

# Frontier ICTs for Sustainable Development for Digital Leaders



## General Overview of Frontier ICTs

Frontier ICTs (Information and Communication Technologies) are recognized as an important means of achieving the 2030 Agenda and the Sustainable Development Goals (SDGs). However, the use, adoption, and adaptation of these technologies are not the same across countries.

Frontier ICTs refer to the digital technologies among Frontier technologies that have the potential to transform societies and economies and promote environmental sustainability.

Frontier ICTs such as Artificial intelligence (AI), Blockchain, and the Internet of Things (IoT) are expected to have great impacts on sustainable development and are also recognized as an important source of concerns for socio-economic development (especially policymaking) in developing countries.

The module provides fundamental information and explores the challenges/risks, policy recommendations, and international cooperation

agendas related to Frontier ICTs that policymakers in developing countries should consider when developing and applying the Frontier ICTs to enable sustainable development through innovation in their public sectors and societies.

Transformative features of Frontier ICTs such as 1) productivity of systems; 2) transparency, traceability, and accountability; 3) decentralization and access; 4) creation of, and access to, new financing models; and 5) discovery, including new materials, lead to a great positive impact on the economy, society, and the environment, thus also contributing to the achievement of the SDGs.

However, Frontier ICTs can disrupt existing social and economic systems and introduce new risks, such as ethical or environmental issues because of their transformative and inherent features. The risks include bias and privacy, job loss, gender and cross-border inequality, greenhouse gas emissions, etc.

Therefore, policymakers should strive to develop the following policy areas for Frontier ICTs in a balanced way: 1) Skills, 2) Innovation, 3) Partnerships, 4) ICT infrastructure, 5) Finance mechanism, 6) Regulatory frameworks, 7) Leadership, 8) Data, and 9) Technology governance.

Some of the suggested policy areas such as regulation, capacity building, and ICT infrastructure cannot be addressed single-handedly in a country that lacks digital assets, capabilities, experience, and finances. Cross-border cooperation is necessary for the world to fully benefit from Frontier ICTs while accelerating sustainable development.

Among the Frontier ICTs, Artificial Intelligence (AI), Blockchain, and Internet of Things (IoT), which have shown high impact and interest, are dealt with individually and in detail.

Each technology is covered in a structured manner with an intentional order to help digital leaders follow a series of practical steps leading to drafting a policy recommendation agenda. The sequence includes five preparatory steps (Technical Overview, Opportunities for Sustainable Development, Considerations, Policies, Case Studies) and two steps of forming corresponding recommendations (Policy Recommendations, Opportunities for International Cooperation).



# Artificial Intelligence (AI)

## 1.1. AI overview

The term AI (since the 1950s) generally refers to computer systems that can perform tasks that normally require human intelligence.

According to the OECD, AI is the ability of machines and systems to acquire and apply knowledge and to carry out intelligent behavior. This includes a variety of cognitive tasks (e.g. sensing, processing oral language, reasoning, learning, making decisions) and demonstrating the ability to move and manipulate objects accordingly.

By benefiting from algorithms like neural networks, AI technology is growing to provide more accurate insights for businesses. AI markets are growing fast thanks to three key factors: availability of more data, better algorithms, and improved computing power.

## 1.2. Opportunities for sustainable development

AI might impact all aspects of sustainable development:

- AI can enable the accomplishment of 134 targets (79 per cent) across all SDGs.
- There is also potential for inhibition of 59 targets (35 per cent).

AI may act as an enabler for all the targets of the social group of the SDGs by supporting the provision of food, health, water, and energy services to the population. AI may exert a net positive impact, such as productivity improvement, for 70 per cent of the economy group of the SDGs. AI could act as an enabler for 93 per cent of environmental groups. The benefits of AI could be derived by the possibility of analyzing large-scale interconnected databases to develop joint actions aimed at preserving the environment.

## 1.3. Considerations for using AI

The risks and challenges associated with AI could potentially have unintended consequences on sustainable development. Therefore, in order to effectively utilize AI for the SDGs, it is necessary to be aware of its potential detrimental effects.

AI considerations summarized using the TESE framework are presented in the table below.

Table 1. Summary of AI considerations using TESE framework

Domain	AI
Technological	<ul style="list-style-type: none"> <li>• Not well-established data collection standards</li> <li>• High privacy and security risks</li> <li>• Lack of interoperability</li> <li>• Lack of transparency and interpretability.</li> <li>• Lack of official industry standards</li> <li>• The bias hidden in data</li> </ul>
Economic	<ul style="list-style-type: none"> <li>• Growing economic disparities between countries due to differences in the availability of data and analytics resources</li> <li>• AI benefits focused on specific developed countries</li> <li>• Need for sufficient financial support</li> </ul>
Social	<ul style="list-style-type: none"> <li>• Unevenly distributed: hard for people in rural areas and developing economies</li> <li>• Unemployment crisis</li> <li>• Increased inequalities in regions</li> <li>• Increased discrimination against women and minorities</li> <li>• Lack of gender, racial, and ethnic diversity in the AI workforce</li> <li>• Lack of talent and knowledge in AI</li> <li>• Control concerns over certain classes</li> <li>• Concern about exploitation for criminal purposes</li> <li>• Responsibility and accountability issues</li> </ul>
Environmental	<ul style="list-style-type: none"> <li>• High energy consumption</li> <li>• Overexploitation of natural resources</li> </ul>

## 1.4. AI-related Policy

Significant implications were drawn by analyzing AI-related policies worldwide.

- Although nations are developing AI governance and regulation, there are still many gaps in AI development and adoption between or within countries. Therefore, it is important to promote collaboration inside and outside national borders.
- North America and Western Europe are best prepared for AI, while the Chinese government has achieved significant progress in its implementation. In contrast, the developing world (i.e. Sub-Saharan Africa, Latin America and the Caribbean, South and Central Asia) has the lowest progress.
- “Responsible Use of AI” is an important motto and initiative undertaken by nations to encourage cooperation with organizations such as the Global Partnership on Artificial Intelligence (GPAI). They also support the responsible development and use of AI.
- Since countries significantly differ in their capabilities, resources, and priorities, cross-border collaborations for data sharing, funding, and policy development must be encouraged to promote equality between nations.

## 1.5. Case studies in the public sector

Bernd et al. (2019) suggested ten AI application areas in a public sector context such as AI-Based Knowledge Management Software, AI Process Automation Systems, Virtual Agents, Predictive Analytics and Data Visualization, Identity Analytics, Cognitive Robotics and Autonomous Systems, Recommendation Systems, Intelligent Digital Assistants, Speech Analytics, Cognitive Security Analytics, and Threat Intelligence.

After analyzing use cases identified from the OECD OPSI (Observatory of Public Sector Innovation), several crucial points for best practices can be identified:

- Assuring accuracy regardless of context, environmental conditions, and other variable factors, and conducting tests through pilot projects.
- Cross-border collaboration
- Demands of industry players can be met using AI projects that help match societal needs (e.g. job search) to the needs of companies (e.g. search for talent).
- For successful projects, the needs of all stakeholders must be considered.
- Designing ways to utilize crowdsourcing from populations appropriate for the project context by providing the right incentives is an effective solution for data collection.
- AI methods and data resources can be catalogued for potential use in AI projects.
- It is critical to have access to top talent in the area of AI.
- Having useful data available publicly can help realize a variety of AI projects.
- AI projects can be utilized in scenarios where there is a lack of human resources.
- It is extremely important to promote public-private partnerships.
- Overall, having an efficient digital infrastructure is essential, especially access to Cloud infrastructure.

## 1.6. Policy recommendations

Based on policy directions identified from AI considerations, extended by the implications and policy insights derived from AI policy analysis and AI use cases, policy recommendations are presented in nine categories below:

- Establish technological standardization based on cross-border cooperation
- Establish a balanced privacy protection
- Acquire talent and mitigate unemployment
- Establish ethical standards
- Design transparency requirements
- Ensure explainability
- Proactively prevent biases related to gender, race and ethnicity
- Implement effective ways for human oversight
- Establish innovation principles for accountability and auditability



## 1.7. International cooperation opportunities

Some of the suggested policy recommendations, such as the development of standards, interoperability and ethical requirements, can fully be addressed only through international cooperation.

The best way to collaborate with and benefit from international efforts in AI is through joint initiatives led by large global organizations or regional alliances. Overall, international efforts and initiatives can take the form of working groups, summits, meetings, and bilateral agreements.

Issues like data sharing, AI in agriculture, and radio spectrum management can be handled in a more effective way when close neighbors or two specific countries with a common interest decide to cooperate.

## 2.1. Blockchain overview

The term blockchain was born around 2008 with the distribution of the Bitcoin white paper made by an anonymous persona known as Satoshi Nakamoto.

According to Merriam-Webster dictionary, blockchain is a digital database that contains information (e.g. financial transactions, real estate records). Blockchain is a decentralized network which combines different technologies to allow a decentralized information exchange environment for its users

Blockchain operates through six layers: data, network, consensus, incentive, contract, and application. The data layer is composed of the block information and an encryption algorithm used by the blockchain.

Blockchain has unique characteristics such as individual transparency, trust, immutability, controllability, security, pseudonymity, verifiability, and decentralization.

At first, blockchain technology appeared as part of a novelty and alternative electronic payment systems, and with time, it has moved to become an essential part of a growing ecosystem of different blockchain-based solutions and applications. Current applications of blockchain (e.g. smart contracts, digital currency, securities, and record-keeping) can facilitate the implementation of blockchain in different markets, sectors, or applications (e.g. government, banking, healthcare, legal, economy, supply chain, real estate, IoT, among others).

## 2.2. Opportunities for sustainable development

Blockchain plays an important role across the 17 SDGs thanks to its ability to ensure data transparency, traceability and accountability. Blockchain provides mediums for increasing public transparency to help combat misinformation through openness and immutability record keeping. Many organizations and businesses have been rethinking their operations based on the blockchain that delivers trust

# Blockchain

through openness and decentralization and create value across different sectors while contributing to the achievement of the SDGs. Countries are using blockchain to gather trusted information to formulate measures that benefit future generations and protect the environment.

## 2.3. Considerations for using blockchain

The risks and challenges associated with blockchain could potentially have unintended negative consequences for the SDGs. Therefore, in order to effectively utilize blockchain for the SDGs, it is necessary to have a good understanding of the negative impact of blockchain on the SDGs.

Blockchain considerations summarized using the TESE framework are presented in the table below.

Table 2. Summary of blockchain considerations using TESE framework

Domain	Blockchain
Technological	<ul style="list-style-type: none"> <li>• Need for a considerable amount of data</li> <li>• High privacy and security risks</li> <li>• Lack of interoperability</li> <li>• Reliability problems because of hierarchical structures</li> <li>• Need for high speed of internet access</li> <li>• A low level of understanding of blockchain</li> <li>• The bias hidden in code</li> </ul>
Economic	<ul style="list-style-type: none"> <li>• Cost of converting physical data to digital</li> <li>• Conflict of interest between participants</li> <li>• Inequal allocation of rewards</li> <li>• Need for sufficient financial support</li> </ul>
Social	<ul style="list-style-type: none"> <li>• Unemployment crisis</li> <li>• Risk of gender inequality</li> <li>• Impossible to secure the right to be forgotten</li> <li>• Ethical issues</li> <li>• Disclosure concern about sensitive information</li> <li>• Lack of talent and knowledge in blockchain technology</li> </ul>
Environmental	<ul style="list-style-type: none"> <li>• High energy consumption</li> <li>• Possibility of water pollution</li> </ul>

## 2.4. Blockchain-related Policy

Significant implications were drawn by analyzing blockchain-related policies worldwide:

- The United States of America is introducing government subsidies and regulatory sandboxes for testing to promote innovation in related industries while granting autonomy to each state in creating blockchain-related policies.
- The European Union is promoting data protection and strengthening and facilitating financing for small and medium-sized enterprises (SMEs) based on an open and innovation-friendly approach that can cover all of Europe.
- The United Arab Emirates is actively promoting blockchain in government services and is participating in international cooperation activities regarding blockchain standards.
- The Republic of Korea is reformulating laws related to virtual assets and actively supporting research and development activities related to blockchain.
- China is promoting public-private partnerships, sandbox pilot projects, and funding for development projects to promote the development of blockchain service.

## 2.5. Case studies in the public sector

OECD OPSI (2018) classified eight blockchain use cases in the public sector such as Identity, Personal records, Land title registry, Supply Chain management, Inventorization, Benefits, entitlements, and aid, Contract and vendor management, Voting, and Streamlining inter-agency processes.

After analyzing use cases identified from the OECD OPSI, several crucial points for best practices can be identified:

- Government should conduct different test-runs in an effort to collect data to measure the impact of blockchain on humanitarian problems.
- User-friendly services should be implemented as users have limited knowledge of how new technologies work.
- The lack of implementation of new technologies implies limited data availability, which makes it difficult to initially assess the impact of blockchain.
- Lack of competitiveness in the related industries can pose challenges to blockchain implementation, hence the necessity to promote and encourage blockchain use within industrial systems.
- Governments should promote funding for the implementation of new technologies.
- Participation of all stakeholders in any specific process is essential to implement prototypes of potential blockchain applications.
- Governments should encourage the use of blockchain in areas with potential social problems (e.g. counterfeit drugs).
- Governments need to define key indicators that allow them to measure the effectiveness of implemented blockchain applications.
- Sharing data between the public and private sectors is important to allow synergies for the analysis of the effect of blockchain applications.
- Political support is essential to provide the resources needed to test and implement new technologies.

## 2.6. Policy recommendations

Based on policy directions identified from blockchain considerations, extended by the implications and policy insights derived from blockchain policy analysis and blockchain use cases, policy recommendations are presented in eight categories below:

- Establishment of standards for interoperability
- Improvement of capacity for policy integration at different levels of the government
- Development of guidelines and principles for the adoption of blockchain
- Creation of a blockchain development committee
- Promotion of participation and inclusion of multiple stakeholders to increase synergy among sectors for the research and development (R&D) of blockchain
- Reduction of inequality and gender Issues
- Provision of incentives for promotion and collaboration
- Promotion of environment protection and use of renewable energy

- Advocate a public-private alliance that enables blockchain communities and law enforcement agencies to work together to tackle societal and gender issues.
- Join efforts to develop technical assistance and investment programs that support blockchain-based innovation solutions that are eco-friendly and consume renewable energy sources

## 2.7. International cooperation opportunities

Some of the policy recommendations suggested can fully be addressed only through international cooperation. Existing initiatives and opportunities for international cooperation related to blockchain are presented below:

- Establish a mechanism to collaborate and exchange ideas on blockchain related regulations, policies, or innovations
- Join annual conferences dedicated to blockchain
- Foster an enabling tax, legal and regulatory environment for blockchain initiatives
- Participate in the open-source initiatives to enable innovation and a quicker adoption of blockchain



# Internet of Things (IoT)

## 3.1. IoT overview

Since 2011, IoT has been used to describe different applications and developments where a “thing” is connected to the Internet.

ITU defines IoT as a “global infrastructure for the information society that enables advanced services working as a link to connect physical and virtual world things based on existing and evolving, interoperable information and communication technologies.”

IoT is composed of four layers that form IoT architecture: smart device/sensor, network/communication, service support and application support, and application layer.

IoT has key characteristics such as interconnectivity and heterogeneity, accessibility, things-related services, dynamic changes, enormous scale, and safety.

IoT is a keystone for the digital transformation and foundation for data collection and the operational efficiency of most industries such as manufacturing, government, transportation, healthcare, agriculture, logistics, and so on.

## 3.2. Opportunities for sustainable development

With the collection of significant amounts of data per different sectors, IoT can enable a correct follow-up of the status of the SDGs. It can also foster smart and big data ecosystems that integrate different technologies to help achieve the SDGs. With these technical characteristics, IoT's positive effect can help address sustainability and development challenges.

As IoT enables real-time monitoring of progress on social and environmental issues related to quality of life, city development, and water and waste management, it can contribute to diagnosing problems and also creating better solutions. Specifically, IoT solutions can help provide better resource allocation, increase efficiency and effectiveness, track systems that allow reduced losses and control of stakeholders.

## 3.3. Considerations for using IoT

The risks and challenges associated with IoT could potentially have unintended negative consequences for the SDGs. Therefore, in order to effectively utilize IoT, for the SDGs, it is necessary to have a good understanding of the negative impact of IoT on the SDGs.

IoT considerations summarized using the TESE framework are presented in the table below.

Table 3. Summary of IoT considerations using TESE framework

Domain	IoT
Technological	<ul style="list-style-type: none"> <li>• Vulnerable to bad actors</li> <li>• Own technical standards</li> <li>• Lack of awareness on security risks &amp; no globally recognized IoT security certification</li> <li>• Lack of interoperability</li> <li>• Lack of spectrum resources</li> </ul>
Economic	<ul style="list-style-type: none"> <li>• Waste of energy</li> <li>• Unclear and hard to trust IoT value chain</li> <li>• Underestimated cost of maintenance</li> <li>• Increased inequality between countries because of tech infrastructure</li> </ul>
Social	<ul style="list-style-type: none"> <li>• Hard to opt-out from data collection</li> <li>• Ubiquitous and hard to notice IoT hardware</li> <li>• Considered creepy and untrustworthy</li> <li>• Limited information sharing between regions</li> <li>• Amplifies the digital divide.</li> <li>• Little understand of how sensors collect data</li> </ul>
Environmental	<ul style="list-style-type: none"> <li>• Increase of e-waste</li> <li>• A lot of untapped heat into the environment</li> </ul>

## 3.4. IoT-related Policy

Significant implications were drawn by analyzing IoT-related policies worldwide:

- IoT policymaking is still in the early stages of maturity. One of the main reasons for the low level of maturity is that IoT is often addressed indirectly in policy documents.
- Technologically advanced nations share common characteristics such as government sponsoring R&D efforts in IoT, using tax breaks and other incentives for IoT promotion, and high awareness of the need for cross-border cooperation.
- It is important to apply both sector-specific and technology-specific policies. Sector-specific policies can take the form of policy instruments supporting smart manufacturing, smart cities, or other specific adoptions of IoT. At the same time, long-term national policy should be developed as well.
- Even though international standardization is hard to achieve, it is important to kick off internal efforts for standardization in a given country.
- It is necessary to establish strong partnerships in the field of technology and knowledge sharing.
- It is needed to develop policy initiatives that support and promote the whole ICT ecosystem rather than target only IoT.

## 3.5. Case studies in the public sector

It is predicted that IoT technologies can affect almost every public service and significantly improve processes and human efficiencies. According to Gil-Garcia et al. (2020), applications that are expected to create value by utilizing IoT in the public sector can be divided into public services, response, cost efficiency, and proximity to citizens.

Even though there are very few countries with advanced levels of IoT development, there are many successful use cases globally. After analyzing use cases identified from the OECD OPSI, the following best practices have been identified:

- The key success factor for IoT pilot projects is to ensure inter-agency cooperation.
- Design projects that provide direct benefits to the citizens can ensure the highest rates of approval and effective promotion of IoT,
- Demonstrating political willingness and technological leadership is necessary.
- Crowdsourcing is an important source of input for IoT projects for the public good. Therefore, policy instruments that provide the basis for crowdfunding should be developed.
- To secure continuous benefits from IoT projects, it is necessary to make sure the data and results generated can be shared and reused for other projects.

## 3.6. Policy recommendations

Based on policy directions identified from IoT considerations, extended by the implications and policy insights derived from IoT-related policy analysis and use cases, policy recommendations are presented under the 13 categories below:

- Develop a national IoT strategy
- Establish a government body dedicated to IoT
- Ensure the security and safety of IoT through effective policy
- Ensure equality and social benefits for all
- Close the digital gender gap
- Reduce the data divide
- Build trust and demonstrate transparency
- Provide a mechanism for data sharing and reusing
- Governments must become early adopters
- Embed support for interoperability and standardization within IoT policy
- Address radio spectrum scarcity
- IoT R&D and education should be included within policy
- Provide incentives to engage in IoT initiatives

### 3.7. International cooperation opportunities

Policymakers should work together to find efficient mechanisms for developing mutually compatible IoT policies. It is important to note that since AI is a key component and tool within IoT infrastructures, reviewing and applying the recommendations for international cooperation in AI is extremely important.

In addition, e-Waste management security, and IoT standardization can benefit from international cooperation.