private blockchain technology, based on Hyperledger Indy, which comes with its own built-in consensus algorithm. The FAO/ITU blockchain solution was developed on Ethereum Blockchain, using a public blockchain with proof-of-work consensus.[26] UNDP Mongolia used a public Ethereum-based blockchain network for its pilot, but recommends a public view, permissioned write structure for any further development of the experiment.

159. Only two technical infrastructure-related issues are addressed briefly in the present report, as they are relevant for the beneficiaries of United Nations operational activities and for the choice of use cases, namely connectivity and data protection.

Connectivity problems

160. The practices or views reported by the participating organizations fall largely into one of the following categories:

[25] Proof of authority provides decision-making power to one of multiple clients on the database that have specific private keys allowing them to create transactions and blocks on the blockchain. See, for example, Mark Gates, *Blockchain. Ultimate Guide to Understanding Blockchain, Bitcoin, Cryptocurrencies, Smart Contracts and the Future of Money* (Wise Fox Publishing, 2017).

[26] Proof of work was the original consensus mechanism, which is based on a competition between computers (called miners) to verify transactions and certify new blocks to be added to the blockchain. See Alan T. Norman, Blockchain Technology Explained. The Ultimate Beginner's Guide About Blockchain, Copyright, @ 2017.

- Projects are in the early stages or have limited pilot implementation, there is no data as yet about their performance in low bandwidth categories or they have not been tested in those conditions (United Nations Office at Geneva);
- Some responses, for example one from (UN-OICT) focus only on the point that (server) nodes do not have to be located in low bandwidth environments;
- No problems are experienced when both the (server) nodes and user points are located in areas with good connectivity and sufficient bandwidth (UNHCR) and when the end user application was designed to work asynchronously and contains considerable autonomous 'logic' built in. In other circumstances, there are no major problems, but that is mainly due to low data requirements or additional connectivity provided by the national telecom regulator.

161. The main problems experienced by organizations in this respect:

- The challenges experienced in remote sites and States that have a fully developed version of the application should contain comprehensive offline features (UNDP – Mongolia).
- The general lack of investment into developing appropriate blockchain solutions for remote areas (UNICEF).
- The fundamental challenge of verifying a digital signature online even with asynchronous solutions, in cases where Internet connection is interrupted (UNICEF).
- The loss of transactions in cases where connection drops intermittently. To avoid that proper network infrastructure should be ensured for projects that depend on the connectivity (UN-Women).
- The duplication of transactions when the system is not responsive due to poor connectivity and the need for additional work-around to overcome this problem (WFP).
- The connectivity problems encountered and (partly) resolved by using the blockchain cloud infrastructure from Amazon AWS and IBM (the pastoralism experiment), while the Papua New Guinea system was designed to connect online and offline (FAO).

162. The Inspector notes that connectivity challenges will be frequent for blockchain applications aimed to be used in rural, remote and other areas with poor and unreliable connectivity. Technical and design solutions that overcome these problems are possible in some cases. Such challenges must be taken into consideration at the onset. The project and technology design should include solutions that could work under the conditions of poor connectivity. To address connection drops, for example, the Building Blocks project has an in-built logic to automatically detect and correct transactions affected.

163. If a solution is intended to be deployed in areas where there are frequent losses of connectivity cannot assure smooth functioning offline (asynchronous approach), then blockchain might not be the best approach. **The cost aspects of solving the connectivity problems should be included in any analysis of blockchain solutions.**

Encryption, generation and storage of data

164. The current practices of protection, generation and storage of data in the blockchain applications used by the United Nations system organizations include:

(a) Privacy related farmers data is provided using APIs[27] and is stored in off-chain database with only references to the farmer ID in blockchain. Some data (such as pictures) are used on the basis of signed consent-forms (UNDP, Ecuador);

(b) Biometric recognition (eyes) is used to identify and authenticate refugees in the Building Blocks system. Based on eye recognition, the implementing partner

[27] Application programming interfaces (APIs) are programmatic interfaces that allow applications to speak to each other.

(IrisGuard)[28] returns a case number, which is in turn translated into a key to sign transactions. Each user that has created an account is issued with a set of private keys, which they are responsible for managing.[29] The signed transactions are completed locally and sent to the blockchain (WFP);

(c) Public and private keys were never exposed to the Internet or to other users on the platform (Digicus, UNICEF);

(d) Identity is based on a possession of a combination of private and public cryptographic keys. That is achieved by establishing a trust model which boils down to authentication of transaction. Cryptography is provided by the key management service of Amazon Web Services (Building Blocks, UN-Women);

(e) Encryption is provided through standard Node.js[30] functionality based on the condition that end-users own and control their own private keys (Building Blocks, WFP);

(f) Using radio-frequency identification tags and a smartphone (FAO);

(g) Encryption and public/private keys are handled by a niche protocol, Geora[31] (ITU).

165. The Inspector notes that one of the main potential advantages of blockchain technology is the use of cryptography to ensure the authenticity and immutability of the data. Public key authentication is a crucial technique supporting this objective. It is based on the principle that all users of an application possess a private encryption key that they use to sign transactions and/or assert their identity and that is not known to anyone else. That makes the private key a highly sensitive data asset. A loss of one's private key would mean a loss of access to one's records and assets or to services provided by the system for which the key grants access.

166. Consequently, private access keys need to be stored safely and in a form which is easy to use. That is relatively easy when they are integrated in user-friendly applications on smartphones, but even then, it requires reliable backup and adherence to a certain protocol. However, in many humanitarian projects the beneficiaries are not in a position to own a smartphone or a computer on which to maintain their keys. According to the responses received by JIU, some of the practical workarounds described imply that the organizations should act as custodians for the private keys of beneficiaries, which are linked to the users' biometric data. While that is a practical solution, as noted by UNHCR with respect to the Building Blocks system, it negates one of the essential properties of blockchain architecture in terms of decentralization and user autonomy.

167. It follows that blockchain projects in the humanitarian and development context should consider the issue of beneficiary personal key management from the very start of the project and develop realistic solutions that are appropriate for the particular conditions of each use case.

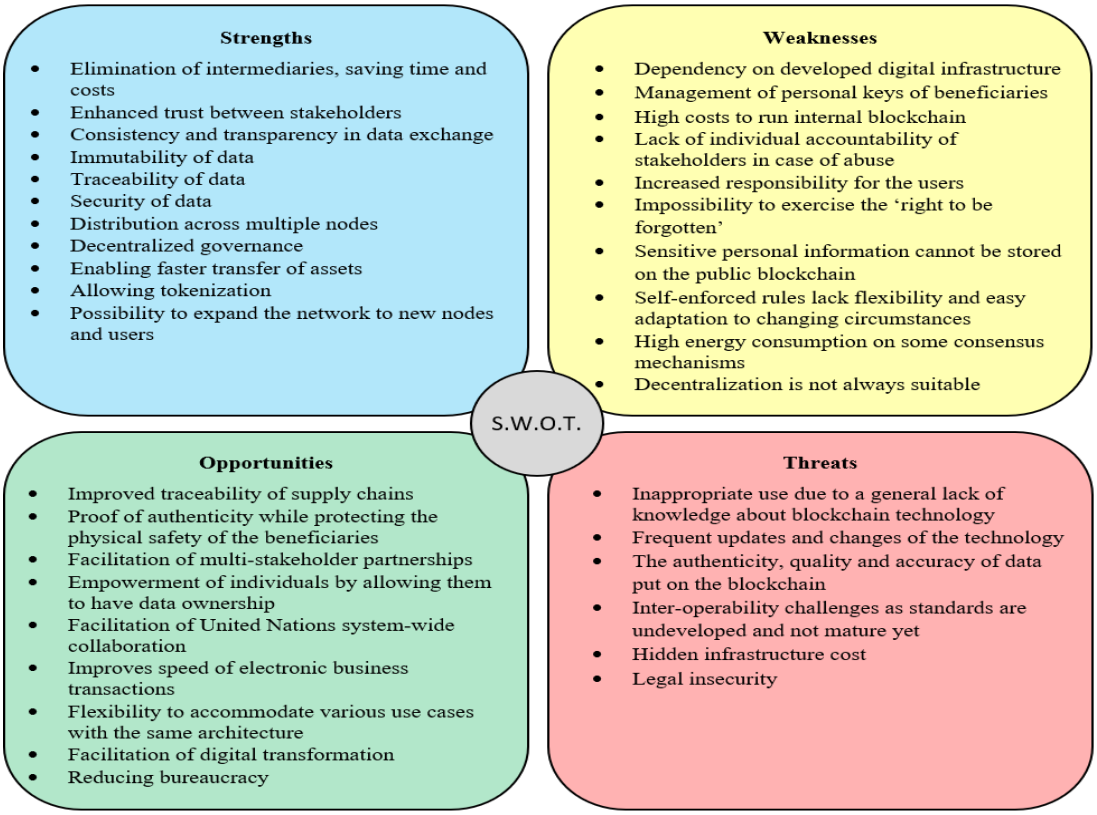
[28] IrisGuard is a supplier of end-to-end iris recognition biometric technology.

[29] WFP notes that, in practice, as most people served by the project do not currently have smartphones and connectivity to the Internet, the members of Building Blocks act as custodians on their accounts. However, as devices become increasingly more affordable in the future and global Internet coverage expands, it is anticipated that private keys for blockchain accounts will be fully transferred to the end users.

[30] Node.js is an open-source, cross-platform, JavaScript runtime environment that executes JavaScript code outside a web browser.

[31] The Geora blockchain protocol is a distributed data layer and smart contract library built using Ethereum-based technology designed specifically for agriculture.

Figure III
A SWOT summary



168. Figure III provides an overview of the strengths, weaknesses, opportunities and threats (SWOT) associated with the use of blockchain. It is based on an analysis of the existing blockchain applications in place in United Nations system organizations. However, due to the limited data available and the incipient level of maturity of blockchain applications in the United Nations, the information should be considered with these limitations in mind, not as a result of a SWOT analysis in the strict sense, but rather as an indicative and not exhaustive list which provides a selection of the most relevant elements noted by the participating organizations.

IV. Risk management

A. Risk management needs to be adapted to specific vulnerabilities

169. Several organizations noted that blockchain was still being actively developed and continuously upgraded. For users and potential implementers this can mean frequent updates, changes in system operators, etc. In that context, UNICEF noted that, while this dynamic might not be challenging for a smaller, agile organization, in large organizations implementing changes took longer and was more complex and they might not therefore be able to move as fast as the industry.

170. Having reviewed the weaknesses and threats listed by the organizations, it could be observed that many do not appear to be directly linked to blockchain technology and its intrinsic features, but rather to the general weaknesses and threats that implementing any new technology or application and modernizing existing systems will bring. For example, some of the inherent value-adding features of blockchain, such as the immutability and integrity of data, may be compromised if inadequate attention is paid to the quality and accuracy of the data put on the blockchain.

171. For instance, FAO and ITU stress that the main weakness of blockchain is the quality of the data stored and the process of ensuring that the data corresponds to the expected quality of data (the "garbage in, garbage out" concept).[32] In the case of blockchain applications for the supply value chain, the quality of the envisaged traceability and transparency depends directly on the quality of the information which goes into the blockchain. The authenticity or trust level of the original data entered still need to be ascertained.

172. Another point brought up was that blockchain at an enterprise level requires a different set of skills and expertise than the small-scale prototypes being completed by smaller groups within an organization – it requires an enterprise approach. The coordination of UNDP country office projects is a case in point. Innovation and rapid prototyping are challenging to translate at an organizational level. Furthermore, the lack of local expertise to develop and maintain blockchain applications was considered a major challenge by ITU where blockchain applications were used in programme countries.

173. UN-Women pointed out one of the most likely vulnerabilities associated with the solution originated from the point where human and machine meet. It was very important to input correct information. Besides, even if the solution was a fully secured application, exposing information to integrate with third-party applications might trigger a potential threat of data being compromised. The views of the organizations concerned do not necessarily converge on that point. UNHCR noted that there was no reason to use blockchains to store sensitive data under the scope of its data protection policy. It referred to security audits on the Building Blocks project, which had concluded that further analysis was needed to verify that the system was compliant with the agreed standards of information security.

174. While not having a blockchain application in use, the United Nations Office at Geneva noted that if the size of the network was small and the data not well distributed, it would be vulnerable to attack. In large public networks, where each transaction is broadcast to many nodes, transactions are inefficient. Also, users still need to depend on third parties for the exchange of value and privacy remains difficult to implement while complying with national jurisdictions.

175. UNIDO listed weaknesses and threats related to:

(a) Hype: discussions focused on potential rather than shortcomings can lead to unrealistic expectations;

[32] In computer science "garbage in, garbage out" is the concept that flawed or nonsense input data produces nonsense output.

(b) Scalability: technical improvements continue to offer more potential to scale up blockchain applications. However, three core features in particular are very difficult to change without significantly affecting the others: decentralization, scalability and security;

(c) Interoperability: the lack of standardization between blockchains can be the source of problems related to systems integration. For example, integrating blockchains into financial infrastructures such as payment and settlement systems not only requires coordination and collaboration, but also incurs significant expense.

176. The Inspector observes that several of the weaknesses and threats highlighted may not be specific to blockchain but rather apply to the choice and implementation of new technologies. Blockchain should fit the business case and have a competitive advantage over other alternative solutions. Small, limited pilots of applications are easier to implement than organization-wide systems, but the potential for scalability should be also examined. **The Inspector emphasizes that the best way to optimize the use of blockchain, anticipate the related weaknesses, threats and vulnerabilities and mitigate the associated risks is to have a rigorously informed and documented decision-making process and risk assessment.** The risk assessment needs to cover all risks, those directly linked to the intrinsic features of blockchain technology as well as those stemming from the use of new technologies and implementing new systems in general. Organizations need to be aware of the key risks in order to put appropriate mitigation measures in place.

B. There is awareness of the risks associated with blockchain

Key risks

177. The risks brought up by organizations can be categorized into risks directly associated with blockchain, based on its inherent features, and risks that may occur with the use and implementation of any new technologies in general.

178. For instance, UNICEF noted that many of the risks that apply to any traditional IT projects, such as lack of leadership buy-in or information security, apply to blockchain projects as well. Those that are more specific to blockchain projects include:

(a) Governance of the network: for private blockchains, a clearly defined governance framework is required;

(b) Lack of the required IT support to maintain projects: ensuring that there are both internal staff that understand the technology but also vendors who can augment staff capacity when needed. The staff concerned should have adequate training in the basics of the technology;

(c) Handling of private keys: the appropriate key management strategy depends on the users of the platform;

(d) Vulnerabilities in smart contracts: code must be properly audited and proxy smart contracts used to ensure that any issues can be addressed.

179. WFP and UNHCR highlighted as a risk specific to blockchain the issue of private key custodianship that would need attention. UNHCR flagged up in this regard that key management is the most sensitive process and needs to be carefully implemented and regulated. For example, making refugees responsible for their keys is not realistic. A major risk is having to keep the keys centrally, if only for backup purposes. The breach of such keys could essentially void the security control of the blockchain. Transferring data ownership, for example identity data, which is usually managed centrally in traditional databases, into the hands of the individuals concerned is unacceptable, so technical remedies should be sought to mitigate such risks. In the view of UNDP, the main risk is the low level of scalability. For UN-Women, the cost of the new system and resistance to cultural change are also risk factors.

180. On a more general but essential note, UNIDO referred to the risks entailed in the adoption of blockchain from the perspective of the 2030 Agenda for Sustainable Development, a view also supported by UN-Habitat. Those risks included:

(a) Potential inequitable distribution of the benefits: the integration of blockchain into development initiatives could aggravate the prevailing asymmetries among direct recipients. The associated technological demands, such as Internet access and access to appropriate hardware (for example, computers and mobile phones with minimum technical requirements), can be exclusionary for specific segments of a population. Similarly, although sensors are increasingly affordable, their cost can be a major limitation for many small-scale farmers and producers;

(b) Concentration: the significance of the lopsided geographical location of service providers is usually not carefully considered. While some entrepreneurs in developing countries are already experimenting and developing blockchain applications, the higher concentration of blockchain companies, both in number and in capital investment, is mostly located in developed countries.

C. Risk mitigation should start at the inception of a blockchain project

181. Most organizations that use blockchain indicated that they had measures in place to mitigate blockchain-related risks, including cybersecurity and data privacy risks.

182. For both the Venture Fund and the Digicus project, UNICEF has specific rules and standards related to cybersecurity and data privacy that are also followed for blockchain projects. However, it is not clear how and to what extent those rules and standards would address risks that are specific to blockchain in addition to general ICT risks. FAO, for instance, noted that it did not currently undertake specific blockchain actions, other than relying on its regular ICT security practices.

183. **The Inspector recommends that blockchain projects that are enterprise-ready be subject to an assessment of compliance with the ICT standards and policies of the organization, including those related to cybersecurity, as are all other ICT projects**. **Such assessments should include (a) verification as to whether the ICT rules and policies of the organization (including for cybersecurity and data privacy) also apply to blockchain projects; (b) ensuring that those policies and standards take into account risks that are specific to blockchain; and (c) exploring common United Nations system-wide standards, as appropriate.**

184. WFP noted that in the case of the Building Blocks project, it aimed to perform an extensive security review at least annually. That may be a good practice, but it should probably be based on a risk assessment to better understand the security risks, i.e., if they are high-level risks and need continuous or annual review. WFP further noted that the Building Blocks project had already undergone several reviews, including (a) an assurance exercise by its internal audit function in 2018; (b) a code and security review by an independent blockchain audit firm (in 2018 and 2019); and (c) a review of Building Blocks against ISO 27001 in late 2019. Moreover, WFP does not store any sensitive beneficiary information such as names, dates of birth or biometrics anywhere on the system. Even the anonymous beneficiary identifiers are hashed on the private-permissioned network.

185. UNDP listed the following risk mitigation measures: (a) ensuring that privacy-related data (e.g., a farmer's personal information) is stored off-chain; (b) referencing only anonymized data sources in the blockchain; and (c) using standard tools to control customer interaction.

186. The key steps taken by UN-Women to mitigate the risks to data include:

(a) Applying a selective approach to entering data: the fact that the data written to the digital ledger is stored on a distributed system can carry significant privacy and security risks, without a full understanding of which data should be used on a blockchain network;

(b) Validating data quality before it enters the blockchain: making sure that the data pulled out from other systems is of good quality. Data sets such as beneficiary identities and family group numbers should adhere to the standard protocol that has been established;

(c) Protecting data: all the components and objects stored in the Amazon Web Services cloud environment strictly follow standard cloud privacy and security models. Data stored in the database is fully encrypted.

187. Several organizations warned that following unconditionally the hype and the media buzz about the technology can lead to suboptimal decisions. UNIDO flagged up the risk of the "inappropriateness" of blockchain solutions for some use cases, stating that it would be essential to further inquire into the method employed for carrying out an objective evaluation of the suitability of blockchain vis-à-vis other more developed or cheaper alternatives. UN-Habitat noted that in the case of land registries, there was a high risk of blockchain-based systems entrenching unjust and inequitable outcomes, unless there were clear and enforceable measures to prevent and mitigate this.

188. UNHCR emphasized that, while blockchain was considered to be robust and safe in terms of cybersecurity risks, such risks still existed. While blockchain applications were usually presented as far more secure than other technologies, that was not always true, particularly if they were not implemented properly. UNHCR noted that personal data must be fully protected throughout the whole life cycle, from capture to decommissioning and destruction.

189. While not actually using blockchain applications, the UN-OICT, UNFPA and ICAO listed several potential risks and mitigating measures:

(a) UN-OICT: misuse (wasted effort on the wrong use cases) or poor implementation leading to data privacy issues, security flaws, a waste of computing resources or data inconsistency. These could be mitigated by sufficient expertise, careful planning and security reviews;

(b) UNFPA: choosing a technology that might not become standard in the future could lead to lock-in with providers that might not survive the maturity process of that business sector. A form of risk mitigation would be to closely follow the market and its evolution and/or to enter into a deep partnership with a provider that could lead to the development of a technology owned by the United Nations;

(c) ICAO: risks of interoperability, which could be mitigated by finding the right balance between the need to set appropriate regulations and standards or recommended practices and the need not to hinder or stifle innovations through an overly cautious approach.

190. The implementation of the following recommendation will lead to enhanced efficiency and effectiveness and strengthen risk management. The Inspector notes that in assessing risks, a distinction should be made between early exploration attempts and pilots (which can be tested in sandbox arrangements) on the one hand and larger scale usage on the other. Such an approach is needed because it is not always possible to anticipate all the implications of an innovation.

Recommendation 2

The executive heads of the United Nations system organizations should make sure that the examination of possible blockchain use cases will be based on assessments of project risks, including with respect to relevant organizational policies and regulations on privileges and immunities, data protection, confidentiality, cybersecurity, system integrity and reputation.

191. Other categories of risks could be mitigated by the application of the decision-making matrix proposed in section V below.

V. Blockchain: a solution in search of a problem?

192. The Inspector believes that exploring possible uses of blockchain in the abstract, as determined by theoretical assumptions on its potential benefits rather than on evidence-based arguments tested in practice, can be misleading and conducive to a waste of resources.

193. This is why crucial importance should be attached to a rigorous choice of use cases. In that sense, the Inspector welcomes the technical report produced by the ITU-T focus group on application of distributed ledger technology.[33] The report is based on lessons learned in practice from use cases that have reached the proof-of-concept stage.

194. The present report offers to the United Nations organizations that are interested a presentation of distributed ledger technologies, including blockchain, use cases from the perspective of both horizontal and vertical domains and the barriers to the adoption of such technologies. It also includes notable connotations of their significance for the achievement of the Sustainable Development Goals. In annex III, JIU summarizes some interesting findings from ITU, which offer illustrations of one possible use of blockchain for each of the 17 Goals.

195. **The Inspector recommends reference to the ITU taxonomy of use cases, in their dynamics, as an initial step in the consideration of the available and realistic options for the use of blockchain.**

A. Applying the lessons learned, while going ahead

196. The lessons drawn from the early experience of using blockchain applications indicate that the gains in efficiency, as suggested by the theoretically competitive advantages of blockchain, are not self-evident. Blockchain use is not an end in itself and its adoption should follow both specific business and project needs and general principles.

197. The usability of blockchain applications still needs to be developed and simplified, in particular in terms of key management and evidence of value added. Onboarding to blockchain-based applications can block projects, even if the platform is good. UNICEF cited the example of an internal prototype of a decentralized decision-making application with a token-based platform. Setting up a blockchain-based wallet to interact with the application required an effort which was disproportionate to the benefits. Potential users stopped using the platform even before signing up. That is not a problem specific to the United Nations; it reflects the general need for increased usability and accessibility of this new technology.

198. The low level of knowledge related to building blockchain is an obstacle to the effective generation of ideas, experimentation and exploration of the potential uses of blockchain and hackathons, even when blockchain platforms and coders are available. The technological component or challenges can be relatively easier to overcome than the related change management component.

199. The initial costs, the limited data size of blocks and speed remain a deterrent for a significant use of blockchain. The number of use cases that are truly suitable for blockchain solutions is limited. Even in cases where blockchain is considered a solution, it may not necessarily be better than a traditional database.

200. Decentralization implies the involvement of many different stakeholders dispersed across many locations. Dispersion of knowledge should therefore precede the use of blockchain solutions. In the same vein, administrative and financial capabilities, as well as basic infrastructure, should be available for blockchain solutions, whether designed for piloting or for future scaling.

201. Users should be able to reap the benefits of blockchain in a transparent manner. The added value from which end users as well as other users will benefit, should be assessed prior

[33] International Telecommunication Union, ITU-T Focus Group on Application of Distributed Ledger Technology, “Technical report FG DLT D2.1 - distributed ledger technology use cases” (1 August 2019).

to undertaking any blockchain application-based project. Incentivizing participation is an essential condition for a blockchain network to be effective.

202. Based on its own practical experience, FAO outlined several lessons learned that are worth noting.[34] At the operational level, blockchain architecture should be considered in both on-chain and off-chain scenarios in connection with blockchain 'oracles'.[35] Moreover, in order to increase its efficiency and effectiveness, blockchain adoption should be considered in conjunction with the appropriate project management methodologies that can speed up and help decision-making, including Agile Scrum,[36] Agile Kanban,[37] proof of concept and minimum viable product.[38]

203. According to the same FAO source,[39] and more recent analyses, the United Nations system needs to develop a methodology for each of the blockchain sustainability attributes that may be particularly relevant for supply chain applications, including agrochemicals, biodiversity, labour, climate, deforestation, land management, value distribution and water productivity.

204. Several participating organizations, including UNICEF and FAO, consider that the nine Principles for Digital Development should be the starting point and basis of decision-making processes on the use of blockchain.

205. Above all these considerations, two major lessons learned in the practice of one organization have an emphatic relevance for the overall picture of the use of blockchain in the context of the 2030 Agenda:

> "… if we do not build openly and collaboratively and create pathways for other open-source projects, entrepreneurs and organizations to participate in developing new distributed approaches to development, we will end up replicating entrenched systems of control, ambiguity, and isolation."[40]

> "We […] will have many failures as we begin to translate the potential, and limitations, of blockchains into accessible principles and practice. We must share our failures with the public and try not to repeat them as we build new ways to address some of the most pressing problems our planet faces."[41]

Conclusions

206. The Inspector shares the view that the cost-efficiency aspect of blockchain applications should be seen in a longer-term perspective and gains should not be expected overnight. He encourages the use of pilots of blockchain applications in very clearly determined cases, containing the risks but exploring the promised benefits of a technology that is still in its infancy.

207. Such cautious, but determined, innovation efforts will be considerably helped if the United Nations organizations systematically and openly share their practices, analyses and lessons learned. The decision-making matrix elaborated below may help to anticipate problems and make optimal choices.

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[34] FAO and Blockchain, internal paper.

[35] Blockchains and smart contracts cannot access data from outside their network. In order to know what to do, a smart contract often needs access to information from the outside world that is relevant to the contractual agreement in the form of electronic data, also referred to as oracles. These oracles are services that send and verify real world occurrences and submit this information to smart contracts, triggering state changes on the blockchain.

[36] Agile Scrum methodology is a project management system that relies on incremental development.

[37] Agile Kanban is a software development methodology that focuses on just-in-time delivery of functionality and managing the amount of work in progress.

[38] A minimum viable product is a version of a product with just enough features to satisfy early customers and provide feedback for future product development.

[39] FAO and Blockchain, op. cit.

[40] Christopher Fabian, "Un-chained: experiments and learnings in crypto at UNICEF", *Innovations: Technology, Governance, Globalization*, vol. 12, No. 1-2 (Summer-Fall 2018).

[41] Ibid.

B. There is a need for system-wide guidance on the decision-making on and use of blockchain applications

208. Most of the representatives of organizations participating in the review agreed that, in addition to the effort to acquire knowledge about blockchain, system-wide guidance is needed, in particular for the United Nations entities that are not already experimenting with blockchain.

209. Proposals to that effect covered a wide range of guidance tools from sharing knowledge and expertise to future standards. JIU has summarized the proposals as they evolve from soft or already available to more elaborated and institutionalized forms, as follows:

- Endorsement and application of the Principles for Digital Development;
- Access to a library of training materials;
- General lessons learned and descriptions of various technical set-ups;
- A library of blockchain uses and summary findings on their implementation;
- Establishment of a pool of senior and experienced professionals on blockchain, available internally and externally, to which all organizations should have access;
- A decision-making process for deciding if there is a business case for the use of blockchain;
- A whole-house approach based on the establishment of guidelines and a legal framework governing engagement with blockchain technologies.

Box 5
Principles for Digital Development

The Principles for Digital Development are a set of nine generic principles intended to give guidance to practitioners for the application of digital technologies to development programmes. It originated in a UNICEF initiative and counts over 200 participating organizations at present. Among them are numerous JIU participating organizations and other United Nations entities, including UNICEF, UNDP, WHO, WFP, ILO, UNFPA, UN-Habitat, UNEP, UNIDO, the Office for the Coordination of Humanitarian Affairs, the International Computing Centre, the United Nations Interregional Crime and Justice Research Institute and the United Nations University.

The Principles were inspired by the recognition by donors and implementing organizations that digital development programmes were fragmented, uncoordinated and siloed, and that organizations struggled to scale up or sustain them in the long term. The Principles include guidance for every phase of a project life cycle and they are part of an ongoing effort among development practitioners to share knowledge and support continuous learning.

There are nine principles: (1) Design with the user. (2) Understand the existing ecosystem. (3) Design for scale. (4) Build for sustainability. (5) Be data driven. (6) Use open standards, open data, open source and open innovation. (7) Reuse and improve. (8) Address privacy and security. (9) Be collaborative (see www.digitalprinciples.org).

210. The Inspector notes that all the proposals in paragraph 209 above are realistic and feasible, and open the way to a gradual but robust process for creating a coherent and convergent system-wide approach. To that effect, a simple but meaningful step would be the endorsement of the Principles for Digital Development by all United Nations system organizations. Adhesion to that set of principles would be a contribution to the creation of a new culture of digital transformation and provide a basic knowledge of the proper use of new technology in an institutional way.

211. The implementation of the following recommendation will foster coherence and facilitate collaboration and a common approach to the use of blockchain and other digital technologies in the context of digital transformation.

Recommendation 3

The executive heads of the United Nations system organizations, if they have not already done so, should endorse the Principles for Digital Development by the end of 2022, as a first step to ensuring a general common understanding of digital transformation at the organizational level, including the possible use of blockchains.

212. Some of the proposals set out above have been addressed in previous sections, while others are reflected in the decision-making matrix for determining whether there is a business case for blockchain and in section VI below.

C. A decision-making matrix

213. The right choice of the use case is not only a prerequisite for a good return on investment, but also a way to mitigate risks and solve other problems, such as those identified in previous sections of the report. Blockchain has particular features that can provide added value compared to alternative solutions, but it is primordial to be able to demonstrate that the theoretical assumptions are proved in practice and that the value added can be proven. At the same time, it also comes with some disadvantages, as described in sections III and IV of the report. Furthermore, some of the virtues extolled by its champions might be incompatible with the values of the United Nations and with its responsibility for the use of public money. Blockchain needs to be the best suitable option or fit-for-purpose system for the use case selected.

214. The Inspector proposes a matrix for the determination of the business case for the use of blockchain in a sequence of layers that follow (a) criteria pertaining to the core features of the blockchain technology; (b) other criteria to which blockchain can add value; (c) considerations as to the choice of specific blockchain architecture; and (d) aspects to be considered in the design of solutions and their respective governance arrangements. By following such a matrix, many of the risks and problems highlighted in previous sections could be anticipated and surmounted.

Is blockchain a suitable solution to our problem?

215. In table 1 several key questions are set out that should be given full consideration before deciding whether blockchain can indeed provide better solutions than non-blockchain alternatives to particular operational needs. The questions are not exhaustive, but they are the first that need to be answered as they help the initial fundamental choice between blockchain and other options. The decision tree is minimalistic, but it covers the basic prerequisites for the choice of a blockchain solution.

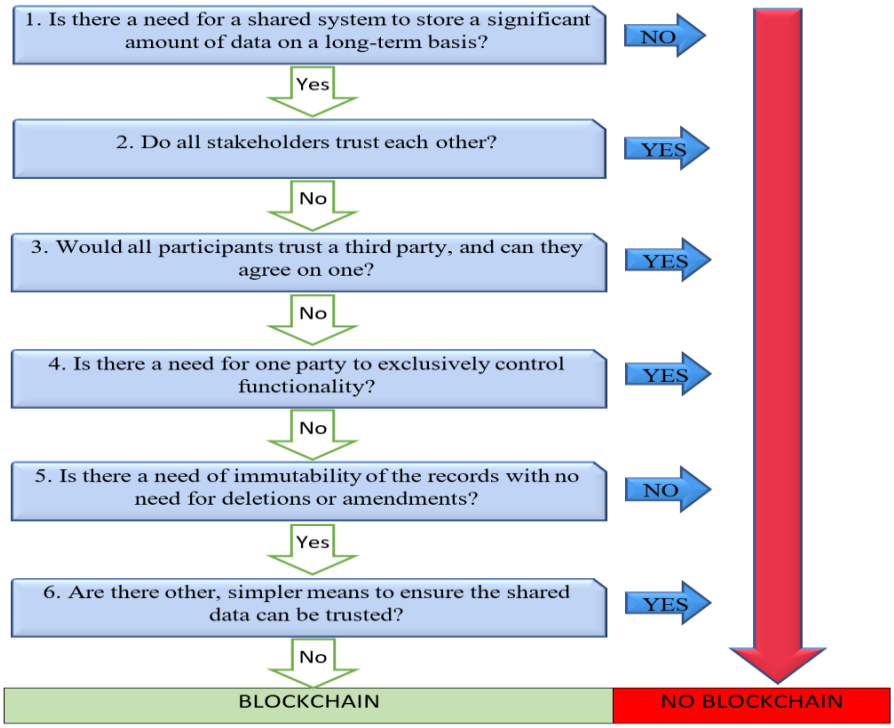
Table 1
Preliminary analysis (first layer)

Questions on the main features of blockchain	Y/N	**Conclusions**
Decentralization		
1. Is there a need for a shared system to store (a significant amount of) transactions, document signatures, identities or verifiable claims[a] on a medium- or long-term basis?	Yes	Blockchain could be an option, if no traditional database can meet such requirements
	No	Highly unlikely unless there is a very special case

2. Do all stakeholders trust each other?	Yes	The use of a traditional database should be considered first
	No	Blockchain could be an option
3. Would all participants trust a third party and can they agree on one?	Yes	The use of a traditional database should be considered first
	No	Blockchain could be an option.
4. Is there a need for one party to exclusively control functionality?	Yes	In principle blockchain should not be considered as a solution, unless there are very specific governance arrangements
	No	Blockchain could be an option
Immutability of data stored		
5. Is there a need for immutability of the records with no need for deletions or amendments?	Yes	This is a good case for blockchain
	No	If there might be a possible or probable need to amend or remove some records for legal or enforcement reasons, other solutions should be envisaged
Trustless		
6. Are there other, simpler means to ensure the shared data can be trusted?	Yes	Explore alternative solutions.
	No	There is a case for the use of blockchain

[a] Verifiable claims cover "zero-knowledge" proof and other possible notarization and verification scenarios.

Figure IV
Is blockchain an option?



216. Figure IV is a minimalistic and simplified representation of the decision tree as it results from a preliminary analysis. It should be understood in relation to the more nuanced conclusions indicated in table 1.

217. Once it has been established that there is a convincing case for using blockchain, against its core features, the analysis should continue as to the value that is added by using it, according to an additional set of criteria. That second layer should ensure that if a blockchain option is possible, it also provides gains in terms of efficiency, sustainability and scalability compared with other means.

Does blockchain add value?

218. Table 2 indicates several criteria that are examined with respect to any projects, but whose relevance is particularly pregnant where technology-dependent solutions are envisaged.

Table 2
Blockchain value-added analysis (second layer)

Questions on other criteria in a blockchain context	Conclusions	
Efficiency		
Does a blockchain solution bring sufficient efficiency gains?	Yes	Make sure that the efficiency gains are greater than in other alternatives, considering all the costs triggered by investing human and financial resources in blockchain
	No	If blockchain is not the most efficient solution, there should be other prevailing strategic or operational objectives that prevail over efficiency
Sustainability		
Does the organization have the capacity to participate or at least actively observe a decentralized governance process of the system?	Yes	Blockchain could be a realistic solution
	No	The distribution of roles and responsibilities (nodes, participants, observers) in the various forms or consortia and burden sharing should be carefully considered.
Does the organization have the capacity to understand and follow the key technical aspects of a blockchain?	Yes	Blockchain could be a realistic solution.
	No	Make sure that there is a minimum technical in-house capacity Consider using United Nations system (or inter-agency) resources Try to reduce the vendor lock-in challenge and assure business continuity
Scalability[a]		
Is there a need to process a high number of transactions (for example more than 1,000 transactions per second)?	Yes	Blockchain could still be a solution, as the technology is evolving, but available validation processes should be examined comparatively
	No	Blockchain may work
Would there be a prohibitive cumulative cost of the technical infrastructure (for example, the cost of mobile phones for hundreds of thousands of users) for scaling up the number of users?		The responses will depend on the specificity and objectives of each project, but scalability, in technical and infrastructure terms, should be considered in the design of any blockchain solution
Would there be a prohibitive cumulative cost of scaling up the number of transactions, users, nodes?		
Confidentiality		
Does personal identifiable data need to be stored in the blockchain?	Yes	Public blockchain is not an option, unless personal identification data are stored off-chain Alternatively, private, permissioned blockchain may work
	No	In all instances of the use of blockchain, sensitive data should be handled in accordance with United Nations rules and regulations

[a] In table 2, scalability is considered under a technical angle. Scalability in terms of costs is to be assessed under efficiency.

219. With respect to efficiency, the Inspector notes that at the current stage of its development, blockchain technology can be inefficient because many copies of transactions are sent many times over the Internet network to many nodes. However, that is a trade-off that was accepted by the designers of the original bitcoin and other blockchains. They practically assumed that the cost of sending data over the Internet was close to zero once it had been accessed and that redundant network traffic came at a small price for the security and trust achieved. Special attention should therefore be paid to the efficiency factor in both its technical and broader sense.

220. The Inspector notes that technical performance is still a problem for some *public* blockchains of the first generation, but in recent times there are some major chains with considerably improved performance, able to deliver several thousand transactions per second and transaction (confirmation) time below five seconds.[42] On *private* blockchains configured with an efficient consensus algorithm, both transactions per second and transaction time are much more rapid today and they might be completely satisfactory for any realistic United Nations use case.

D. Optimizing the choice

221. Once the decision on the use of a blockchain solution takes shape, the third layer of analysis should lead to a clear vision as to which type of blockchain best fits the envisaged purpose. There is no one-size-fits-all consideration of the final choice and the present review does not venture into micromanagement. Indeed, beyond existing standards on the use case, there are diverse solutions that depend on specific needs and circumstances. However, the Inspector recommends examination of the basic properties of private/permissioned and public/permissionless blockchains in correlation with the possible implications for the use cases. Table 3 indicates several such correlations.

Table 3
Final analysis of the most adequate blockchain choice (third layer)

Adequate choice	Properties	Use when
Public 	Ready-made infrastructure No upfront investment needed for establishing a blockchain network/infrastructure layer No maintenance needed It can be very secure, more secure than private blockchain	A limited budget to develop your own blockchain infrastructure There is a need to minimize development time The focus is on a higher-level application, not on infrastructure
	No control over basic functionality Private applications can be developed on top of a public blockchain	The organization does not have the capacity or the wish to run its own nodes and network There is no need to store personal identifiable data on the blockchain (or they can be stored off-chain and linked safely to blockchain data)
	There is a (financial) transaction cost Public blockchains are evolving systems that may change in time Splits (forks[a]) are possible	The benefits of the blockchain applications outweigh the cumulative transaction costs All the risks are carefully analysed and can be managed There is an affordable exit strategy (including, where appropriate, a fork)

[42] See AlephZero.org, "What is the fastest blockchain and why? Analysis of 43 blockchains", 4 January 2021.

Adequate choice	Properties	Use when
Permissioned 	Consortium/partnership builds and runs a private network of nodes Initial investment is needed for establishing a blockchain network Maintenance must be provided It is typically less secure than a public blockchain	There is a budget for developing a network and maintaining it The time needed for initial development is not critical for the project
	Consortium/partners control functionality through an agreed governance mechanism The infrastructure layer can be customized if necessary	The organization needs to control the functionality and customize the basic layer
	There is practically no transaction cost	There is a need to record many transactions and keep the cost low or zero The savings on cumulative transaction costs over time outweigh the investment in network development and maintenance
Permissioned with public viewing 	Same as in permissioned blockchain but selected blockchain records can be exposed for public viewing	The organization needs to control permission to write transactions into the blockchain, while allowing the public to view the records and to make the process transparent[b]

[a] A fork is the creation of two or more different versions of distributed ledgers.

[b] For example, land records could be registered only by authorized notaries, but the general public is allowed to view all the records.

222. The implementation of the following recommendation will lead to enhanced efficiency and effectiveness.

Recommendation 4

The executive heads of the United Nations system organizations should ensure that any decision on using blockchain should be based on an appropriate determination of the business case and of the most suitable solution, using as guidance a decision-making matrix (as described in the present report, as well as any enhancements and/or adaptations).

Project design adjustments and governance issues to be considered (fourth layer)

223. Once the main decisions are made as to the use of blockchain and the choice between permissioned, permissionless or hybrid formulas, there are a number of additional considerations that have to be scrutinized in the design of individual projects, which are prerequisites or may optimize the outcome.

224. All participants, including end users, should have reliable Internet access and the capacity to manage their credentials securely (private keys or their equivalent). In the absence of such assurance, a blockchain solution would require a biometric identity solution or a trusted and reliable local solution/partner/intermediary, as well as other arrangements.

225. The fundamental feature of the blockchain in its original design is to automate decision-making and governance ("trustless"[43]). By design, blockchain use implies that there are no disputes, as the consensus processes rule them out, and therefore no arbitrator or other dispute resolution mechanism is needed. However, in the practice of the United Nations an

[43] "Trustless" in blockchain means that no trust is required between transaction participants, as entries in the ledger are permanent and visible, with encryption technology and protocols effectively replacing third-party intermediaries or arbitrators.

off-chain arbitration mechanism may be necessary, even if that contradicts the concept of blockchain per se. The experience of the Building Blocks project shows that compromises may be necessary. The validation processes should be carefully designed in relation to other governance arrangements.

226. As the peer-to-peer nature of blockchain builds trust without institutions, the technology offers the possibility of turning competition into partnership, in particular when blockchain is used for social impact. In the words of one expert, interviewed by the team:

> "rather than evaluating competition, the priority is to identify key partners, define alliances, leverage from existing systems and platforms [...] for many successful blockchain projects encompass turning competitors into partners will allow the community to grow and create sustainable ecosystems for the entire market".[44]

227. As blockchain technologies evolve, it appears that their core benefits can only be achieved through collaboration with other parties in existing ecosystems or by forging new partnerships. According to an expert consulted by JIU,

> "blockchain can be used as a "digital notary", as it imbues trust into transactions between businesses, Governments, and non-governmental organizations, protecting stakeholders from fraud and mismanagement".[45]

228. If in the private sector the main blockchain governance problem is to make competitors cooperate, in the United Nations system the propensity to cooperate is assumed beforehand. In an ideal scenario, the United Nations system organizations should engage in networks of nodes, using blockchain in collaboration, in support of the Sustainable Development Goals.

229. Blockchain consortia are, by definition, possible and desirable in the United Nations system. According to a recent study, there are three major emerging governance options in blockchain.[46] Two of them are close to United Nations specificities:

(a) The working group type: parties have equal power and contribution; decisions are made through consensus and members contribute resources in the pursuit of a shared objective. The group does not operate as a legal entity, rather each participant owns and operates his own node. The Building Blocks project is close to this type;

(b) The hybrid type: a shared infrastructure operator acts as the key facilitator of a jointly owned operation. The UNICC/UNSJPF and the aspirational joint United Nations digital identity system would fall into this category.

230. As noted by some participating organizations, all participants in a blockchain, whether they individually pursue a shared objective on an equal basis or accept a facilitator in a jointly owned operation, have to be motivated and incentivized. The motivation and incentivization should come with the good choice of a business case and, among others, achieve savings in resources and gains in efficiency.

Compatibility with the Sustainable Development Goals: a crucial criterion

231. It goes without saying that more important than all the technical criteria for assessing the applicability of blockchain solutions is compatibility with the Sustainable Development Goals. For example, validation protocols that would imply a high level of energy consumption (such as proof of work) and other negative consequences for the environment, are not legitimate options.

232. The anonymity of the participants, which may be an advantage in some blockchain applications, may be sharply incompatible with the practices of the United Nations. Anonymity and lack of accountability can be seen, by all accounts, as major limitation factors for the use of blockchain. Participants in United Nations projects should be known,

[44] Paul Wang, head of corporate governance at Geneva Macro Labs, statement made in the context of a blockchain project of the Stellar Development Foundation and Terre des Hommes.

[45] Vlad Trifa, CEO and founder of Zimt, a digital traceability start-up, www.zimt.co.

[46] See Deloitte, "C-suite briefing, 5 blockchain trends for 2020" (March 2020), p. 9.

trustworthy and vetted. Alternatively, when unavoidable, the level of anonymity and accountability should be defined to the maximum extent possible.

233. Blockchain triggers a delegation of power by virtue of its automation mechanisms, which may save time and resources. However, the values embodied in the 2030 Agenda for Sustainable Development, including ethical and human rights considerations, cannot be compromised. On the contrary, the first objective of any blockchain use should be to support the achievement of the 2030 Agenda for Sustainable Development with full respect for its values.

VI. Ways forward

A. Rigid regulation of blockchain might be premature but minimum policies and standards are needed

234. The views of the JIU participating organizations on the need for regulations applicable to the use of blockchain are quite diverse and do not necessarily converge on which issues need regulation and to what extent. However, the underlying reasons for the diversity of standpoints reflect the specific reality of blockchains on the one hand and the challenges related to the dynamic environment of digital technologies in general on the other.

235. The problems of a legal nature reported by the organizations, which relate to the specific technical features of blockchain are:

(a) The decentralized nature of distributed ledger technologies;

(b) The "trustless" computing paradigm of blockchain;

(c) The contradictory relationship between transparency and privacy;

(d) The absence of a central authority (for a public blockchain), with its corollary that there is no ultimate accountability for the data;

(e) The risk of irreversible actions, such as losing one's private key credentials;

(f) The diversity of consensus or validation mechanisms;

(g) The difficulty of determining liability for faulty smart contracts and legal responsibility in general;

(h) The risk of hosting illegal activities when the users are anonymous;

(i) The protection of privacy and identity.

236. The second category consists of problems that are also valid for other current areas of digital transformation (cloud computing, communication on social media, artificial intelligence, etc.). They include:

(a) The disconnect between the pace of technology and regulations, as digital technologies tend to develop faster than the regulations or social structures governing them;

(b) The difficulty of establishing rules in view of the continuous blurring of the boundaries between markets and sectors, users and producers, vendors and distributors;

(c) The difficulty of apportioning and attributing responsibility for damage or harm caused by using technology;

(d) The difficulty of enforcing intellectual property rights and data privacy;

(e) The transversal challenges raised by digitalization when technologies can span multiple regulatory regimes;

(f) The intensity of cross-border flows and transactions;

(g) The different perceptions of the protection against or resilience to cyber threats;

(h) The need to respect the privileges and immunities of the United Nations and the specialized agencies.

237. For all these reasons, most respondents acknowledged that it was too early to impose a rigid legal framework on a technology that was subject to dynamic evolution. However, there is an emerging consensus that soft rules and regulations are needed, at least in the United Nations system. They should not inhibit innovation but offer some basic safeguards and common standards, which can then be gradually refined and updated. The proposals and opinions put forward by the participating organizations together provide a coherent list of basic assumptions and actions.

238. One such assumption is the case-by-case approach to the possible use of blockchain, based on the rigorous determination of a business case. Analytical tools are needed to limit the "hype" effect on technological investment, which may lead to operational challenges (UNFPA). The need for rules depends on the blockchain applications employed and should be considered on a case-by-case basis (UNICEF). The regulatory approach may also differ between a public and a private blockchain or in a permissioned and a permissionless blockchain (UN-Women and UNICEF). Cryptocurrencies, identity and the supply chain may need different regulations, beyond commonalities (WFP).

239. Having considered the differences and specificities of the various blockchain use cases, there are generic features and commonalities for all blockchain applications. The review identified, among others, the following areas that might need rules, policies and standards, which also would support interoperability, common standards and inter-agency cooperation:

- The standardization of blockchain architecture which would allow and stimulate collaboration and pooling of expertise (UN-OICT);
- Risk assessment policies with respect to partners (reputation, technical capabilities, resilience), security and operational risks (including the lock-in effect) (UNFPA and UNIDO);
- The existing support for the collection of data (quality, frequency) and providing an ethical approach to big data (FAO);
- Providing rigorous code audit and code publishing procedures (UNICEF);
- Ensuring interoperability between various distributed ledger technology applications (FAO);
- Using and improving the clarity of blockchain-related terminology (UNIDO).

240. The United Nations Secretariat signaled that in the potential use of blockchain, the organizations should carefully consider how the new technology would operate within the current legal framework, including the financial and administrative rules. The organizations must take into account the status, privileges and immunities enjoyed by the United Nations and the specialized agencies. In considering blockchain solutions, they must ensure that appropriate safeguards are in place for the protection of personal and organizational data.

241. The Inspector emphasizes the importance of a carefully considered balance and fine-tuning between the need for minimum rules and standards and the importance of not inhibiting innovative applications of blockchain. In relation to this dilemma, the Inspector shares the remark made by UNIDO:

> "On the one hand, the lack of regulation limits the capacity of Governments to cope with fraud, local regulatory compliance evasion, financing of illicit activities, scams and Ponzi schemes. On the other hand, it hinders technology adoption and innovation, especially affecting entrepreneurs and start-ups which are often confronted with the uncertainty of incurring a legal problem."

B. Standards and legal framework: work in progress

242. The Inspector notes that among the risks associated with the use of blockchains by the participating organizations, two have special importance from a system-wide perspective, which are the focus of the present report: interoperability and standardization.

243. Interoperability is a factor that underlies and makes collaboration possible. It is the ability of two or more systems or applications to exchange information and to mutually use the information that has been exchanged.[47] The distributed nature of blockchain adds to the complexity of this factor. For blockchain platforms, interoperability implies that

[47] See www.iso.org/standard/73771.html for fundamental terminology for blockchain and distributed ledger technologies.

"transactions involving parties or assets that belong to different blockchain platforms can be executed as if they belong to the same blockchain platform".[48]

244. Furthermore, the United Nations organizations should not have their options for external cooperation limited by one blockchain platform but foresee scalable solutions that can grow both within the United Nations system and for external partners.

245. According to the same source, a comprehensive interoperability framework should be examined at three levels: business model (which includes the governance model, data standardization and the legal framework; (b) the platform, which includes the consensus mechanism, smart contracts, authentication and authorization; and (c) the infrastructure.

246. In this context, a few findings about standards and legal framework are necessary, as they are crucial from a United Nations standpoint. The business model dilemmas are considered above, in section V.

Standards are being developed - more awareness of them and participation is needed

247. Against the overall perception that resulted from the responses to the JIU questionnaire, the Inspector notes that in fact some standards have already been produced and there are numerous initiatives aimed at developing standards at industry, governmental or intergovernmental level. Among many others, the British Standards Institution works on blockchain standards for supply chains and the National Institute for Standards and Technology of the United States of America works on blockchain-based identity management systems. The European Blockchain Partnership aims to establish a European blockchain services infrastructure to support the delivery of cross-border digital public services.

248. It appears that problems may arise from the disorderly development of emerging national or international standards rather than from their absence. The Inspector therefore believes that for governance-related standards, special attention should be paid to the work of the International Organization for Standardization (ISO).

249. At the time of the review, ISO was working on several standards on topics under ISO/TC 307, Blockchain and distributed ledger technologies. Three such standards were already published and available: Overview of and interactions between smart contracts in blockchain and distributed ledger technology systems (2019);[49] Privacy and personally identifiable information protection considerations (2020);[50] vocabulary (2020);[51] Security management of digital asset custodians (2020).[52]

250. Other standards are under development, among which: Guidelines for governance; Use cases; legally binding smart contracts; taxonomy and ontology; overview of existing DLT systems for identity management; overview of smart contract security good practice and issues; data flow model for blockchain and DLT use cases; identifiers of subjects and objects for the design of blockchain systems.[53] Box 6 illustrates an example of legal and practical challenges in relation to smart contracts, from a national law perspective.

Box 6
Smart contracts v. traditional contracts: legal and practical challenges

Legal issues:

- Judicial enforcement: as smart contracts are self-enforcing, judicial enforcement is not necessary. The nature of smart contracts challenges judicial enforcement mechanisms and presents difficulties in relation to whether a court has jurisdiction and over what specifically it can exercise that jurisdiction. Nevertheless, if a smart

[48] World Economic Forum, "Inclusive deployment of blockchain for supply chains", White Paper, (March 2019).
[49] https://www.iso.org/obp/ui/#iso:std:iso:tr:23455:ed-1:v1:en.
[50] https://www.iso.org/obp/ui/#iso:std:iso:tr:23244:ed-1:v1:en.
[51] https://www.iso.org/obp/ui/#iso:std:iso:22739:ed-1:v1:en.
[52] https://www.iso.org/obp/ui/#iso:std:iso:tr:23576:ed-1:v1:en.
[53] Source: International Organization for Standardization.

contract violates applicable laws to the detriment of one of the parties, legal remedies may be sought before the competent courts.

- Coding errors: the questions are whether the court has jurisdiction and how it can interpret the intent and position of the parties in relation to the code.
- The decentralized and anonymous nature of blockchain technology: if a court identifies damages that must be compensated, it may be unable to enforce this, due to the anonymity of a party.

Practical considerations

- The accuracy of the code: the code must reflect the will of the parties. The parties to a contract may want confirmation of this assumption.
- The interpretation of a smart contract: as this essentially involves the interpretation of programming language, it is important to define the extent to which smart contract code can be used for interpretation.
- The immutable nature of blockchain technology: traditional contracts are often modified and in the case of general terms and conditions, parties can withdraw from a contract. Smart contracts should allow enough flexibility for modification.

Source: Thomas Naegele, Liechtenstein: Blockchain Comparative Guide (15 May 2020).

251. **The Inspector recommends that the existing ISO standards be examined as part of the preparation and planning for blockchain applications. He also recommends the participation of representatives of the United Nations system, when possible and as appropriate, in the working groups of ISO that develop relevant standards.** Those who participate should inform all interested organizations on the status of the standards and their updates. Such an approach will help the organizations to mitigate risks, prevent problems and anticipate solutions. It will allow the United Nations system organizations to bring into the process a United Nations perspective and specificity. It will reduce duplication, save human and financial resources, improve coherence in the United Nations system and enable inter-agency cooperation.

252. A special role in the development of standards is played by the Telecommunication Standardization Sector of ITU. Between May 2017 and July 2019, the ITU-T focus group on application of distributed ledger technologies produced five technical reports (on overview, concepts, ecosystem; standardization landscape; use cases; regulatory framework; and distributed ledger technology outlook) and three technical specifications (terms and definitions; reference architecture; and assessment criteria for platforms).[54]

253. The Inspector notes that the standards developed by ITU have the legitimacy of an intergovernmental organization where Member States are represented by both national telecommunication regulators and private sector experts. Moreover, in developing those standards, ITU took into consideration the ISO standards and is involved in the working groups of the latter.

254. However, the analysis of the responses provided by the participating organizations show little awareness of the standards developed by ITU. There is a tendency to seek resources elsewhere, rather than in the United Nations system.

255. **The Inspector recommends that all United Nations system organizations start their evaluation of the potential use of blockchain applications by considering the relevant ITU technical reports. He recommends that ITU regularly inform all United Nations system organizations, through the mechanisms of the United Nations System Chief Executives Board for Coordination (CEB), about the standards developed for digital technologies, distributed ledger technologies, blockchain included.**

256. In both the responses to the JIU questionnaire and the interviews that were carried out as part of the review, the need for interoperability was manifestly one essential prerequisite

[54] See www.itu.int/en/ITU-T/focusgroups/dlt/Pages/default.aspx.

for the facilitation of inter-agency cooperation. The efforts made within the United Nations system in the direction of developing standards and interoperability should be corroborated with a good knowledge of the dynamics of the blockchain platforms developed by the industry. It might be also advisable for the legal networks to collaborate in such efforts, with a view to addressing the legal issues related to blockchain.

257. The implementation of the following recommendation will lead to the dissemination of good practices, elimination of duplications and saving resources.

Recommendation 5

The Secretary-General, in consultation with the executive heads of the United Nations system organizations, with support from the International Telecommunication Union, should assign, by the end of 2021, to a United Nations representative in charge of digital technologies and related issues, the task of following the development of blockchain interoperability standards and open-source projects aimed at blockchain interoperability, as part of an overall consideration of the policy implications of the technology, and to work with all organizations accordingly.

Work on legal issues has already started in the United Nations system

258. As in the case of standards, the Inspector found that the work done by the United Nations Commission on International Trade Law (UNCITRAL)[55] on the legal aspects relevant to blockchain and other distributed ledger technologies is not well known among many of the United Nations system organizations. As some JIU participating organizations suggested that the United Nations should initiate actions for "*the establishment of an international regulatory framework*" or convene "*negotiations on the smart contracts*", the reference to the work of UNCITRAL in the present report became imperative.

259. The Inspector notes that the General Assembly of the United Nations recently endorsed the initiatives of UNCITRAL,

> "as the core legal body within the United Nations system in the field of international trade law, aimed at increasing coordination of, and cooperation on legal activities of international and regional organizations active in the field of international trade law, including on legal issues relating to the digital economy".[56]

260. A 2020 report[57] published by the UNCITRAL secretariat contains already legal analysis that is relevant for blockchain and blockchain-based applications, based on its exploratory work. It contains confirmations or preliminary answers to legal challenges signaled by some United Nations organizations and converges with the expectations as to the role of the law:

(a) The law can create certainty in the digital economy and predictability in commercial transactions, which means reduced risk and costs;

(b) The law can foster the use and development of the tools of the digital economy, such as data, digital assets, artificial intelligence systems, smart contracts and distributed ledger technologies, and should not be used as an obstacle to such use and development;[58]

[55] UNCITRAL is one of the two subsidiary organs of the General Assembly of the United Nations with a legislative mandate. It is composed of 60 Member States and its sessions are open to United Nations system organizations (https://uncitral.un.org/).

[56] United Nations, General Assembly, resolution 74/182, Report of the United Nations Commission on International Trade Law on the work of its fifty-second session, paragraph 9 (doc. A/RES/74/182).

[57] United Nations, General Assembly, Report of the United Nations Commission on International Trade Law, Legal issues related to the digital economy, Note by the Secretariat (doc. A/CN.9/1012), 8 May 2020.

[58] In the context of UNCITRAL, distributed ledger technologies are defined as technologies and methods (including blockchain) that support a record of data (i.e., a "ledger") that is retained on multiple networked computers (or "nodes"). Those technologies and methods include cryptographic

(c) International efforts to develop a harmonized response to legal issues could pre-empt fragmented national legal responses and contribute to bridging the digital divide.

Box 7
Examples of legislation enacted to specifically address blockchain

Most of this legislation deals with cryptocurrency and is predominantly regulatory in nature.

Moreover, some of the legislation does not expressly refer to blockchain, but it is inspired by blockchain solutions, as is the case for the Liechtenstein law. These laws include:

Belarus – Decree of the President of the Republic of Belarus No.8 of 21 December 2017 on development of digital economy establishes a regime to support the use of blockchain solutions at the Minsk Hi-tech Park;

Italy – Law Decree No 135/2018, enacted with modifications by Law No 12 of 11February 2019, gives the same legal effect to documents recorded using blockchain as an electronic timestamp;

Liechtenstein – Law of 3 October 2019 on Tokens and TT Service Providers establishes a legal framework for transacting in digital tokens;

Malta – the Innovative Technology Arrangements and Services Act, 2018, establishes a regime for the certification of blockchain software and architecture;

United States – several States have introduced laws to enable the use of blockchain. Notable examples are the Electronic Transactions Act of Arizona (which states that "data on the ledger is protected with cryptography, is immutable and auditable and provides an uncensored truth") and the "Blockchain Act" of Vermont.

Source: UNCITRAL

261. The work plan proposed by the secretariat of UNCITRAL includes a legal taxonomy and preparatory work on legislative texts dealing with automated contracting (including smart contracts), [59] the rights and obligations of parties to data transactions, asset tokenization,[60] digital assets in the form of cryptocurrency, digital platforms and dispute resolution.

262. The Inspector notes for the benefit of innovation units and other interested departments in the United Nations organizations that for the fifty-third session of UNCITRAL in 2020, the secretariat submitted additional reports on the context, definition, actors, legal regimes and a preliminary appraisal of existing UNCITRAL texts on artificial intelligence,[61] data transactions[62] and digital assets,[63] which will form the basis of the legal taxonomy. As a coordinating body within the United Nations system on legal issues relating to the digital economy and digital trade, including the use of blockchain and blockchain-based applications, the work of UNCITRAL is not only relevant to States, but also to the United Nations system organizations themselves. For instance, the UNCITRAL secretariat

techniques and consensus mechanisms that are designed to ensure that the same data is retained on each node (i.e., shared, replicated and synchronized) and that the data retained on each node remains complete and unaltered (i.e., immutable). Distributed ledgers are maintained by software run on the various nodes.

59 In keeping with the UNCITRAL practice of respecting the principle of technology neutrality, the work on smart contracts does not focus solely on their development in distributed ledger technology systems, but through the prism of artificial intelligence and automated contracting. Although smart contracts are commonly associated with distributed ledgers, they predate the advent of distributed ledger technology and are deployed in other electronic environments (A/CN.9/1012, paras. 17 and 18).

60 A comprehensive analysis of the legal aspects of "token economy" can be found in Thomas G. Duenser, Legalize Blockchain!, 2020.

61 A/CN.9/1012/Add.1. This document also includes an analysis of smart contracts.

62 A/CN.9/1012/Add.2.

63 A/CN.9/1012/Add.3.

has indicated that the above-mentioned legal taxonomy may serve as a reference document for any organizations looking to deploy blockchain-based applications as tools to administer their internal regulations and contractual arrangements.

263. This is work in progress, at the initial stage, but it is worth noting another UNCITRAL finding with an important bearing on the topic of the present report and the concerns expressed by current or potential users of blockchain applications:

> "… the administration and operation of distributed ledger systems does not itself appear to give rise to any novel legal issue, although certain legal issues, such as private international law issues, may become more prominent on account of the geographical distribution of nodes".[64]

264. At this juncture, it is useful to note that UNCITRAL is the only body in the United Nations system that has an institutionalized and systematic relationship with the International Institute for the Unification of Private Law (UNIDROIT).

Conclusion

265. UNCITRAL has been mandated by the United Nations General Assembly as the core legal body in the United Nations system to coordinate legal activities in the field of international trade law for one main reason:

> "to avoid duplication of efforts, including among organizations […], and to promote efficiency, consistency and coherence in the modernization and harmonization of international trade law".[65]

266. The implementation of the following recommendation will lead to enhanced efficiency and effectiveness, to improved coordination and dissemination of practices and lessons learned.

Recommendation 6

The governing bodies of the United Nations system organizations should encourage Member States to engage with the United Nations Commission on International Trade Law in its exploratory and preparatory work on legal issues that relate to blockchain in the broader context of the digital economy and digital trade, including on dispute resolution, which is aimed at reducing legal insecurity in that field.

267. **The Inspector also recommends that the United Nations system organizations cooperate with the UNCITRAL secretariat by providing documentation on their experience, the lessons learned from their use of blockchain-supported applications and on their prospective needs from a legal standpoint.**

C. Developing in-house technical expertise on blockchain is useful and realistic

268. Preparedness, at the operational and strategic levels, for using blockchain applications depends to a considerable extent on knowledge and understanding of blockchain. In the United Nations system, such preparedness should not be based exclusively on theoretical assumptions, which are abundantly present in the specialized literature. The lessons learned from the actual practice of blockchain applications should underlie all decisions made.

269. For practical reasons, the United Nations system can take a proactive stand on blockchain, rather than a wait-and-see attitude, which will eventually lead to dependence on various vendors on the market. Such a dependence is not only a possible, but also a predictable, negative development. From a system-wide logic, it will lead to fragmentation,

[64] A/CN.9/1012, para. 15.

[65] United Nations, General Assembly, resolution 73/197, Report of the United Nations Commission on International Trade Law on the work of its fifty-first session (doc. A/RES/73/197).

new silos, duplication and a waste of resources. To counteract that, consideration should be given to using solutions that are portable from one service provider to another. The novelty of blockchain offers a golden opportunity to the United Nations system to try, at this early stage, to develop its own minimum technical expertise including on its own blockchain protocols.

270. Starting from this assumption, the participating organizations were asked to respond to the following question: "*Would it be useful for the United Nations system to develop its own expertise in coding/programming/mining for blockchain applications?*"

271. Most of the respondents to that question answered in the affirmative. The main arguments for the system to develop its own expertise included:

- Making certain basic coding available, on which the United Nations entities can build, may be a way to have a unified system-wide approach;
- A joint resource could eliminate parallel and upfront investment for many organizations, thus benefiting the United Nations system as a whole;
- The use of its own blockchain platform could help the United Nations system to leverage the technology while avoiding exclusive dependence on market providers whose resilience is not yet fully proven;
- Building internal knowledge would be useful to serve as guidance and to increase the negotiating power of the United Nations organizations, even if the option chosen will be to work with external vendors;
- Whether blockchain solutions are developed in-house or by external commercial partners, internal expertise is needed to safeguard implementation;
- To assess the value of blockchain in the context of SDGs, such expertise will be necessary to run all categories of proofs of concept in the short term and the development of more mature prototypes in the longer term;
- Internal expertise will allow the United Nations to remain up to date in handling financial transactions with banks and financial institutions, which increasingly use this technology;
- The United Nations will be able to make sure that blockchain applications comply with international regulations, including with respect to human rights and environmental protection norms.

272. Several other organizations also supported the idea of building in-house expertise on blockchain, with very pertinent caveats that are worth noting: (a) it should be limited to areas where high-volume usage or a critical mass of blockchain-related projects justify the effort; and (b) a business case should be rigorously identified. In addition, the coding needs to be collectively vetted, to be the best available and provide adequate security.

273. Only one organization responded negatively to the question, pointing out that there was "an abundance of competent and (often) relatively affordable technical partners to leverage for coding". In the view of that organization what was needed was "the ability to translate technical understanding into business applications/requirements and vice versa" and the ability to maintain the solutions that were adopted.

274. A primordial condition for the best use of existing resources relates to building capacity and reducing dependence on the market by the use of open-source options. The implementation of the following recommendation may lead to more efficiency and savings of financial resources. It would support a learning curve for blockchain adoption by the entire United Nations system, while leading to more efficiency and cost saving through reducing duplication of effort.

Recommendation 7

The executive heads of the United Nations system organizations that have developed blockchain applications – in line with the call by the Secretary-General in his Roadmap for Digital Cooperation for the United Nations to deploy digital public goods – should follow, whenever possible, open-source principles when they develop software, and make available the codes to other United Nations organizations.

275. JIU found overall support for the idea of building a minimal in-house technical expertise on blockchain in individual organizations. At the same time, there is also a realistic alternative to start such an effort with an entity that might have a pivotal role to that effect at the system-wide level. The UNICC reported that it had such capacities and it is already engaged in developing blockchain solutions.

276. The Inspector admits that the best available option for organizations is often to resort to external resources. Even in such cases, there is a need for cautious approach in selecting such support. The number of blockchain solutions providers is increasing, but not all of them have a proven capacity to deliver and update in the longer term.

277. **The Inspector recommends that the United Nations Innovation Network establish a roster of external providers of blockchain solutions, accessible to all interested organizations.** He notes that such rosters may exist at the level of some individual organizations. For example, WFP has established long-term agreements with providers of blockchain solutions and has procurement processes that could inspire, or be used by, other interested organizations.

278. The in-house capacity of understanding and mastering emerging and innovative technologies, including blockchain, is an essential characteristic of an effective, modern and learning organization dedicated to effectively and efficiently delivering on its mandate and playing an important role in the achievement of the Sustainable Development Goals. Owing to its decentralized structure and unique features, blockchain poses new challenges for the United Nations system at both the technical and strategic levels on issues such as project management and governance.

279. Most organizations admitted the need for their staff to acquire a certain level of knowledge and understanding of blockchain and other digital technologies, in view of the need to adapt to a fast-changing technological environment.

280. The type and level of training required will depend on the concrete forms of blockchain technology that organizations use or deal with. Entities that actually have blockchain applications in place would require a more elaborate and different type of training compared to those that are (only) dealing with some aspects of blockchain technology in other ways. The type and level of training should vary depending on whether it is addressed to technical staff, programme staff or management and decision makers.

281. While the majority of organizations agreed that some training related to blockchain would be useful, different views were expressed as to which groups of staff should be trained and what type of training would be most useful: technical blockchain-related training for coding and programming or rather general training on blockchain for staff to better understand the functioning, opportunities and limitations of the technology.

282. UNICEF took the view that entities could benefit from understanding how blockchain-based applications were designed, developed and managed. UN-Women noted that blockchain projects might involve disruptive collaboration and service models, at both the technical and programme levels. Being equipped with enough knowledge was the key prerequisite for starting and implementing any projects.

283. FAO suggested that training on innovation methodologies would be most suitable, as blockchain projects might not work well if traditional project methodologies were adhered to. UNEP favoured the idea of regulatory sandboxes, which could allow practitioners to test products, services and business models in a lively environment while being exempt from the normal regulatory consequences.

284. Overall, training on management of blockchain was considered important, as blockchain might not be the best solution in many cases. Promoting awareness sessions would be a very valuable tool to counteract the pitfalls the technology might bring. Similarly, content-specific training programmes about the real capabilities and limitations of the technology could provide suitable guidance to those planning to integrate blockchain into their projects. Finally, not only technical or project staff, but the line-of-business functions, finance, legal and other teams within an organization also needed to understand the business boundaries of blockchain.

285. In conclusion, there are several arguments in favour of training on blockchain:

- Blockchains may result in and involve disruptive collaboration and service models at both the technical and programme levels if not implemented properly. On the programme and design side, it is necessary to undertake a business process mapping prior to the application of blockchain for the activities envisaged;
- On the technical side, staff must be aware of the potential benefits, limitations and risks of blockchain and the approach to project implementation should be based on the intrinsic features of blockchain technology. Blockchain projects may not work well if they follow the traditional United Nations project methodologies;
- Training should create an understanding of how blockchain-based applications are designed, developed and managed to prepare staff and their organizations for new and innovative technologies and the future;
- It could provide suitable guidance on the real capabilities and limitations of the technology to those planning to integrate blockchain into their projects.

286. According to the arguments set out above and the responses of the organizations to the questionnaire, the following three levels of knowledge and understanding of blockchain applications may be useful and suitable for the following broad categories of staff/officials:

(a) For programme staff a general understanding/basic knowledge of blockchains, including the arguments for and against them, and how blockchain-based applications are designed, developed and managed, as well as some understanding of how blockchain is selected (decision tree);

(b) For technical staff handling blockchain projects, guidance on connecting blockchains to United Nations scenarios and understanding the technical details of the capabilities and limitations of blockchains and how blockchain technology and applications could be implemented;

(c) For senior management and other decision makers, a basic understanding and knowledge of blockchain, including its general advantages and disadvantages, in the context of emerging technology and innovation, which would be useful in relation to taking strategic decisions for investing in those new technologies, including blockchain.

287. The Inspector notes the existence of numerous online courses that can adress different levels of learning needs. Many courses are available at low cost, affordable for both interested staff members and organizations with smaller resources, in particular when training resources are limited. The implementation of the following recommendation may enhance efficiency in the use of resources and improve the professional skills of the staff involved, while facilitating the capacity of organizations to become more agile.

288. **The Inspector recommends that the executive heads of the United Nations organizations consider including in the organizational learning curricula, where appropriate and necessary, basic training on how blockchains and other digital technologies work, adapted to the organizational needs for (a) senior management and policy-makers, (b) project managers and (c) staff at technical levels.**

D. First steps towards a culture of collaboration and inter-agency action in the use of blockchain

289. In theory, blockchain seems to offer considerable potential for inter-agency cooperation and joint activities, by virtue of its strengths as a distributed system in an environment without central control. The advent of blockchain at this early stage of development therefore comes with the reasonable assumption that the United Nations system organizations, when contemplating its adoption, should primarily consider projects that would imply a pooling of resources, sharing knowledge and expertise, scalability and collaboration, rather than the development of new silos.

290. According to the views collected by JIU, the participating organizations almost unanimously share such an assumption, based on a variety of arguments:

- Blockchain being a new technological tool, few organizations have enough expertise to fully understand what it offers. A system-wide approach to blockchain will facilitate the access of such organizations to knowledge and expertise;
- Setting up a blockchain infrastructure could be costly. It is preferable that organizations seek collaboration and co-scaling, instead of undertaking small pilots in isolation;
- Organizations that have managed to make good use of blockchain in support of the 2030 Agenda for Sustainable Development can make that practice available, so that the organizations of United Nations system as a whole can leverage each other's knowledge;
- Irrespective of the specific mandates of various organizations, some processes that can be automated through blockchain (grant disbursements, transparent and traceable supply chains, etc.) could be adopted by multiple programmes and funds;
- By using blockchain, the United Nations system could leverage its convening power, forge more results-oriented partnerships with the private sector and promote applications to the field programmes; Blockchains allow the integration of systems when the same population is targeted by multiple organizations and when holistic outcomes are desirable;
- Joint learning, knowledge and experience-sharing among United Nations organizations would provide not only a deeper common understanding of innovation across sectors, but also lead to a coordinated approach to blockchain at the global level;
- Joint blockchain technical capabilities could facilitate coordination mechanisms for distributing funds among stakeholders to counteract overlapping and harmful competition for funds. They may also promote higher levels of accountability and transparency with respect to the allocation of funds.

291. The emerging consensus on the need for inter-agency cooperation in awareness-raising, knowledge-building and coordinated projects is supported by two important initiatives: the **United Nations Digital Solutions Centre** and the **United Nations Innovation Network**. What is particularly significant about these initiatives is that they have a system-wide vocation, which adds to the operational mandate of the **United Nations International Computing Centre. The Inspector recommends coordination and communication between those three entities on digital transformation processes, including on the potential use of blockchain, as a way to improve system-wide coherence and action, and improve the access of all interested organizations to an understanding of blockchain.**

292. The United Nations Innovation Network is conceived as an informal, collaborative community of United Nations innovators interested in sharing their expertise and experience with others to promote and advance innovation within the United Nations system. It has already created promising tools related to blockchain. One is an inter-agency platform for blockchain technology (the Atrium), designed to support learning, collaboration and conversation. The other is a publication entitled "A practical guide to using blockchain within

the United Nations" that is intended to offer a basic understanding of blockchain and general guidance on evaluation of its possible uses.

Box 8
The Atrium – an inter-agency collaboration tool

The Atrium is an inter-agency decentralized blockchain-based collaboration tool designed to both enable collaboration and reduce the friction related to innovating across United Nations agencies that are interested in blockchain. It was established by UNDP, UNICEF and WFP under the auspices of the United Nations Innovation Network and is open to all United Nations agencies. At a high level, the Atrium consists of three components:

- A curated list of learning resources;
- A list of blockchain-based applications built within the United Nations, including project overviews, team contact information and access to details, such as code;
- A community forum to engage with United Nations innovators in knowledge-building.

As a permissioned, private blockchain, accompanied by a distributed applications store, the Atrium allows interested United Nations agencies to share intellectual property and test applications in a secure, sandbox environment.

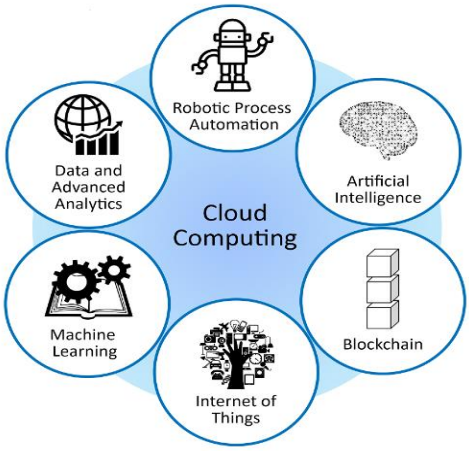
Source: United Nations Innovation Network, WFP, UNICEF

293. **The Inspector welcomes the work done so far by the United Nations Innovation Network and hopes that the network will keep instilling a new culture of inter-agency cooperation with respect to blockchain and other digital technologies.**

294. The Inspector notes with interest that most of the participating organizations have a system-wide vision and can envisage, at this early stage, the establishment of system-wide entities dealing with blockchain, rather than individual undertakings and developing new silos. The most notable of those proposals is the creation of a *blockchain shared-service centre* to provide a mechanism for technical operations, strategic guidance on the adoption of blockchain technology and technical support for implementation of projects. Such a mechanism may also, as suggested by UNFPA, "enable capitalizing on experiences from the entire United Nations system by reducing the number of one-off initiatives that might prove not scalable". **The Inspector notes that this desideratum is already taking shape through the establishment of the United Nations Digital Solutions Centre.**

295. The **United Nations Digital Solutions Centre is** the second major initiative aimed at enabling synergies and collaboration across the United Nations system and bringing a holistic view of digitization. Its mission is to test and implement cutting-edge technology pilots that can be scaled across multiple United Nations organizations. The Centre was founded by UNHCR and WFP and utilizes the operational capacity of UNICC. Figure V represents the technologies used by the Centre including blockchain.

Figure V
Technologies used by the United Nations Digital Solutions Centre



296. **The Inspector welcomes the creation of the Digital Solutions Centre, which heralds the beginning of a new era in the way the United Nations system will handle digital transformation in the future, and he recommends that the participating organizations support it.**

297. The most important project proposed by the Digital Solutions Centre is the creation of a unique personal United Nations ID, using blockchain technology, which is portable across organizations. The proposal foresees that every United Nations organization could become a trusted authority writing information onto the blockchain. The organizations could run their own nodes separately, while the system will ensure scalability and interoperability.[66]

298. **The Inspector recommends that the executive heads of the United Nations organizations support the creation of a United Nations digital ID which will have multiple positive consequences in the longer term in terms of saving time and resources, facilitating staff mobility by allowing certification and recognition of their knowledge and skills, reducing bureaucracy and enhancing system-wide coherence.**

299. The promise of more cooperation in the field, in terms of effective inter-agency collaboration, is also tested through the Building Blocks project, currently the largest and most complex blockchain application in the United Nations. **The Inspector encourages support for and adherence to this pioneering initiative, which has the value of an experiment of system-wide relevance for humanitarian operations.**

300. The implementation of the following recommendation will strengthen coherence at both strategic and operational levels and inter-agency cooperation.

Recommendation 8

The executive heads of the United Nations system organizations, through the relevant coordination mechanisms, including with support from the United Nations International Computing Centre, should consider the adoption of a non-binding inter-agency blockchain governance framework for use by interested organizations, with a view to ensuring coherent and consistent blockchain approaches across the system by the end of 2022, including for projects that may involve multiple United Nations organizations.

[66] A full description of the project is available in the interim report of the CEB task force on the future of the United Nations system workforce (CEB/2020/HLCM/13), 21 August 2020.

Annex I

Summary table of blockchain applications currently used by United Nations system organizations

Organization	Project overview	Blockchain technology used and service providers	Participants
FAO/ITU	Livestock traceability in Papua New Guinea. Using the system, farmers can record important information about their pigs, including their pedigrees, breed, weight, growth pattern, feed, sickness records and medicines administered. The implementation of this new tracking system is vital for establishing consumer trust and ensuring that farmers can expand their markets and earn a fair return on their investment.	Ethereum Public blockchain proof-of-work consensus Technology provider: Switch Maven	The key stakeholders were national public sector organizations (including the provincial administration, the Department of Agriculture and Livestock, the Department of Communications, Information Technology and Energy and the National Information and Communications Technology Authority).
UNDP (1) Mongolia country office	Tracking commodities (cashmere), from point of origin through to sale.	Ethereum-based blockchain network for the pilot, but UNDP recommends a public view, permissioned write structure for any further development of the experiment. Technology provider: Convergence	UNDP deals directly with farmer producers and supplier producers (for example, farmers, herders, supermarkets); sustainability certifiers (Sustainable Fibre Alliance); and end consumers (chocolate bar purchasers, clothing manufacturers, food donation recipients).
UNDP (2) Ecuador country office	Tracking commodities (cocoa), from point of origin through to sale. A digital token was created for each product (i.e., a chocolate bar), which had a monetary value attached (10–25 cents). Each token could be redeemed for a discount on the consumer's next purchase or returned to the original farmer for reinvestment in the production process.	Hyperledger blockchain. Blockchain Middleware KrypCore The Fairchain Node Network manages the underlying infrastructure.	
UNDP (3) Serbia country office	Tracking of food donations from retailers to an NGO that receives donations. The intention is to extend the tracking to the full donation process from farm production to food being received by supermarkets, storage in food banks and finally to individuals.	Stellar Consensus Protocol for transaction verification, which is public and permissioned.	

Organization	Project overview	Blockchain technology used and service providers	Participants
UNDP (4) India country office	Land registry for the city of Panchkula in Haryana State, India.	Ethereum blockchain Technology support: Blockchain Learning Group Focus on smart contracts	
UNICEF (1) Kazakhstan country office	Digicus: a project aimed at using blockchain to digitize and consolidate UNICEF agreements with its implementing partners as smart contracts, including streamlined verification of the results achieved by partners, automatic release of payment after verification and authorization.	Ethereum Ropsten test network and the ERC20 token Service provider: iSKY Solutions	UNICEF Kazakhstan and its local partners.
UNICEF (2) Venture Fund	A pooled fund investing in early stage, open-source, emerging technologies. It provides product and technical assistance, support for business growth and access to a network of experts and partners.	• OS City (Mexico)/bitcoin, Ethereum, Ethereum Classic • Atix Labs (Argentina)/bitcoin, RSK • W3 Engineers (Bangladesh)/Ethereum • Statwig (India)/Ethereum • Prescrypto (Mexico)/Dash, Ethereum, Ethereum Classic • Utopixar (Tunisia)/Ethereum • Trustlab (South Africa)/Ixo	UNICEF headquarters UNICEF investment companies
UNICEF (3) CryptoFund	The first crypto investment vehicle in the United Nations system, whereby UNICEF can receive, hold and disburse donations of cryptocurrencies ether and bitcoin. Following the structure of the Venture Fund, companies are selected to receive investments in either bitcoin or ether.	Bitcoin Mainnet Ethereum Mainnet	UNICEF national committees UNICEF headquarters UNICEF investment companies (early stage start-ups in UNICEF programme countries)
WFP and UN-Women	Building Blocks solution (cloud-based) is a joint effort of WFP and UN-Women under a cash-based intervention initiative. Building Blocks is currently serving 822,000 Syrian and Rohingya refugees in Jordan and Bangladesh respectively. It contributes to transformative change for women and girls in the Azraq and Za'atari refugee camps in Jordan.	Private, permissioned blockchain using the Parity Technology. Ethereum client with a proof of authority consensus algorithm. Technology providers: • Parity Technologies: blockchain and smart contract components	Transactions initiated are validated by both nodes (WFP and UN-Women). The beneficiary benefits can come from any registration/entitlements systems (e.g., WFP SCOPE or UNHCR proGres); authentication of beneficiaries can be done against any

Organization	Project overview	Blockchain technology used and service providers	Participants
	It allows the humanitarian organizations to coordinate the determination and delivery of mutual assistance without any hierarchies.	• Baltic Data Science: infrastructure, back-end, front-end and mobile app • ConsenSys: governance framework • IrisGuard: biometric technology • Amazon Web Services: cloud hosting services	biometric system (e.g., UNHCR PRIMES or WFP SCOPE) or with passwords/tokens.
UN-Women	Blockchain-based cash transfer test in the Kakuma refugee camp in Kenya.	Ethereum	
WFP **Ethiopia and Djibouti country offices**	Blocks for Transport: the aim of the project is to explore ways to improve the timely availability of shipping documents using blockchain. The long-term vision for the project is to establish a blockchain-powered modular supply chain platform for the humanitarian community, thus strengthening and supporting the role of WFP as the leading United Nations agency in supply chain and logistics.		Clearing agents Shipping agents Ports Transporters Customs
UNICC/ UNJSPF	Technical implementation of the digital certificate of entitlement. Blockchain and machine-learning technology are expected to provide immutable records of transactions for pension recipients. Proof of concept includes the use of biometrics for personal identification and "proof of existence". Creation of traceable, immutable and independently auditable evidence, geo-location for confirmation of "proof of residence" and a mobile application to provide convenience for the beneficiaries.	Permissioned/private blockchain, based on Hyperledger Indy, which comes with a built-in consensus algorithm. UNICC manages and hosts the entire blockchain infrastructure, although it is owned by both participating agencies. All nodes are on servers/computers hosted in the UNICC data centres. Outside technical services and support are also engaged.	The consumers of the full-technology solution are the retirees of the United Nations system. The system has two parties on the chain for now – UNJSPF and UNICC. Ideally, in the future all United Nations agencies, programmes and offices that will participate in the common digital ID will be able to run a node, which can be physically hosted at UNICC but be owned by the participating agency.
Office of Information and Communications Technology/ UN-Habitat	Tracking the ownership of parcels of land in Afghanistan. An immutable version of land records is created, which can then serve as the basis for other government services, such as urban planning, citizen engagement and revenue generation.	Anchoring on a blockchain is used for this implementation. It is a simple way to notarize documents or time stamp data by adding a hash on the blockchain, which makes data tamper-proof. LTO Network is the service provider.	Ministry of Urban Development and Land

Annex II

Blockchain applications that organizations envisage using in the future

Organization	Potential use
UNCTAD	**Online dispute resolution for consumers:** a project to deliver blockchain-based online dispute resolution for consumers as a means of improving international trade and electronic commerce. UNCTAD could provide expertise on consumer protection issues within the United Nations and covers capacity-building and technical assistance issues relating to consumer protection. A partner will develop the blockchain technology.
UNEP	**Money transfer and smart contracts:** a tool for Member States to check how resources are allocated and distributed to UNEP partners or service suppliers and to which project they are linked. A smart contract feature added to the money transfer would automatically unleash part of the allocated project funding only when goals are achieved. **Supply chain tracking and monitoring:** the purpose is to trace and follow environmentally sensitive commodities in order to create a safer environment, with possible use of blockchain-based tokenization. **Funding and fund disbursements** to partners could run on blockchain for transparency and accountability in the framework of the United Nations Decade for Ecosystem Restoration. **Certificates of participation** with associated carbon sequestration impacts could be automatically issued to donors. The Decade could use blockchain to develop an ecosystem services marketplace and an ecosystem services standard and tradeable tokens to incentivize restoration.
UNFPA	UNFPA is considering the use of blockchain technology in the context of **registering childbirth** and **health supply chain management**.
UNRWA	**Voucher transfer:** transfer of vouchers to refugees and distribution of funds through the social safety-net system. **Digital health:** storage of patients' medical history through the eHealth system. **Supply chain:** tracing ingredients in the supply chain.
ITU	Use of blockchain-based systems in some of its internal processes, e.g., for the **management and verification of documents and business processes**.
UNESCO	**Educational certification:** an option to open education credentials to potential employers. **Resource mobilization:** informing the general public about UNESCO projects and allowing donation of funds using smart contracts.
UNICEF	**Innovative financing:** increase in the transparency of the movement of funds and micropayments, and possible leveraging of decentralized financing mechanisms enabled by blockchain. **Child rights**: potential applications to protect children's data, manage digital identification and/or create and manage digital credentials.
UNIDO	**TruBudget:** an open-source application developed to increase efficiency and traceability of funds by providing Member States and donors with greater transparency on the allocation of resources. **Agriculture food chain:** potential use of blockchain for inclusive and sustainable industrial development in agrofood chains in the country by improving traceability and transparency in the value chain. **Trade finance tools:** trade finance tools based on blockchain for supporting small and medium enterprises in Africa to access financing. **Crucial supply chains:** the use of blockchain for increasing the efficiency, transparency, traceability and security of crucial supply chains.

Organization		Potential use
ILO		**Digital signatures and smart contracts:** potential application at the ILO for internal administrative purposes in the light of digital transformation. **Supply chain monitoring:** leveraging blockchain technologies to achieve transparency and security in monitoring labour conditions in the supply chain.
UPU		**Postal supply chain:** blockchain as an alternative for electronic data interchange transmissions among actors in the postal supply chain to fulfil the need for data privacy, with a model where every actor (the post, customs organizations, air transport security) will see only the data it needs, when needed, to perform its duties. **eWallet:** a blockchain-powered solution to complement the UPU offer for postal payment services.
WHO		**Health information exchange:** patient data management, electronic health records, prescriptions and billing claims management, international vaccination certification. **Supply chain management:** combating counterfeit medications and other forms of medical fraud. **Digital credentials:** Blockcerts is currently being considered for issuing, viewing and verifying blockchain-based credentials for the WHO Academy.
WIPO		Potential uses of the technology in the ecosystem of intellectual property.
WMO		**Weather data exchange**: blockchain technology will possibly be implemented to support the exchange of licensed data.
UNITED NATIONS SECRETARIAT	**Economic Commission for Europe**	A white paper on the technical applications of blockchain to the United Nations Centre for Trade Facilitation and Electronic Business proposed several deliverables on smart contracts, inter-ledger interoperability frameworks, trade data semantics frameworks, legal and regulatory frameworks and blockchain application data needs (see ECE/TRADE/C/CEFACT/2019/8).
	Economic Commission for Africa (ECA)	ECA is considering conducting a study in 2021 to determine possible applications of blockchain technology.
	United Nations Office on Drugs and Crime	Explores the area of cryptocurrency donations.
	Office of Information and Communications Technology	Consideration of the use of a blockchain-based Unite token to gamify collaboration among United Nations employees, incentivize innovation, greening the United Nations and diversity, or any other mindset or behaviour to be promoted and encouraged among staff.
	United Nations Office of Counter-Terrorism	The Office is considering building blockchain elements into its vulnerable targets and countering terrorist travel programmes.

Annex III

An indicative overview of distributed ledger technology solutions for use cases for key challenges in the 17 Sustainable Development Goals (JIU summary)

Source: International Telecommunication Union, Telecommunication Standardization Sector, ITU-T Focus Group on Application of Distributed Ledger Technology, Technical Report FG DLT D2.1, Distributed ledger technology use cases, 2019.

Sustainable Development Goal	Challenge	A possible distributed ledger technology (DLT) approach
Goal 1	One in 10 people in lower middle-income countries living below the international poverty line.	DLT can automatically record transactions on a secure ledger with near-instantaneous financial settlement. Shorter payment cycles could be harnessed to help address poverty and promote equal rights to economic resources.
Goal 2	Insufficient access to nutritious food all year round.	DLT could strengthen the supply side, particularly for small-scale food producers and family farmers, enabling them to better access markets and receive equal treatment in the supply chain.
Goal 3	Non-communicable diseases and mental health have been attracting new attention and funding, competing with infectious diseases.	DLT can support enhanced prevention and treatment outcomes through breaking down data silos across medical providers and enabling the tokenization and incentivization of physically or mentally beneficial activities.
Goal 4	Access to inclusive education.	DLT-based platforms could connect students, educators and service providers in online sessions where progress, attendance and completion are automatically tracked.
Goal 5	Gender equality and empowerment of women.	DLT could help women earn and retain control over additional income and mitigate online harassment.
Goal 6	The distribution of clean water is globally unbalanced.	DLT combined with Internet of Things sensors, would enable households, industries, water managers and policymakers to make more informed decisions.
Goal 7	Increase the share of renewable energy and double the efficiency of energy production.	DLT enables the tokenization of energy trading platforms and the use of peer-to-peer networks to trade renewable energy.
Goal 8	Government access to domestic financing at a reasonable cost.	DLT can allow the sale of small-value mobile retail bonds and promote inclusive growth by democratizing sovereign debt.
Goal 9	Economic development.	Trading with a DLT-based regulatory-compliant global currency can enable microtransactions, which can be an important enabler of services tailored for the poor.
Goal 10	Reducing inequalities in the economy, governance, rights and decision-making.	DLT can enable better economic equality by reducing the cost of remittances and open new ways for citizens to get involved in decision-making.
Goal 11	The increasing urbanization and number of megacities.	DLT can provide a cost-effective and trustworthy enhancement for local democracy within cities.
Goal 12	More transparency and visibility of value chains and production processes in order to gain a better understanding of risks and ensure due diligence.	Tracing of products in supply chains relates closely to consumer awareness of the origins of products, sustainable production methods and health implications.

Sustainable Development Goal	Challenge	A possible distributed ledger technology (DLT) approach
Goal 13	The risk of irreversible ecological disaster.	DLT can support the development of carbon marketplaces by using platforms for the trading of assets that represent carbon, while guaranteeing immutability and transparency.
Goal 14	Protect marine and coastal ecosystems from pollution and overexploitation.	DLT can provide the baseline architecture for interoperable data collection, allowing better management of ecosystems, more informed decision-making and increased accountability.
Goal 15	Reversing the effects of land degradation and desertification.	DLT can be used to incentivize organizations and individuals to increase the scale and efficiency of conservation protection by offering small cash payments in exchange for conserving nature.
Goal 16	Strengthening the rule of law.	Smart contracts executed on DLT platforms can be used to automate and enforce agreements between business entities.
Goal 17	Improving the debt management of and promote investment in developing countries.	DLT can be used to facilitate partnerships and collaboration between Governments, companies, academia, civil society and individuals where trustworthy information and value transfers are needed.

Annex IV

Overview of actions to be taken by participating organizations on the recommendations of the Joint Inspection Unit

JIU/REP/2020/7

		Intended impact	CEB	United Nations, its funds and programmes															Specialized agencies and IAEA										
				United Nations*	UNAIDS	UNCTAD	ITC	UNDP	UNEP	UNFPA	UN-Habitat	UNHCR	UNICEF	UNODC	UNOPS	UNRWA	UN-Women	WFP	FAO	IAEA	ICAO	ILO	IMO	ITU	UNESCO	UNIDO	UNWTO	UPU	WHO	WIPO	WMO
Report	For action		☐	☒	☒	☒	☐	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒
	For information		☒	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Recommendation 1		d		L	L			L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
Recommendation 2		f		E	E	E		E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
Recommendation 3		d		E	E	E						E		E	E	E	E		E		E		E	E	E		E	E		E	E
Recommendation 4		f		E	E			E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
Recommendation 5		b		E																											
Recommendation 6		b		L	L			L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
Recommendation 7		h		E				E			E		E				E	E	E					E							
Recommendation 8		d		E	E	E		E	E	E	E	E	E	E	E	E	E	E	E		E	E	E	E	E	E	E	E	E		

Legend:

L: Recommendation for decision by legislative organ

E: Recommendation for action by executive head

: Recommendation does not require action by this organization

Intended impact:

a: enhanced transparency and accountability **b:** dissemination of good/best practices **c:** enhanced coordination and cooperation **d:** strengthened coherence and harmonization

e: enhanced control and compliance **f:** enhanced effectiveness **g:** significant financial savings **h:** enhanced efficiency **i:** other.

* As listed in ST/SGB/2015/3.