ITUPublications

International Telecommunication Union
Development Sector

Output Report on ITU-D Question 6/2
ICTs for the environment
Study period 2022-2025

Output Report on ITU-D Question 6/2

ICTs for the environment

Study period 2022-2025

ICTs for the environment: Output Report on ITU-D Question 6/2 for the study period 2022-2025

ISBN 978-92-61-41141-1 (Electronic version)
ISBN 978-92-61-41151-0 (EPUB version)

Acknowledgements

The study groups of the International Telecommunication Union Telecommunication Development Sector (ITU-D) provide a neutral platform where experts from governments, industry, telecommunication organizations and academia from around the world gather to produce practical tools and resources to address development issues. To that end, the two ITU-D study groups are responsible for developing reports, guidelines and recommendations based on input received from the membership. Questions for study are decided every four years by the World Telecommunication Development Conference (WTDC). The ITU membership, assembled at WTDC-22 in Kigali in June 2022, agreed that, for the period 2022-2025, Study Group 2 would deal with seven Questions within the overall scope of digital transformation.

This report was prepared in response to Question 6/2: **ICTs for the environment**, under the overall guidance and coordination of the management team of ITU-D Study Group 2 led by Mr Fadel Digham (Arab Republic of Egypt), as Chair, supported by the following Vice-Chairs: Mr Abdelaziz Alzarooni (United Arab Emirates), Ms Zainab Ardo (Federal Republic of Nigeria), Mr Javokhir Aripov (Republic of Uzbekistan), Ms Carmen-Mădălina Clapon (Romania), Mr Mushfig Guluyev (Republic of Azerbaijan), Mr Hideo Imanaka (Japan), Ms Mina Seonmin Jun (Republic of Korea), Mr Mohamed Lamine Minthe (Republic of Guinea), Mr Víctor Antonio Martínez Sánchez (Republic of Paraguay), Ms Alina Modan (Romania),[1] Mr Diyor Rajabov (Republic of Uzbekistan),[1] Mr Tongning Wu (People's Republic of China) and Mr Dominique Würges (France).

The report was developed under the leadership of the Rapporteur for Question 6/2, Ms Aprajita Sharrma (Republic of India), in collaboration with the following Vice-Rapporteurs: Mr Apollinaire Bigirimana (Republic of Burundi), Mr Issa Camara (Republic of Mali), Mr Jean-Manuel Canet (Orange), Mr Gregory Domond (Republic of Haiti),[1] Ms Gnakri Isabelle Sonia Gnabro Epouse Kakou (Republic of Côte d'Ivoire), Mr Sang-hun Lee (Republic of Korea), Mr Shang Li (People's Republic of China), Mr Thomas Wambua Luti (Republic of Kenya), Mr Ethan Mudavanhu (Access Partnership Limited), Ms Julia Nietsch (France)[1] and Mr Yasumitsu Tomioka (Japan).

Special thanks go to the chapter authors for their dedication, support and expertise.

This report has been prepared with the support of the ITU-D Question 6/2 focal points, editors, the publication production team and the ITU-D Study Group 2 secretariat.

[1] Stepped down during the study period.

Table of contents

List of figures

Figures

Executive summary

The ITU-D Question 6/2 Final Report (2022-2025) explores the role of information and communication technologies (ICTs) in advancing environmental sustainability, focusing on climate change mitigation and adaptation and on electronic waste (e-waste) management. Rising temperatures and sea levels and the degradation of polar ice highlight the urgency for action. Human-induced emissions contribute significantly to global warming, driving the Paris Agreement's goals to limit temperature rise and reduce emissions. ICTs are vital in these efforts, facilitating the data collection, analysis and dissemination that can enhance our understanding of climate systems and support strategic interventions. Technologies like Earth observation, big data analytics, and the Internet of Things (IoT) provide real-time insights into environmental changes, allowing for accurate predictions and informed decision-making.

The rapid growth of e-waste presents significant environmental and health challenges. The proliferation of electronic devices has led to increased e-waste, which, if improperly managed, releases hazardous substances into the environment. The report emphasizes the importance of sustainable e-waste management practices, and the role ICTs can play in promoting a circular economy and reducing the environmental impact of e-waste.

This report is a comprehensive resource for stakeholders, drawing from global experiences, practices, contributions from ITU members, case studies and workshops. It highlights the pivotal role ICTs play in supporting environmental sustainability through innovative solutions. Specifically, this report:

- explores the transformative potential of ICTs, particularly big data, in climate adaptation and prediction. ICTs facilitate advanced analytics, including artificial intelligence (AI), for targeted climate resilience strategies, with Earth observation data providing foundational insights;
- presents case studies demonstrating successful ICT applications in climate change mitigation and adaptation across various countries, emphasizing good practices in disaster management and integrating ICTs into national climate commitments;
- provides guidelines for integrating ICTs with sustainability objectives, discussing the digital and green transformations. It emphasizes policies and regulatory measures to balance the environmental impacts of ICTs and promote energy-efficient technologies;
- addresses e-waste management challenges, focusing on regional needs and sustainable practices. It highlights the consequences of unmanaged e-waste for the environment and health, and advocates for formalizing the informal sector and promoting a circular economy;
- outlines actions and case studies from countries tackling e-waste, emphasizing policy amendments and green technology. It calls for increasing consumer awareness and integrating e-waste into national plans;
- provides strategic recommendations for leveraging ICTs in climate action and e-waste management. It advocates for enhanced collaboration and investment in sustainable technologies. ICTs are central to fostering environmental resilience and sustainability.

Abbreviations and acronyms

Abbreviation	Term
5G	fifth generation mobile technology[2]
AI	artificial intelligence
BDT	Telecommunication Development Bureau
CO2	carbon dioxide
CODES	Coalition for Digital Environmental Sustainability
EEE	electrical and electronic equipment
EO	Earth observation
EPR	extended producer responsibility
ERA5	European Reanalysis of the 5th Generation
EU	European Union
GEDS	Global Environmental Data Strategy
GEM	Global E-waste Monitor
GEO	Group on Earth Observations
GHG	greenhouse gas
GIZ	German Agency for International Cooperation (*Deutsche Gesellschaft für Internationale Zusammenarbeit*)
ICT	information and communication technology (plural ICTs)
ILO	International Labour Organization
IoT	Internet of Things
IPCC	Intergovernmental Panel on Climate Change
ISRO	Indian Space Research Organization
ITU	International Telecommunication Union
ITU-D	ITU Telecommunication Development Sector
ITU-R	ITU Radiocommunication Sector
ITU-T	ITU Telecommunication Standardization Sector

[2] While care was taken in this document to properly use and refer to the official definition of IMT-generations (see Resolution ITU-R 56, "*Naming for International Mobile Telecommunications*"), parts of this document contain material provided by the membership which refers to the frequently used market names "xG". This material cannot necessarily be mapped to a specific IMT-generation, as the underlying criteria from the membership are not known, but in general, IMT-2000, IMT-Advanced, IMT-2020 and IMT-2030 are known as 3G/4G/5G/6G, respectively.

(continued)

Abbreviation	Term
ML	machine learning
Mt	metric ton
NASA	National Aeronautics and Space Administration
NDCs	nationally determined contributions
OECD	Organisation for Economic Co-operation and Development
R&D	research and development
SDGs	Sustainable Development Goals
UN	United Nations
UNDP	United Nations Development Programme
UNEA	United Nations Environment Assembly
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNITAR	United Nations Institute for Training and Research
WEEE	waste electrical and electronic equipment
WHO	World Health Organization
WIPO	World Intellectual Property Organization
WMO	World Meteorological Organization

Chapter 1 – Introduction

1.1 Climate change

According to the State of the Global Climate report of the World Meteorological Organization (WMO) for 2024,[3] the global mean near-surface temperature is 1.55 ± 0.13°C higher than the average for the years 1850-1900 and 1.5°C higher than the pre-industrial era. This year was the warmest in the 175-year observational record. The concentration of carbon dioxide (CO_2) in the atmosphere has reached its highest level in 800 000 years. Over the past decade, the global mean each year has been the warmest on record. The ocean's heat content has increased every year for the last eight years. The Arctic for the last 18 years has seen its sea-ice extent lower than ever previously recorded, as has Antarctica for the past three years. These three years have also witnessed the largest three-year loss of glacial mass ever documented. This comprehensive report underscores the alarming trends in global warming and the ongoing degradation of polar ice masses.

According to the 2021 Sixth Assessment Report[4] of the Intergovernmental Panel on Climate Change (IPCC), human-induced emissions have caused the Earth to warm by roughly 1.1°C since the late 1800s. Global temperatures are predicted to increase by 1.5°C or more over the coming years, which might be a turning point that causes serious problems for the environment and society. Sea levels are already rising, sea ice is melting and heatwaves are becoming more regular and severe, all of which experts have long predicted will happen.

The threat that climate change poses to human lives and the well-being of our planet is grave and only getting worse. Delaying action any further would only worsen the situation and make it more difficult to guarantee a future that is liveable for everyone. Coordinated, immediate action is necessary to lessen the effects of climate change and save the planet for coming generations. The window of opportunity for significant global action is closing fast.

Burning fossil fuels, which emits greenhouse gases, is thought to be the main human activity causing global warming. Its impact can be seen in the increased frequency of extreme weather events over the last 20 years such as heatwaves, flooding, the melting of permafrost and glaciers causing the sea level to rise, and crop failures causing food scarcity and the loss of livelihoods.[5]

The comparison of current global temperatures to pre-industrial levels underscores how much warming has already taken place. The Paris Agreement on climate change, adopted in 2015, aimed to limit the global temperature rise to well below 2°C above pre-industrial levels, cap it at 1.5°C, reduce global greenhouse gas emissions by half by 2030 and reach net zero before 2050. Reducing emissions requires generating electricity from low-carbon sources and enabling technologies in order to reduce global energy consumption, the effects of CO_2 pollution, and the inefficient use of resources.[6]

3 https://wmo.int/news/media-centre/wmo-report-documents-spiralling-weather-and-climate-impacts
4 https://www.ipcc.ch/assessment-report/ar6/
5 https://wmo.int/news/media-centre/eight-warmest-years-record-witness-upsurge-climate-change-impacts
6 https://openknowledge.worldbank.org/entities/publication/6be73f14-f899-4a6d-a26e-56d98393acf3

The summer of 2023 was the hottest ever recorded, with temperatures 0.23°C higher than any summer previously documented by the National Aeronautics and Space Administration (NASA) of the United States of America, and 1.2°C warmer than the average summer temperatures from 1951 to 1980.

The ICT sector's contribution to global carbon emissions is estimated to be between 1.5 per cent and 4 per cent; the World Bank estimates it to be at least 1.7 per cent.

With regard to user devices, usage accounts for about half of their emissions, with the rest of their lifecycle accounting for the other half. The ICT footprint is expected to grow linearly, but the Internet of Things (IoT) will affect this rate in the future.

There are three pillars of climate action which are crucial for the survival of our planet:

- Mitigation, which refers to human interventions to reduce the sources or enhance the sinks of greenhouse gases;
- Adaptation, which refers to the process of adjustment to the actual or expected climate and its effects; and
- Resilience, which is the capacity to cope with the effects of climate change.[7]

As climate change presents increasingly urgent challenges, the demand for ICTs to contribute to environmental sustainability has never been greater. Big data, especially through Earth observation (EO) technologies, has emerged as a critical tool. The application of advanced analytics, like machine learning (ML) and artificial intelligence (AI), is pivotal in deriving insights from massive datasets, enabling more focused and effective climate resilience strategies. However, to fully harness the potential of big data, challenges such as data quality, privacy and the digital divide need to be addressed. Automation, enabled by advanced analytics, can help fight climate change by improving climate models, guiding improved approaches to disaster management, cutting emissions and optimizing energy consumption. For instance, by using predictive algorithms, forms of automation can improve building and transportation energy efficiency and lower carbon footprints. New forms of automation are also improving sustainability by managing agricultural operations and tracking deforestation, and are helping businesses like Google and Microsoft lower energy usage in their data centres.[8]

These technologies are projected to be capable of contributing about 24 per cent of the overall effort towards achieving the 2030 climate targets, with AI alone anticipated to cut greenhouse gas emissions by 16 per cent and enhance power efficiency by 15 per cent in the next three to five years. The development of green ICT policies and international standards is crucial for driving a sustainable digital shift. Ultimately, digital solutions are helping to reduce various industries' environmental impact and strengthen climate resilience through data-driven approaches in key sectors, such as telecommunication/ICT infrastructure, in the face of the climatic and environmental-related risks.

By analysing Earth observation data with cutting-edge techniques like AI and ML, we can expand the human capacity to understand and respond to climate-related issues. This technological advancement is not only deepening our understanding of climate patterns, but also empowering communities, businesses and policy-makers to enhance resilience to climate impacts.

7 https://www.somersetwildlife.org/blog/steve-mewes/mitigation-adaptation-and-resilience
8 https://www.microsoft.com/en-us/sustainability/emissions-impact-dashboard

On the other hand, e-waste proliferation continues to pose a number of challenges. As we continue to strive towards universal and meaningful connectivity, this proliferation will cause the challenge to continually grow and make solutions increasingly urgent.

1.2 Electronic waste

E-waste, also known as waste electrical and electronic equipment (WEEE),[9] refers to the discarded residue of a multitude of components and devices: battery chargers, music systems, cell phones, computers, refrigerators, televisions, monitors, printed circuit boards, televisions, power supply units, fluorescent lights, smoke detectors and so on. The proliferation of devices reaching the end of their useful lives has made e-waste into a serious problem. E-waste that is discarded represents an economic loss, in the shape of valuable components. If improperly handled, it also creates a hazard to the environment and human health. Accordingly, there is a pressing need for sustainable recycling and disposal methods.

According to the Global E-waste Monitor (GEM) 2024,[10] published by ITU and the United Nations Institute for Training and Research (UNITAR), global e-waste generation hit a record 62 million metric tons (Mt) in 2022, an 82 per cent increase from 2010, and was expected to reach 82 million Mt by 2030. Yet, in 2022, only 22.3 per cent of electronic waste was appropriately collected and recycled, with reusable components worth USD 62 billion going unaccounted for. This massive loss of precious metals (such as gold, silver, copper and platinum), whose value exceeds the GDP of many countries, also raises the danger of contamination. The production of e-waste is increasing by 2.6 million Mt per year globally and is expected to exceed 82 million Mt by 2030, an additional 33 per cent rise from 2022 levels. The Asia-Pacific region generated the highest volume of e-waste (24.9 million Mt), followed by the Americas (13.1 million Mt), Europe (12 million Mt) and Africa (2.9 million Mt).

E-waste poses potential environmental and health risks for humans and other animals through physical contact with and inhalation of hazardous gases, exposure to toxic and contaminated food products and water, and in the form of toxins from discarded products that leach into the soil and water. The accumulation of e-waste in soil, water, air and other natural resources may enter the food chain and produce toxic by-products that metabolize slowly in the human body, leading to long-term negative effects. Children and young people are especially susceptible.[11] The rising use of electrical and electronic equipment (EEE), characterized by short shelf life, with limited and costly repair options, makes e-waste into the world's biggest environmental hazard.

We must re-examine the impact of e-waste on the environment and how market pressures might affect this relationship in the future. Research and development (R&D) are urgently needed to minimize the depletion of limited natural resources.

[9] https://ewastemonitor.info/the-global-e-waste-monitor-2024/
[10] https://unitar.org/about/news-stories/press/global-e-waste-monitor-2024-electronic-waste-rising-five-times-faster-documented-e-waste-recycling
[11] https://ceh.unicef.org/spotlight-risk/e-waste

Of the 62 million Mt of e-waste produced in 2022, an estimated 14 million Mt (22.3 per cent) was simply discarded, most of it ending up in landfills. That waste included about 31 million Mt of metals, 17 million Mt of plastics and 14 million Mt of other commodities like minerals, glass and composites. The worth of the metals alone was estimated at USD 91 billion, including USD 19 billion in copper, USD 15 billion in gold and USD 16 billion in iron. The recycling of e-waste that year produced a 93 million Mt reduction of CO_2-equivalent emissions, including 52 million Mt from avoided metals mining and 41 million Mt from recaptured refrigerants, and helped avoid the extraction of 900 million Mt of primary ore.

Chapter 2 – Enabling new technologies for climate change

2.1 Big data and its relevance in climate change adaptation and prediction

This chapter discusses the role of telecommunications/ICTs in enabling new technologies and big data to mitigate climate change, enhance adaptation and improve predictions.

As climate change presents unprecedented challenges, the need for actionable data is critical. The emergence of big data, particularly through Earth observation technologies, has revolutionized our understanding of climate systems. Satellite imagery, remote sensing and IoT networks provide real-time insights into temperature variations, sea level rise and extreme weather events.

Telecommunications/ICTs provide the basis from which it is possible to collect data to then leverage advanced analytics, including ML and AI, to play a crucial role in extracting insights from these vast datasets and enable targeted climate resilience strategies. However, challenges such as data quality and the digital divide must be addressed to fully leverage this potential.

The Global Environmental Data Strategy (GEDS), led by the United Nations Environment Programme (UNEP), aims to harness big data to effectively address environmental challenges. By promoting data governance, enhancing accessibility and building capacity among Member States, GEDS seeks to create a comprehensive framework for environmental data management, emphasizing data quality and interoperability.

2.1.1 Earth observation data: the foundation of climate insights

Earth observation data has become the cornerstone of climate change research and prediction models, providing scientists with an unprecedented view of our planet's dynamic climate systems. The Group on Earth Observations (GEO), an intergovernmental partnership, plays a pivotal role in coordinating and integrating this vast collection of data from diverse sources.[12]

Satellite imagery and remote sensing technologies are at the forefront of this data revolution. These advanced systems capture a wealth of information about our planet's climate, including temperature variations across land and oceans, sea level rise, ice sheet and glacier melt, deforestation, land use changes and atmospheric composition.

This continuous stream of data enables scientists to monitor climate change in real-time and detect long-term trends with remarkable precision. For instance, Earth observation big data from sources like NASA and the National Centres for Environmental Information of the United States provides crucial insights into current climate conditions and helps predict future changes.

The integration of this data with advanced processing techniques, such as AI and ML, is transforming raw Earth observation data into actionable climate intelligence at unprecedented

[12] Sara Venturini. Group on Earth Observations (GEO). GEO for climate action. ITU-D Workshop on green ICT and emerging technologies towards climate change mitigation, Geneva, 29 May 2023.

speeds. This synergy of technologies is not only enhancing our understanding of climate dynamics but also empowering communities, businesses and policy-makers to build resilience against the impacts of climate change.

2.1.2 The possibility: telecoms/ICT-enabled data collection and analytics

The exponential growth of Earth observation data has ushered in a new era of climate research and prediction, in which big data analytics, particularly ML and AI, play a critical role in extracting meaningful insights from vast datasets.[13]

These advanced analytical techniques are transforming our ability to understand and respond to climate change. By applying ML algorithms to extensive Earth observation datasets, researchers can identify complex patterns in climate systems that were previously undetectable. This enhanced pattern recognition allows for more accurate predictions of future climate scenarios, enabling policy-makers and scientists to develop more effective strategies for climate change mitigation and adaptation.

One of the most promising applications of telecommunications/ICTs in climate science is the development of early-warning systems for extreme weather events. These systems can not only save lives in the face of disasters but can also collect the data required to enable the analysis of historical data alongside real-time observations. The likelihood and severity of events such as hurricanes, floods and heatwaves can thereby be predicted with unprecedented accuracy and lead time.

For instance, thanks to telecoms/ICTs, advanced models can now analyse historical flood data to make more precise predictions about future flood risks. This capability enables authorities to implement targeted flood defence measures, potentially saving lives and reducing economic losses.

Moreover, ML algorithms are optimizing climate adaptation strategies by processing vast amounts of data on local conditions, infrastructure and socio-economic factors. This allows for the development of tailored adaptation plans that are more effective and resource-efficient than one-size-fits-all approaches.

This intersection underlines both the importance and the potential of reaching universal and meaningful connectivity and sustainable digital transformation. Through the possibilities of environmental data collection enabled by telecommunications/ICTs, governments and researchers are able to strengthen societal resilience in the face of climatic disasters and risks.

2.1.3 Telecommunications: the backbone of data collection and dissemination

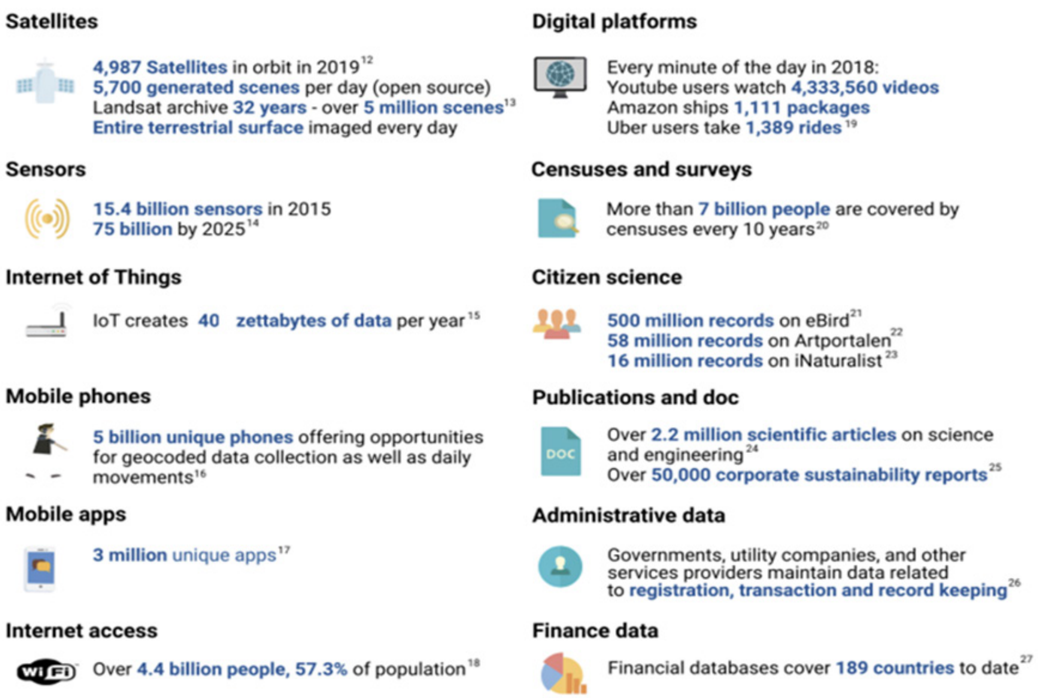
Telecommunications/ICTs such IoT devices and sensor networks are revolutionizing the way we collect climate data, creating a dense network of data collection points that provide granular, real-time information to complement satellite observations.

The network includes a diverse array of sensors, such as weather stations, ocean buoys, air quality monitors and soil moisture sensors. Each of these devices contributes to a comprehensive picture of our planet's climate systems, offering insights that were previously unattainable.

[13] However, there are certain limitations as regards the carbon footprint of AI and ML. These are explored later in the next section.

The IoT-driven approach to data collection allows for unprecedented spatial and temporal resolution in climate monitoring. For instance, a network of interconnected weather stations can provide minute-by-minute updates on local conditions, while ocean buoys transmit critical data on sea temperatures and currents from remote locations.

Figure 1: An array of big data sources



Source: UNEP[14]

2.1.4 Challenges and future directions in climate big data

While big data offers immense potential for climate change adaptation and prediction, several significant challenges must be addressed to fully harness its power. Ensuring data quality and reliability is paramount, as inaccurate or inconsistent data can lead to flawed predictions and misguided policies.

A critical issue is bridging the digital divide to ensure equitable access to climate information. Many regions, particularly in developing countries, lack the infrastructure and resources to fully participate in and benefit from big data initiatives. This disparity could exacerbate existing inequalities in climate change preparedness and response.

Moreover, interpreting and acting on big data insights requires interdisciplinary expertise that combines climate science, data analytics and policy-making. Developing this expertise globally is crucial for translating data into effective action.

As we move forward, addressing these challenges will be essential to maximize the potential of big data in combating climate change and building a more resilient future for all.

[14] David Jensen. UNEP. Harnessing the power of big data and frontier technologies for climate action. ITU-D Workshop on Frontier ICTs for Climate Action, Geneva, 15 October 2019.

2.1.5 Global Environmental Data Strategy

The United Nations Environment Assembly (UNEA) has recognized the urgent need for a global environmental data strategy (GEDS) to address critical environmental challenges and tasked UNEP with developing such a strategy[15] by 2025. GEDS is designed to unlock the full potential of environmental data, ensuring its effective use in tackling climate change, biodiversity loss and pollution. By focusing on key areas like data interoperability, quality, governance, access, and capacity building, GEDS aims to break down the barriers that hinder data sharing and utilization, fostering innovative solutions for sustainable development.

In conclusion, the development of GEDS will empower governments, organizations and communities to make informed decisions, accelerate sustainability efforts and enhance global cooperation to protect the environment for future generations.

2.2 Telecommunications/ICTs as a foundation for solutions towards mitigation of harmful effects of climate change

Telecommunications/ICTs have emerged as a powerful tool that can significantly contribute to climate change mitigation and adaptation efforts. This section explores the various applications of telecommunication/ICT-enabled automation and advanced analytical models in addressing climate-related challenges, highlighting their benefits and potential and the critical need for responsible implementation, particularly concerning the energy needs of such processes.

Fundamentally, it is important to remind ourselves that this progress and these opportunities are only achievable if telecommunications/ICTs are available and affordable across the globe. This requires collaborative action to build infrastructure and capacity to close the digital divide. Only with this foundation can we see the potential benefits described in this chapter.

2.2.1 Benefits of using advanced analytics

Enhanced data analysis and insights

Advanced computing can significantly improve the analysis of large-scale environmental data, providing actionable insights that were previously difficult or impossible to obtain. Key benefits include:

- **Accurate climate modelling and predictions**: enhancing the precision of climate models and allowing for better forecasting of climate-related events.
- **Understanding ecosystem interactions**: facilitating a deeper understanding of complex interactions within ecosystems and aiding in the development of effective conservation strategies.
- **Informed decision-making**: providing robust data analysis and supporting policy-makers in making informed decisions regarding environmental policies and actions.

[15] Global Environmental Data Strategy (GEDS), UNEP, 2024 https://www.unep.org/topics/digital-transformations/global-environmental-data-strategy-geds .

Optimized resource management

Automation enables more efficient use of resources across various environmental sectors:

- **Energy efficiency**: Automation can optimize energy consumption in buildings and industries, reducing waste and lowering carbon emissions. For instance, T-Mobile's strategy to cut energy use through advanced analytics exemplifies this approach.[16]
- **Water management**: Automated systems analyse water usage data, improving resource allocation and minimizing waste.
- **Sustainable agriculture**: Advanced analytics help researchers, farmers and others analyse soil data, predict crop yields and identify pest outbreaks, promoting sustainable farming practices.[17]

Enhanced monitoring and conservation

Automation and advanced computing improve environmental monitoring capabilities:

- **Biodiversity conservation**: processing vast amounts of data from motion-sensing cameras and other sources to track and protect endangered species.
- **Deforestation and poaching prevention**: environmental data can aid in the monitoring of forests and wildlife and help combat illegal activities.
- **Marine ecosystem monitoring**: IoT systems track ocean health and associated risks, contributing to marine conservation efforts.

Improved data interoperability and quality

GEDS aims to leverage advanced analytics to enhance data interoperability across different systems and platforms, improving data quality through automated quality control measures.[18]

Energy management in telecommunications[19]

Telecommunication companies are increasingly adopting AI to manage energy consumption. For example, Sunrise's PowerStar program in the Confederation of Switzerland uses AI algorithms to analyse radio access network traffic, optimizing power supply and achieving energy consumption reductions of more than 10 per cent. Similarly, T-Mobile aims to achieve a net-zero carbon footprint by 2040, utilizing AI to optimize energy use based on traffic and demand.

Disaster preparedness and response

Automation and advanced analytics contribute to better disaster preparedness and response through:

- **Predictive analytics**: predictive analytics for extreme weather events allow for timely interventions and resource allocation.

---

16 ITU-D SG2 Document SG2RGQ/195 from the Republic of Korea.
17 Shanar Tabrizi. (2024). The role of emerging digital technologies for climate change mitigation and adaptation, ITU-D SG2 Q6/2 Workshop, May 6, 2024, 4-9.
18 Global Environmental Data Strategy (GEDS), UNEP, 2024.
19 ITU-D SG2 Document SG2RGQ/195 from the Republic of Korea.

To mitigate these concerns, policy-makers and stakeholders can prioritize the following actions:[20]

- **Promote renewable energy sources**: Encouraging the use of renewable energy for telecommunication/ICT operations can significantly reduce the carbon footprint associated with the energy consumption of advanced analytics and cloud computing.
- **Invest in energy-efficient telecommunications/ICTs**: R&D should focus on creating more energy-efficient telecommunications/ICTs that minimize the negative environmental impact of these systems.
- **Foster collaboration**: Governments, businesses, international organizations and civil society will all benefit from collaborating and sharing good practices and resources to ensure that a society's digital transformation is also a sustainable one.

Telecommunications/ICTs holds immense potential as a solution for mitigating the harmful effects of climate change. By enhancing capacity for remote sensing, data collection and analysis, optimizing resource management and improving monitoring capabilities, telecommunications/ICTs can significantly contribute to climate change mitigation efforts. However, it is vital to implement ICTs responsibly, with a strong emphasis on addressing energy consumption and environmental impact. Through collaboration and innovation, telecommunications/ICTs can be a key catalyst in positive climate actions, paving the way for a greener and more resilient planet.

2.3 Earth observation as a tool for climate change adaptation

Climate change represents one of the most significant challenges facing humanity today, with far-reaching impacts on ecosystems, weather patterns and human livelihoods. As global temperatures rise and extreme weather events become more frequent, the need for effective strategies to adapt to these changes has never been more urgent. In this context, Earth observation (EO) technologies have emerged as a critical resource for understanding and responding to environmental shifts. By providing comprehensive data on the Earth's surface, atmosphere and oceans, EO enables researchers, policy-makers and communities to monitor changes in real-time, assess vulnerabilities and implement informed adaptation strategies.

2.3.1 Growth and advancements in Earth observation technologies[21]

The landscape of EO technologies has experienced remarkable growth and innovation in recent years, positioning them as essential tools in the fight against climate change. In 2022 there were 1 192 EO satellites in orbit, the second-largest category after communication satellites; and the number continues to grow at approximately 10 per cent per year, with 140 new satellites launched that year alone. The importance of Earth observation for monitoring environmental changes is uncontested.

Nearly one-half of EO satellites are utilized for commercial applications, reflecting a burgeoning sector that is driving innovation and investment in satellite technology. Commercial growth is accompanied by a dramatic increase in patent filings related to green applications of satellite-based sensing data, which surged by an astonishing 1 800 per cent from 2001 to 2020. These applications span a wide range of environmental uses, including climate change mitigation, weather prediction, pollution detection and environmental monitoring.

[20] *Ibid*.
[21] World Intellectual Property Organization (WIPO), (2023) Green Technology Book: Solutions for climate change mitigation, 96-97.

Technological advancements have played a pivotal role in this growth, with significant developments in signal processing, miniaturization of instruments and the integration of AI into EO systems. These innovations enhance the ability to collect, analyse and interpret vast amounts of data, enabling more detailed assessments of vegetation, forest conditions and crop development. As EO technologies continue to evolve, they are becoming increasingly vital for supporting efforts in climate change adaptation and resource management, providing critical insights that inform decision-making and policy development.

2.3.2 Role of ICT in enhancing Earth observation capabilities through the initiatives of the Group on Earth Observations[22]

Recognizing the potential of ICT for enhancing how EO systems acquire, process and use data, GEO is promoting the use of ICT tools to collect vast amounts of data from a diverse array of sensors deployed in space, on land and in oceans. This collaboration allows for seamless data transmission, enabling researchers and decision-makers to access real-time information about the Earth's physical, chemical and biological variables.

GEO emphasizes the importance of data analysis and visualization as critical components in making EO data accessible and actionable. Advanced ICTs enable sophisticated analytical techniques that help identify trends, patterns and anomalies in environmental data. Visualization tools, supported by GEO's initiatives, further enhance understanding by presenting this information in user-friendly formats, making it easier for stakeholders—including policy-makers, scientists and community leaders—to interpret and act upon the findings.

The GEO Global Ecosystems Atlas provides comprehensive and accessible information about the world's ecosystems. It is designed to serve as an open online resource that allows users to explore various ecosystems, their conditions, and changes in ecosystem extent. The primary goal is to promote action to protect biodiversity and combat climate change, effectively functioning as a Google Earth for nature. The Atlas will include a digital compendium of data layers from geographic information systems, time series satellite imagery and embedded functionalities utilizing AI and ML. This integration aims to enhance the interpretation and understanding of global ecosystem layers.

Moreover, the role of real-time monitoring facilitated by ICT is essential for enhancing disaster preparedness and response, a key focus of GEO's activities. By enabling timely data transmission and processing, ICT tools support early-warning systems that can alert communities to impending natural disasters such as floods, hurricanes and droughts to save lives and reduce the impact on vulnerable populations.

Collaboration among various sectors is another critical aspect of leveraging ICT in Earth observation, and GEO plays a pivotal role in fostering partnerships. By bringing together governments, academia, private sector entities and non-governmental organizations, GEO encourages the co-design of open and accessible information products. This collaborative approach ensures that EO data is used effectively, promoting informed decision-making and coordinated responses to climate-related challenges. As ICT continues to evolve, its integration with Earth observation technologies, supported by GEO's initiatives, will be vital in maximizing the potential of EO for climate change adaptation and sustainable development.

[22] Sara Venturini. Group on Earth Observations (GEO). GEO for climate action. ITU-D Workshop on green ICT and emerging technologies towards climate change mitigation, Geneva, 29 May 2023.

2.3.3 Case study: real-world applications of Earth observation of India[23]

In the face of escalating climate change challenges, India has emerged as a leading example of how advanced EO systems can be effectively used for monitoring weather patterns and managing natural disasters. A notable collaboration between the Indian Space Research Organization (ISRO) and NASA has been instrumental in developing sophisticated EO technologies that enhance the ability of India to respond to environmental threats.

One of the most significant instances of this collaboration was the response to Cyclone Tauktae in May 2021. As the cyclone approached the Indian coastline, ISRO and NASA's Earth observation satellites provided critical data that enabled accurate forecasting of the storm's formation, intensity and trajectory. Thanks to this crucial and timely information, the India Meteorological Department was able to issue early warnings to coastal communities. The alerts were disseminated through various ICT channels, including radio, television, and mobile messaging, thereby ensuring that residents were informed and could take the necessary precautions.

The effectiveness of these early-warning systems was evident in the swift evacuation of vulnerable populations, which significantly mitigated the cyclone's impacts. The accessibility of satellite data from NASA and National Oceanic and Atmospheric Administration of the United States, particularly through the Suomi National Polar-orbiting Partnership with its Visible Infrared Imaging Radiometer Suite, provided local authorities with the insights needed to prepare for the storm's arrival. This integration of EO technologies not only saved lives but also minimized the damage to infrastructure and livelihoods.

Moreover, the response to Cyclone Tauktae highlighted the importance of community engagement in disaster management efforts. The Department of Telecommunications in India played a vital role in ensuring uninterrupted telecommunication services during the cyclone, facilitating communication and information dissemination to affected communities. Major telecommunication operators collaborated with the Department of Telecommunications to maintain infrastructure and set up focused war rooms to manage restoration efforts, demonstrating a coordinated approach to disaster response.

This practice exemplifies how the integration of EO technologies, supported by collaboration between ISRO and NASA, can enhance disaster preparedness and response in India. By leveraging advanced Earth observation systems, the country is better equipped to monitor environmental changes and respond effectively to climate-related challenges, ultimately contributing to more resilient communities in the face of climate change.

[23] ITU-D SG2 Document SG2RGQ/21 (Rev.1) from India.

Policy recommendations

Based on the insights gained from this use of EO technologies in climate change adaptation by India, the following policy recommendations can be made:

Strengthen international collaborations: Encourage partnerships between national space agencies and international organizations, like the collaboration between ISRO and NASA. This can enhance data sharing, technology transfer and capacity building in EO applications for disaster management and climate adaptation.

Invest in EO infrastructure: Allocate funding for the development and maintenance of EO satellite systems and ground-based infrastructure. This investment should focus on expanding the network of satellites and improving data processing capabilities to ensure timely and accurate information dissemination.

Enhance data accessibility and open data policies: Promote open access to EO data as appropriate for all stakeholders, including government agencies, researchers and local communities. Clear policies for data sharing facilitate collaboration and empower communities to use EO data for local decision-making and disaster preparedness.

Integrate EO technologies into national disaster management plans: Incorporate EO technologies into existing disaster management frameworks at the national and local levels. This integration should include training for emergency responders and local authorities on how to effectively use EO data for risk assessment and response planning.

Promote community engagement and education: Develop programmes to educate communities about the benefits of EO technologies and how to interpret and act on EO data. Engaging local populations in disaster preparedness initiatives can enhance resilience and ensure that information is effectively communicated.

Support R&D in EO technologies: Encourage research initiatives focused on improving EO technologies, including advancements in data analysis. Supporting innovation in this field can lead to more sophisticated tools for monitoring environmental changes and predicting disasters.

Establish a national EO strategy: Formulate a comprehensive national strategy for the use of EO technologies in climate change adaptation and disaster management. This strategy should outline clear objectives, roles and responsibilities for various stakeholders, ensuring a coordinated approach to leveraging EO capabilities.

By implementing these policy recommendations, countries can enhance their resilience to climate change and improve their capacity to respond to natural disasters, ultimately safeguarding communities and promoting sustainable development.

Chapter 3 – Challenges and case studies on climate change

3.1 New technologies and case studies towards climate change mitigation and adaptation

The potential of telecommunications/ICTs and other new and emerging technologies to combat climate change have been explored in various frameworks such as the Focus Group on Environmental Efficiency for Artificial Intelligence and Other Emerging Technologies (FG-AI4EE) of the ITU Telecommunication Sector (ITU-T), the ITU report "Turning Digital Technology Innovation into Climate Action," and ITU-T Study Group 5, which covers topics like electromagnetic fields, environment, climate action, sustainable digitalization, and circular economy.

Several case studies have been conducted within ITU-D Study Group 2 during this period.

Haiti presented strategies to promote digitalization and a wider adoption of online services for greater environmental benefits. To effectively digitalize processes, physical documents must be digitized, new processes, including legal and state documents, must be put on a fully digital footing, cloud computing should be available for citizens to store their digital documents, and all transactions must be accessible electronically. Additionally, users must be educated and trained to use these services. To ensure buy-in from citizens and businesses, online services must be fast, accessible 24/7, available worldwide, low-cost, secure, traceable, flexible and backed up by prompt support.[24]

The Republic of Madagascar showcased a study on eSIM technology, a way of embedding subscriber identity module (SIM) cards in mobile devices, which is considered a key part of the future of mobile connectivity and IoT. Unlike traditional SIM cards, eSIMs are more environmentally friendly, as they reduce plastic production, packaging and transportation. According to a study done by the Fraunhofer Institute for Reliability and Microintegration (IZM), eSIMs have a 46 per cent lower carbon footprint compared to traditional SIM cards. In Madagascar, eSIM technology already provides users with seamless connectivity without the need for physical SIM cards. As eSIM device sales are expected to reach 14 billion by 2030, this technology will contribute to reducing CO_2 emissions and promoting environmental protection.[25]

India highlighted the severe impacts of climate-related disasters over the past two decades, particularly the rise in floods, which affect migration and economies. A contribution from India discussed the application of frontier technologies such as AI, unmanned aerial vehicles and IoT in addressing climate change, particularly with regard to water-related issues. WMO, ITU and UNEP are investigating the potential of AI in predicting and mitigating natural disasters. In India, AI is enhancing weather forecasting, a vital contribution given the country's vulnerability to extreme weather events. The National Centre for Medium Range Weather Forecasting of India, the India Meteorological Department and the Met Office of the United Kingdom of Great Britain and Northern Ireland are collaborating on the Indian Monsoon Data Assimilation

[24] ITU-D SG2 Document SG2RGQ/27 from Haiti.
[25] ITU-D SG2 Document 2/138 from Madagascar.

and Analysis project to improve atmospheric data. The document emphasizes role of AI in combating climate change and improving disaster preparedness, supporting the Sustainable Development Goals (SDGs).[26]

3.2 Good practices, case studies of disaster management through Earth observations

In the contemporary world, climate change has emerged as an undeniable reality, and its effects, particularly in the form of extreme weather events such as tropical cyclones, are becoming more frequent and intense. These natural calamities pose significant threats to human life, infrastructure and the environment. However, advancements in technology, especially in the field of Earth observation through satellites, has become a crucial tool in mitigating the impact of such disasters.

Case study: India[27]

Earth observation is an innovative tool that leverages satellite technology to monitor the Earth's atmosphere and weather patterns. This technology plays a pivotal role in managing climate-related risks by providing accurate data on weather conditions, such as rainfall, wind speed and storm formation. Earth observation satellites allow for the continuous monitoring of the Earth's surface and weather movements, which helps create early-warning systems and accurate weather forecasts, enabling authorities to take the necessary precautions before calamity strikes. The ability to predict and monitor cyclones and other geo-hazards using Earth observation has become indispensable in managing the risks associated with climate change.

India is collaborating with various agencies to mitigate the impact of cyclones through advanced Earth observation technologies. ISRO and NASA satellites track and monitor cyclone developments to provide early warnings. The India Meteorological Department plays a central role in forecasting and issuing timely alerts. Collaborative efforts with international bodies and WMO enhance disaster preparedness and response strategies.

India is also using satellites from NASA and the National Oceanic and Atmospheric Administration of the United States to provide essential data and live details on the trajectory and intensity of storms/cyclones using infrared imaging.

In addition to Earth observation, the Department of Telecommunications of India plays a key role in maintaining communication during the cyclones. Indian telecommunication providers like Bharti Airtel, Jio and BSNL coordinate to ensure continuous service by stocking alternative power sources and deploying mobile towers as part of the response. War rooms are established to address service disruptions and ensure service is quickly restored, in a further demonstration of the value of Earth observation and ICT in disaster management. The timely use of satellite data and communication systems minimizes loss of life and infrastructure damage, underscoring the importance of these technologies in managing natural disasters.

Case study: Group on Earth Observations

In addition to the Earth observation work being conducted by various agencies, the work of GEO work is commendable as the Group fosters strategic partnerships that develop scientific

[26] ITU-D SG2 Document 2/236 from India.
[27] ITU-D SG2 Document SG2RGQ/21 (Rev.1) from India.

solutions to support national and international policies. GEO promotes collaborations between public and private satellite data providers and governments to enhance Earth observation data collection and accessibility. The Group also helps low- and middle-income countries by offering free licences and grants from leading cloud service and geospatial companies. Public-private partnerships have become an increasingly important component of GEO work as the Group marks two decades of progress.

Additionally, GEO is co-developing the Global Ecosystems Atlas,[28] an open online resource designed to monitor and report on the condition and changes in ecosystems worldwide. This tool aims to prompt urgent action to protect biodiversity and encourage nature-based solutions in the fight against climate change by providing an accessible platform for understanding and addressing global environmental challenges. It will help reduce the challenges faced by emerging economies in bridging the digital divide and assessing the impact of climate change.

Earth observation is crucial for addressing global challenges like climate change and biodiversity loss. By promoting open access to data and fostering collaborations, it supports sustainable development and informed decision-making. Initiatives like the Global Ecosystems Atlas offer valuable tools to monitor ecosystems and drive action on environmental issues. As Earth observation continues to evolve, its role in tackling global environmental challenges remains essential for creating a more sustainable future.

3.3 Challenges faced by emerging economies in combating the harmful effects of climate change

The digital divide, which restricts access to valuable technological solutions for climate action, presents emerging economies with formidable obstacles in their fight against the negative impacts of climate change. According to the United Nations Development Programme (UNDP),[29] the digital revolution represents both our biggest chance to accelerate development and our biggest risk of leaving people behind. Even though digital solutions can help achieve 70 per cent of SDG targets, 2.6 billion people remained offline in 2023, primarily in low-income nations.

Additionally, as the use of digital products and services increases, so too does the amount of energy, materials and water used, greenhouse gases (GHGs) emitted and e-waste generated, according to ITU.[30] Growing digitalization necessitates more energy, which raises greenhouse gas emissions. The difficulty in acquiring exact data on how much GHG the ICT sector is responsible for emitting, with estimates ranging from 1.5 to 4 per cent of global carbon emissions, has hampered policy-making and mitigation efforts.

Enabling emerging economies to counteract the negative impacts of climate change requires closing the digital divide. These countries face challenges as they seek to adopt sustainable practices, enhance their readiness for disasters and create adaptive strategies, as they lack fair access to digital resources, making them more susceptible to the effects of global warming.

Emerging economies face challenges in leveraging Earth observations, such as satellite imagery and sensor data, to address climate change impacts. While these observations are essential for monitoring environmental changes like GHG emissions, deforestation and wildfires, issues

28 Sara Venturini. Group on Earth Observations (GEO). GEO for climate action. ITU-D Workshop on green ICT and emerging technologies towards climate change mitigation, Geneva, 29 May 2023.
29 https://www.undp.org/blog/undp-core-funding-powering-sustainable-development-where-it-matters-most
30 https://www.itu.int/en/mediacentre/backgrounders/Pages/climate-change.aspx

like fragmented data and limited access hinder their effective use. Despite the technological advances made, the difficulty in accessing high-resolution data and translating it into actionable solutions remains a significant barrier, especially for the countries most affected by the digital divide.

Emerging economies need open access to Earth observation data. Advocating for more open data, open software, open standards and open science (see Figure 2) to bridge the digital divide with open knowledge, will help foster collaboration between public and private satellite data providers, governments, and leading cloud service and geospatial companies to improve data collection and accessibility. For example, GEO assists low- and middle-income countries with free licences and grants to enhance their capacity to utilize Earth observation data.

Figure 2: Open access to Earth observation data to bridge the digital divide

Source: GEO[31]

3.4 Incorporating "green" in national ICT policy

3.4.1 Urgent need for green ICT policies

The rapid advancement of ICT has significantly transformed economies and societies worldwide, yet it has also contributed substantially to GHG emissions and environmental degradation. As the global community confronts the urgent challenges posed by climate change, it is imperative to incorporate green principles into national ICT policies.

The ICT sector, while a driver of economic growth and innovation, is also a substantial contributor to global emissions. According to the World Bank Green Digital Transformation report,[32] direct GHG emissions of the sector are significant, and as digitalization accelerates, these emissions are expected to rise unless proactive measures are taken.

ITU plays a significant role in the global effort to minimize the environmental impact of the ICT sector. In collaboration with the World Benchmarking Alliance, ITU tracks GHG emissions, energy consumption and climate commitments of major tech companies. The 2024 Greening Digital Companies report[33] outlines good practices for achieving net-zero emissions and reducing environmental footprints, encouraging companies to adopt strategies that align with sustainable practices. This initiative is in line with the ITU overarching goal of promoting sustainable digital transformation. ITU also contributes to global climate action by developing tools to track GHG

31 Sara Venturini. Group on Earth Observations (GEO). GEO for climate action. ITU-D Workshop on green ICT and emerging technologies towards climate change mitigation, Geneva, 29 May 2023.

32 World bank (2024). Green Digital Transformation: How to Sustainably Close the Digital Divide and Harness Digital Tools for Climate Action.

33 ITU. Greening Digital Companies Report 2024.

emissions within the ICT sector, including a joint project with the World Bank to create a global emissions database for the ICT industry, aiding countries in their net-zero efforts.[34]

Despite the rapid digitalization taking place in some countries, many others lack the capacity to accurately report emissions from the ICT sector. To address these challenges, national ICT policies should establish clear goals for accurately measuring GHG emissions generated by the digital transition and aim to reduce or minimize the growth of these emissions as much as possible.

Case study: ARCEP (France)[35]

ARCEP, the French Electronic Communications Regulatory Authority, has overseen the economic regulation of network infrastructures since 1997. Recognizing the potential of digitalization to reduce carbon emissions across industries, a concept it calls IT for Green, ARCEP began addressing environmental concerns around 2019-2020, spurred by the rapid growth in data volumes, network capacities and device turnover, and low recycling rates. Public awareness, particularly around technologies like 5G, also contributed to this shift.

In response, ARCEP launched initiatives to assess and mitigate the environmental footprint of the digital sector. This included collecting environmental data from telecommunication operators and conducting annual "Achieving Digital Sustainability" surveys. By using robust and transparent methodologies, the data collected by ARCEP from digital sector players serves several key objectives. It improves the measurement of environmental impacts, which in turn informs policy-makers and supports the development of appropriate regulations. It also encourages businesses to adopt more sustainable practices and provides tools to empower users and the general public. ARCEP also conducted a government-mandated study to evaluate the environmental impact of digital technologies in France, with projections for 2020, 2030 and 2050.

Case study: India

India, with its emerging economy, is aiming to achieve net-zero emissions by 2070, and has made notable progress in climate action. The country has implemented aggressive renewable energy policies and energy efficiency programmes that are on track to meet their 2030 emissions targets. India is also advancing green ICT practices, such as the sharing of telecommunication towers to optimize resources and the use of renewable energy by mobile towers. The country continues to invest in renewable technology R&D, promote green energy equipment and explore alternatives like hydrogen-based fuel cells and bio-diesel generators. Improving power availability at telecommunication sites and reducing diesel consumption will be crucial for the long-term sustainability of the telecommunication sector.

Furthermore, eco-friendly production has been encouraged by the Department of Telecommunications of India. A green passport lab has been established to standardize the testing and certification of telecommunication equipment for green passports. The lab will test energy efficiency for gigabit passive optical networks, gigabit ethernet passive optical networks, IP routers, edge routers and other telecommunication equipment.

---

34 ITU-D SG2 Document SG2RGQ/185 from ITU BDT.

35 Anne Yvrande Billon. ARCEP, France. Measuring the environmental impact of the digital ecosystem: a new chapter of ARCEP regulation. ITU-D Workshop on circular economy considerations and new technologies for combatting climate change, Geneva, 6 May 2024.

3.4.2 Incorporating green principles into national ICT policies

Incorporating green principles into national ICT policies is not merely an environmental imperative: it is also a strategic opportunity for countries to enhance their resilience against climate change. By aligning digital transformation with sustainability goals, nations can foster economic growth while minimizing environmental harm. Furthermore, the transition to green ICT can stimulate job creation in emerging sectors focused on sustainability and innovation. As countries invest in green technologies, they can develop new markets and industries that contribute to economic diversification. This is particularly relevant in the context of the COVID-19 pandemic, during which the need for resilient and inclusive recovery strategies became paramount.

Building on this momentum**,** it is essential to take concrete steps to ensure the successful integration of green principles into national ICT policies. Almost all countries around the world have national IT policies and strategies. These strategies balance economic growth, promotion of ICTs, digital inclusion and environmental sustainability.

Integrating green principles into national ICT policies can help address the challenges of rapid digitalization and climate change. While the ICT sector drives economic growth, it also significantly contributes to global GHG emissions. Countries can set clear goals for measuring and reducing these emissions, as illustrated by the good practices of India, ARCEP in France, and the Republic of Korea, with its green IT initiatives. These examples also highlight the importance of robust methodologies and public-private sector engagement.

Incorporating sustainability into ICT policies not only addresses environmental concerns but also can present strategic opportunities for economic diversification and job creation in green sectors.

Concrete strategies for the deep integration of green principles into national ICT policies:

1) **Policy coherence and integration**: telecommunication/ICT considerations should be integrated into climate policies and vice versa, as this dual approach is essential for greening the ICT sector and enhancing climate action capabilities.
2) **Strategic frameworks**: strategic frameworks should be developed that explicitly link telecommunications/ICTs with climate action. For instance, in the Republic of Korea, the New Deal is cited as a successful example of leveraging digital technologies for climate initiatives while addressing climate action within the ICT sector.
3) **Regulatory measures**: regulatory or non-regulatory measures should be established to reduce the environmental footprint of ICT infrastructure, such as data centres and communication networks. This can include setting energy efficiency criteria and promoting green certifications.
4) **Cross-sector collaboration**: close cooperation should be fostered between different policy areas, including energy, utilities and industry, to promote integrated approaches to policy-making. This collaboration is crucial for enhancing the effectiveness of digital and green transitions.
5) **Innovation and standards**: research, standards and innovation should be improved in the ICT sector in order to better understand its links with climate change. Stronger methodologies and country-level capacities are essential for accurate emissions reporting and the establishment of internationally recognized standards.
6) **Stakeholder engagement**: both the public and private sectors, civil society and consumer groups should be involved in the development and implementation of green ICT policies to promote voluntary initiatives and encourage commitments to sustainability goals.

Case study: green IT initiatives of the Republic of Korea[36]

Since the introduction of its Green IT National strategy in 2009, the Government of the Republic of Korea has implemented numerous initiatives to promote sustainability within the ICT sector. These efforts include launching a green certification programme in 2010, setting standards for green data centres in 2012, and funding various government-sponsored R&D projects focused on eco-friendly data centres and communication network technologies. In May 2017, green ICT policies were integrated into a broader long-term strategy, reinforced by a strong political commitment (2050 carbon neutral strategy), major infrastructure investments (the Korean New Deal), cutting-edge technology R&D (carbon neutral tech innovation strategy) and a comprehensive legal framework to ensure the success of these green initiatives (carbon neutrality act). While the Government leads by using regulatory and economic tools to decarbonize the ICT sector, private companies are also playing a key role by voluntarily adopting sustainability measures to support the national greening efforts.

By supporting telecommunications/ICTs that are mindful of their environmental impact and sustainability, nations can enhance resilience against climate change and foster inclusive recovery strategies. Ultimately, aligning digital transformation with sustainability goals is crucial for ensuring that the benefits of ICT advancements do not harm the environment, thereby paving the way for a greener, more sustainable future.

3.5 Incorporating ICTs into national climate commitments

Climate change represents one of the most pressing challenges of our time, necessitating urgent and innovative responses from nations worldwide. As countries strive to meet their climate commitments under international agreements such as the Paris Agreement, there is a critical need to enhance the effectiveness, transparency and accountability of these efforts. In this regard, incorporating telecommunications/ICTs into national climate strategies is essential for achieving ambitious climate goals and ensuring a sustainable future.

The current landscape of national climate commitments reveals significant challenges that hinder progress. Many countries face insufficient data, monitoring difficulties and a lack of available innovative solutions tailored to their specific contexts. These limitations not only impede the ability of governments to effectively track progress but also restrict their capacity to implement necessary interventions in a timely manner.

Fortunately, telecommunications/ICTs, such as IoT and Earth observation satellites, offer the transformative potential to address these challenges. By improving data collection and informing decision-making processes, telecommunications/ICTs can significantly bolster climate action and drive systemic change.

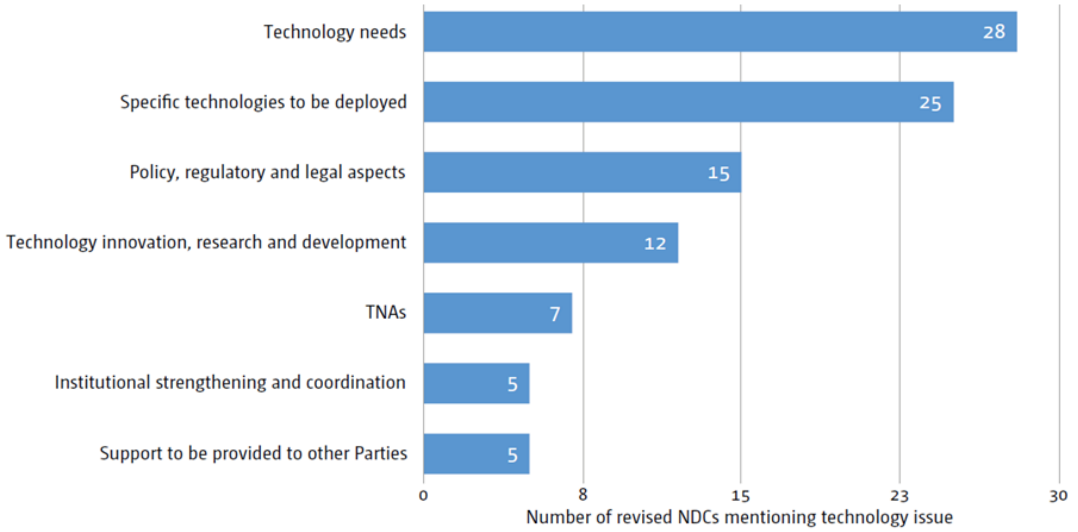
The Green Technology Book (Mitigation Edition) of the World Intellectual Property Organization (WIPO) showcases how telecommunications/ICTs have been effectively integrated into climate mitigation efforts across various sectors, including the agricultural, forestry and manufacturing industries, demonstrating that digital technology has become an important core technology of green technology. It makes multiple references to digitalization, robotics, AI, ICT, and ML

[36] World bank (2024). Green Digital Transformation: How to Sustainably Close the Digital Divide and Harness Digital Tools for Climate Action, 66 Box 2.4.

further show that telecommunications/ICTs play an important role, not just in their own right, but in broader applications.[37]

Telecommunications/ICTs, either on their own or in combination with other technologies, are also helping countries achieve their nationally determined contributions (NDCs). According to the United Nations Framework Convention on Climate Change (UNFCCC) report on technology and nationally determined contributions, 90 per cent of NDCs contain information about technology, despite the absence of any such requirement in the Paris Agreement or the decisions of its associated Conference of the Parties (COP).[38]

Figure 3: Aspects of technology referred to in the nationally determined contributions



Source: UNFCCC[39]

Information on technology in NDCs is focused on the following aspects, as shown in the figure above: overall technology needs (28 Parties); specific technologies to be deployed (25); policy, regulatory and legal aspects (15); technology innovation and R&D (12); technology needs assessments (TNAs) (7); institutional strengthening and coordination (5); and support to be provided to other Parties for technology development and transfer (5). As such, it can be seen that technologies, including digital technologies, are already considered relevant and important factors for achieving NDCs. Therefore, policy-makers should establish the policies and efficient governance necessary for the broader application of these technologies.

As nations increasingly turn to telecommunications/ICTs as a means to enhance their climate commitments, particularly in the context of NDCs, the WIPO Green Technology Book demonstrates the critical role that technology and innovation play in addressing climate challenges. A significant portion of the solutions needed to halve global GHG emissions by 2030 are already available. Thus, it is essential for policy-makers to implement ICT strategies that can be effectively integrated into national climate commitments to drive meaningful progress towards achieving NDCs. These policies and political efforts will bring about rapid effects as

[37] Shanar Tabrizi. (2024). The role of emerging digital technologies for climate change mitigation and adaptation, ITU-D SG2 Q6/2 Workshop, May 6, 2024, 4-9.

[38] UNFCCC. (2021). Technology and nationally determined contributions: stimulating the uptake of technologies in support of nationally determined contribution implementation, 8.

[39] *Ibid*.

telecommunications/ICTs become more widely available at the national and international level, in both the public and private sectors.

Telecommunications/ICTs offer a transformative potential for enhancing the efficiency and effectiveness of climate action. They improve the collection, analysis and dissemination of data, which are essential for informed decision-making. For instance, telecommunications/ICTs, through IoT, can facilitate the real-time monitoring of emissions, resource usage and environmental impacts, allowing governments to track progress against their NDCs more accurately. By leveraging big data and analytics, countries can identify trends, assess the effectiveness of their climate policies and make the necessary adjustments to ensure that targets are met.

Moreover, telecommunications/ICTs can enhance public engagement and participation in climate action. Social media, mobile applications and online platforms can be used to raise awareness about climate issues, promote sustainable practices and encourage citizen involvement in climate initiatives. By fostering a culture of sustainability and collective responsibility, nations can mobilize communities to contribute to their climate goals, thereby amplifying the impact of their NDCs.

The integration of ICT strategies also supports the development of innovative solutions that can address specific climate challenges. For example, telecommunications/ICTs can facilitate the transition to renewable energy sources by optimizing energy management systems and enabling smart grids. These advancements not only enhance energy efficiency, but also reduce reliance on fossil fuels, aligning with the overarching goals of many NDCs. Furthermore, telecommunications/ICTs can support sustainable agricultural practices through precision farming, which minimizes resource use while maximizing yield, thus contributing to food security and climate resilience.

However, the successful incorporation of ICT strategies into national climate commitments requires a robust framework that addresses potential barriers. This includes investing in telecommunication infrastructure, ensuring equitable access to technology and fostering collaboration between governments, private sector actors and civil society. Additionally, capacity building is essential for equipping stakeholders with the skills needed to leverage these tools effectively. By creating an enabling environment for innovation, countries can unlock the full potential of telecommunications/ICTs in achieving their climate objectives.

Chapter 4 – Comparative guidelines to mitigate the impacts of climate change

The twin transition of the digital and sustainability transformations presents a pivotal opportunity to reshape the world. Both transformations can help achieve the SDGs and amplify each other's potential through positive collaborations. This extends to the way we address climate change, biodiversity loss and pollution. The challenge lies in catalysing these two transitions together: policy-makers should consider how telecommunications/ICTs can further sustainability objectives and how sustainability can be enabled through telecommunications/ICTs. UNEA historic decision to adopt digital transformation as a key area of work for UNEP (2022-2025) emphasized the role of telecommunications/ICTs in tackling global environmental crises.

The push towards sustainable digital transformation focuses on minimizing the environmental risks of telecommunications/ICTs. These technologies currently consume 3 per cent of global energy, produce 2 to 4 per cent of global greenhouse gas emissions, and require significant amounts of rare metals, such as lithium and cobalt, demand for which is expected to rise by 500 per cent by 2050.[40] However, telecommunications/ICTs also have the potential to enable sustainability by providing solutions to environmental challenges. For example, some platforms help monitor global air quality and the Methane Alert and Response System[41] uses satellite data to track methane emissions, offering real-time, actionable data for mitigation.

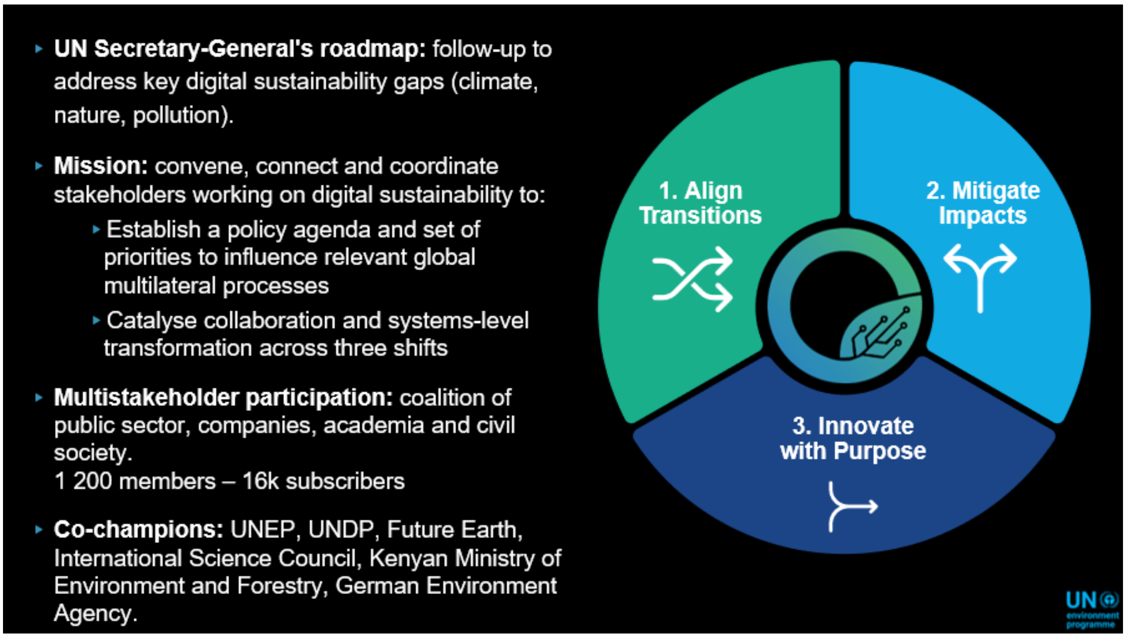
Moreover, telecommunications/ICTs enable transparency and circularity in supply chains, as seen with the digital product passport, which tracks product information to support recycling and waste reduction. Technologies also empower consumers to make sustainable choices, as demonstrated by initiatives in e-commerce and the Playing for the Planet Alliance, where video games promote sustainability. Telecommunications/ICTs also help optimize resource use, as seen with the Sparrow air quality sensors providing real-time data.

National strategies should explicitly address environmental and climate goals, leverage data to support sustainable development and develop green ICT infrastructure to collect and analyse environmental data. Governments and international organizations have opportunities to advance these goals through frameworks like the Global Digital Compact and initiatives like the Coalition for Digital Environmental Sustainability (CODES), which is facilitating collective action in digital sustainability.

[40] David Jensen. UNEP. The twin transition: digital technologies for climate mitigation. ITU-D Workshop on green ICT and emerging technologies towards climate change mitigation, Geneva, 29 May 2023.

[41] https://www.unep.org/topics/energy/methane/international-methane-emissions-observatory/methane-alert-and-response-system

Figure 4: Coalition for Digital Environmental Sustainability



Source: UNEP[42]

In conclusion, the digital and sustainability transformations can work in tandem as a twin transition.[43] Telecommunications/ICTs offer significant potential for environmental monitoring, transparency and decision-making, but their own environmental impact must be addressed. By aligning digital transformation with sustainability goals, we can work towards a more resilient, equitable and sustainable future, supported by robust international collaborations and the sharing of good practices with regard to green ICT policies.

4.1 Policies and guidelines

The application of telecommunications/ICTs across various sectors has brought considerable advances in efficiency and decision-making capabilities. However, these benefits come with a significant environmental cost, particularly in terms of energy consumption. AI systems, especially during the training phase of large models, are known for their high electricity usage, which contributes to CO_2 emissions. The design of chips, cooling systems, data centre architecture, software efficiency, and the sources of electricity generation all influence this energy footprint. Notably, the process of applying trained AI models to new data can account for up to 90 per cent of total energy costs. Policy-makers should also explore the potential of using telecommunications/ICTs and the digital transformation enabled by them to help decarbonize government operations.

Telecommunications/ICTs hold transformative potential for climate change mitigation, offering solutions for optimizing renewable energy integration, grid management, and energy asset maintenance. They can also enhance climate change adaptation through improved early-warning systems, infrastructure resilience and water resource management. Despite its benefits, the telecommunication sector environmental impact must be considered

[42] David Jensen. UNEP. The twin transition: digital technologies for climate mitigation. ITU-D Workshop on green ICT and emerging technologies towards climate change mitigation, Geneva, 29 May 2023.
[43] *Ibid.*

in policy-making, with clear guidelines for balancing energy consumption and sustainability concerns. Governments and international organizations should invest in the development of energy-efficient telecommunications/ICTs to combat climate change. They must also promote international collaboration to share good practices and case studies on the environmental impacts of telecommunications/ICTs.

The telecommunication sector has begun adopting AI solutions to reduce energy consumption and meet climate goals. For example, T-Mobile aims to achieve a net-zero carbon footprint by 2040, focusing on optimizing network energy usage and decommissioning inefficient cell sites. Similarly, Sunrise in Switzerland has implemented AI-driven energy management software, resulting in a 10 per cent reduction in energy consumption. Policies and guidelines should encourage telecommunication companies to adopt energy-efficient technologies and align with national and international climate goals.

Clear policies and regulations can help mitigate the environmental impact of the telecommunication/ICT sector.[44] Governments should encourage the use of renewable energy sources for telecommunication/ICT operations, support energy transparency principles and establish frameworks for monitoring the energy consumption of telecommunication/ICT networks, including their use of AI. They should also promote public-private partnerships to drive innovation in solutions for climate action and ensure that these telecommunications/ICTs are sustainable, accessible to all and beneficial for all nations. To ensure that telecommunications/ICTs contribute positively to environmental sustainability, it is valuable to establish and implement comprehensive policies and standards[45] that address the environmental impact of these systems. By focusing on monitoring standardization, raising awareness, developing a clearer understanding of the environmental impact of telecommunications/ICTs and improving access to environmental data, these policy solutions will enable the development of more sustainable networks and services. A collaborative approach involving stakeholders from government, industry, civil society and academia, will be key to achieving these goals and fostering a future where telecommunications/ICTs enhance environmental sustainability and global resilience to climate change.

4.2 Formulating guidelines on climate change assessment and mitigation

The rapid growth of telecommunications/ICTs has contributed to carbon emissions and resource consumption, heightening the urgency of climate change mitigation strategies for the sector. As connectivity expands, the growth of the environmental footprint of telecommunication networks, data centres and electronic devices has become a key concern. In France, ARCEP has been at the forefront of the response to this issue, initiating efforts in 2019-2020 to assess and reduce the environmental impact of digital services. By collecting environmental data from telecommunication operators and other digital stakeholders, ARCEP aims to inform decision-makers and promote sustainable practices. This initiative is part of the broader goal of achieving digital sustainability and aligns with France's commitment to reducing its carbon footprint and energy consumption.

[44] ITU-D SG2 Document SG2RGQ/195 from the Republic of Korea.
[45] https://www.itu.int/initiatives/green-digital-action/impact/green-computing/

Since 2019, ARCEP[46] has been addressing the environmental footprint of telecommunications/ICTs, focusing on their carbon emissions and resource consumption. Its Achieving Digital Sustainability initiative began by collecting data from telecommunication operators to assess the environmental impact of their services. In 2021, ARCEP expanded its mandate to include mobile equipment manufacturers and data centres, publishing annual surveys on energy consumption and greenhouse gas emissions. For instance, in 2022, telecommunication networks consumed 4.1 TWh of electricity, with emissions equivalent to 382 000 Mt of CO_2. In 2020, the telecommunication/ICT sector accounted for 10 per cent of France's electricity consumption and 2.5 per cent of its carbon footprint. To address this, the French Government introduced a law in 2021 on reducing the environmental footprint of the digital sector, known as the REEN Law, as part of a broader roadmap to reduce the sector environmental impact. ARCEP efforts illustrate the value of clear policies, collaboration, and sustainable practices to promote sustainability within the telecommunication/ICT sector.

The expansion of data collection to include mobile equipment manufacturers, data centres and telecommunication operators will provide a comprehensive picture of the sector environmental footprint. By promoting collaboration and encouraging sustainable practices across the ICT ecosystem, ARCEP initiatives play a crucial role in shaping a greener, more sustainable digital future.

Energy transparency standards are being developed to ensure digital technologies, such as AI, contribute to climate mitigation in an environmentally transparent manner. Governments should encourage public-private partnerships to foster innovative solutions and sustainable practices while preventing digital technologies from worsening environmental challenges.[47]

The development of telecommunications/ICTs and their integration into climate policies plays a crucial role in driving climate change mitigation. International collaboration and a multi-stakeholder approach will be essential to achieving sustainable ICT solutions and ensuring these technologies contribute to a low-carbon economy.

4.3 Role of emerging technologies and applications for climate change adaptation and mitigation

Climate change impacts are undeniable, particularly in emerging economies, many of which are prone to frequent tropical cyclones. Emerging ICTs, such as Earth observation, remote sensing, and IoT, play a critical role in addressing climate change through both adaptation and mitigation efforts. These technologies offer innovative solutions for monitoring, predicting and responding to environmental challenges. Additionally, digital twins – virtual replicas of real-world systems – are transforming environmental monitoring, enabling predictive analysis that can be based on real-time data collection. While telecommunications/ICTs can improve efficiency across industries, its energy consumption and environmental impact require attention to ensure sustainable practices.

[46] Anne Yvrande Billon. ARCEP, France. Measuring the environmental impact of the digital ecosystem: a new chapter of ARCEP regulation. ITU-D Workshop on circular economy considerations and new technologies for combatting climate change, Geneva, 6 May 2024.

[47] David Jensen. UNEP. The twin transition: digital technologies for climate mitigation. ITU-D Workshop on green ICT and emerging technologies towards climate change mitigation, Geneva, 29 May 2023.

India is among the countries that are particularly susceptible to cyclones, due to its geographical location. Taking a proactive approach and using Earth observation technologies to improve forecast accuracy and early warnings has made it possible to significantly reduce the impact of cyclones, saving lives, protecting infrastructure and minimizing the impact on the economy.

Earth observation technologies,[48] including satellites, provide real-time data on weather patterns, enabling accurate cyclone predictions and early-warning systems. For example, during Cyclone Tauktae in 2021, Earth observation satellites from ISRO and NASA tracked it's development, allowing authorities to forecast wind speeds and issue timely warnings. This early alert system, coupled with effective communication, facilitated evacuations and minimized casualties. The Department of Telecommunications of India and telecommunication operators play a crucial role in maintaining communication networks during such cyclones.

Telecommunications/ICTs help collect vast datasets to optimize energy use, predict climate events and inform policies, driving efficiency in sectors like agriculture, transportation and energy. Earth observation systems using satellites and sensors provide real-time data on weather patterns, deforestation and natural disasters, enabling better mitigation strategies.[49] Big data complements these technologies through the analysis of large amounts of environmental information to predict events like cyclones and floods, and track trends in global warming. Together, these technologies offer a more comprehensive understanding of climate change, improving decision-making and disaster preparedness.

In the Russian Federation, the Digital Ob-Irtysh Basin project[50] exemplifies the use of digital twins for water conservation and ecosystem management. Initiated in 2019, the project focuses on the Ob-Irtysh river basin, one of the most industrially impacted water bodies in the country. The digital twin integrates multimodal data from satellite imagery, unmanned aerial vehicles and on-site measurements to monitor water quality, pollution levels and ecosystem health in real time, facilitating timely interventions and accountability for environmental violations. The project, supported by various regions and stakeholders, serves as a model for broader ecological management strategies.

GEO fosters partnerships across the public and private sector to enable real-time data sharing, monitoring and forecasting. By utilizing satellite sensors and geospatial data platforms, GEO helps enhance climate resilience and improves understanding of environmental changes. Key projects[51] like the Global Ecosystems Atlas provide critical insights into ecosystem shifts, supporting nature-based solutions for climate mitigation. GEO collaboration with low- and middle-income countries ensures equitable access to advanced technologies, helping all regions contribute to climate change mitigation and resilience.

[48] ITU-D SG2 Document SG2RGQ/21 (Rev.1) from India.
[49] ITU-D SG2 Document SG2RGQ/27 from Haiti.
[50] ITU-D SG2 Document SG2RGQ/171 from the Russian Federation.
[51] Sara Venturini. Group on Earth Observations (GEO). GEO for climate action. ITU-D Workshop on green ICT and emerging technologies towards climate change mitigation, Geneva, 29 May 2023.

The integration of telecommunications/ICTs, Earth observation and IoT enables strategies such as digital twins and advanced analytics, and is pivotal in addressing climate change. These technologies enable smarter decision-making, enhanced forecasting and more effective resource management. The success of the Digital Ob-Irtysh Basin project demonstrates the usefulness of digital twins for climate change mitigation and ecosystem restoration. Telecommunications/ICTs, however, must be utilized sustainably and investments must be made in energy-efficient solutions and renewable energy. Public-private partnerships will be critical in driving innovation globally and ensuring that telecommunications/ICTs support climate action, especially in developing countries. Initiatives like GEO further enable real-time monitoring and resilience efforts worldwide.

Chapter 5 – Challenges of e-waste

Connectivity and ICT services contribute to growth, productivity, employment, equity, and poverty reduction. However, the proliferation of these technologies has led to an explosion of e-waste affecting human health and the environment, with social and economic impacts.

That has created a pressing need to protect the environment, conserve increasingly scarce raw materials and promote the circular economy and a system for the reuse of manufactured products at the end of their lifecycle. The role of policy in this domain is give top-level guidelines on the definition, recognition and treatment of WEEE, while management tools focus on e-waste collection, sorting, separate processing, and recovery of valuable waste fractions.

5.1 Overview of regional needs for e-waste management

Management of WEEE has proven to be a challenge in many developing economies, especially in Africa. To aid in the coordination of efforts to combat the destructive effects of WEEE, countries such as Burundi and Kenya are in the process of developing national policies for e-waste management. The national policies inform the implementation of WEEE management tools that make it possible to recycle WEEE constituent materials, a potential source of revenue in the circular economy. For its part, ITU has provided technical and financial assistance, supporting Burundi in developing a national policy document for WEEE management.

In many emerging economies and developing countries, WEEE management is essentially left to the informal sector, which lacks the material, human and financial resources that the task requires. The predominance of the informal sector over the formal sector is reflected in the statistics on the e-waste problem.

5.2 Raising awareness for sustainability[52]

Overall, the level of awareness about WEEE could be higher and there are not enough appropriate disposal options to meet current or future needs. Moreover, the gap between awareness and actual action and implementation remains huge, as many high-income countries have experienced. Given the limited options for WEEE disposal and the ecological footprint of production, there is momentum to promote the extended use of EEE products with repair and refurbishment. However, environmentally sound recycling practices are scarce, and hampered by low collection rates and limited recycling infrastructure in many parts of the world. To address this, greater investment in infrastructure development, greater promotion of repair and reuse, capacity building, and measures to stop illegal movement of WEEE are crucial.

North African countries suffer a persistent lack of awareness of the importance of collecting and recycling WEEE, although some mobile network operators and WEEE treatment facilities are implementing awareness-raising initiatives. In Tunisia, a WEEE treatment facility, Collectun D3E Recyclage, partnered with the German Agency for International Cooperation (GIZ) for an advocacy campaign that motivated more than 30 companies to hand over WEEE for recycling. In Egypt, some operators have designated several branches as WEEE collection points and the Ministry of the Environment is supporting the construction of WEEE treatment facilities to high

[52] UNITAR, ITU and Fondation Carmignac. The Global E-waste Monitor 2024.

environmental and technological standards. Throughout the region, open markets for collected WEEE provide a stream of materials for recycling.

A WEEE collection and sorting centre has recently opened in Soukra, Tunisia. A WEEE treatment facility is being set up with the help of the Korea International Cooperation Agency, which supports projects to improve WEEE management in low-income countries. The facility will handle some of the WEEE that is currently not being recycled, such as coolers, polyurethane foam, freon and other chlorofluorocarbons/hydrofluorocarbons, and screens containing cathode-ray tubes. Given the shortage of WEEE treatment facilities in the region, a more coordinated approach could facilitate the movement of materials across borders to locations where the environmentally sound management of WEEE can be guaranteed.

In West Africa, Ghana, Nigeria and Côte d'Ivoire have enacted specific legislation on WEEE management. Both the National Environmental (Electrical and Electronic Sector) Regulations (2022) in Nigeria and the Hazardous and Electronic Waste Control Act (917) (2016) in Ghana underscore the principle of extended producer responsibility (EPR), but there is little information on how EPR systems operate and perform, and it is therefore unclear to what extent the principle is being enforced.

In Ghana, all EEE producers pay an eco-levy to the Ghana Revenue Authority, according to their market share. The funds thus raised are allocated to the Environmental Protection Agency of Ghana, which is responsible for setting up a dedicated WEEE recycling facility. Ten WEEE management companies in 2020 established an association called the Electronic Waste Round Table Association under the Electronic Waste Control Act.

The German Development Bank is funding the construction of a dedicated centre for the purchase of WEEE from informal collectors and private individuals and the establishment of a sustainable national WEEE recycling system.

In Nigeria, the EPR system is led by the private sector, operationalized by the E-waste Producer Responsibility Organisation Nigeria (EPRON) and regulated by the Government. EPRON maintains a registry to determine the market share of EEE producers and on that basis then collects an EPR fee that it allocates to collection and recycling, awareness-raising, research, standards development and its own administrative functions.

Progress is being made in other West African countries, too. In the Republic of Senegal, plans were announced in 2022 to set up a regulatory framework for WEEE management but are currently facing delays. Pending the entry into force of the legislation, awareness raising, collection and pre-treatment activities continue, supported by the telecommunication regulatory authority. The Republic of the Niger and the Republic of Gambia are in the process of preparing and approving national WEEE management strategies. Neither country currently has an official WEEE management system or an adequate regulatory framework or collection network. Although WEEE generation in countries like Niger is not at the levels seen in Nigeria and Ghana, there is the possibility that Niger will experience an increase in the near future as a result of digitalization.

Other initiatives in West Africa have been driving the formal collection of WEEE; for example, by training informal sector workers and arranging for donations of personal protective equipment. Mobile phone repair has emerged as a highly marketable opportunity for technical employment, and some countries in the region have established training centres to this end. For example, in

Côte d'Ivoire, a project launched in 2020 in Abidjan called Create Lab has been teaching the public how to repair, reuse and recycle WEEE in their communities.

5.3 Environmental and health consequences of ignoring e-waste as a hazardous substance[53]

WEEE management remains a cause for concern and requires urgent attention and action: since 2010, the volume of WEEE has grown five times as fast as it can be collected and properly recycled . Despite this, there is room for optimism if developing countries take action to establish WEEE management infrastructure and regulate its management.

At the global level, a progressive scenario envisages an increase in the worldwide collection and recycling rate to 38 per cent by 2030; economic assessment suggests that this would bring net zero within reach. This could be realized if high-income countries with WEEE management infrastructure and legislation attain collection rates of 85 per cent by 2030 (the target set in European Union (EU) legislation on e-waste) and if developing countries take action to collect and manage WEEE in an environmentally sound manner at a rate of 10 per cent.

In an aspirational scenario, the global collection and recycling rate would increase to 60 per cent by 2030. The overall economic assessment indicates that the benefits would then be greater than the costs and amount to over USD 38 billion, thanks to lower externalized costs for the population and the environment, positive monetized contributions to combat global warming, and the value of resources recovered. In this scenario, all countries with WEEE management infrastructure boost their collection rates to 85 per cent (the EU targets); upper-middle-income and high-income countries with no formal WEEE management infrastructure start to divert WEEE from landfills; low- and lower-middle-income countries improve the working conditions of the informal sector with a view to collecting and managing 40 per cent of their WEEE in an environmentally sound manner; and further collaborative efforts between low-income and high-income countries leads to increased treatment of imported WEEE.

Uncontrolled disposal of WEEE has a direct impact on the environment and people's health. A particular source of concern are the estimated 58 thousand kg of mercury and 45 million kg of plastics containing brominated flame retardants that are released into the environment every year as a result.

Flame retardants and other toxic and persistent substances are used in appliances and in EEE containing plastics. There are currently 17 billion kg of WEEE plastics being generated annually. Of that, 59 million kg contain flame retardants, an estimated 45 million kg of which are not correctly managed. Most flame retardants (80 percent) are found in screens and monitors, but they are also found in computer chassis, printed wiring boards, connectors, relays, wires and cables. The recycling of plastic containing brominated flame retardants represents a major challenge because of the cost of separating them from other plastics. International studies of the emissions caused by uncontrolled incineration of various materials, including hazardous materials, highlight the health risks of inhaling the heavy metals (e.g. lead, cadmium, chromium and copper) and brominated flame retardants contained in plastic e-waste.

A recent study revealed a high risk of harm to 11 million informal entrepreneurs in low- and middle-income countries, who work directly with waste, and to the local communities.

[53] *Ibid*.

The recycling of temperature exchange equipment also contributes to climate change and the depletion of the ozone layer. These environmentally harmful effects are due in part to some of the refrigerants this type of equipment can contain. According to the GEM datasets, 73 per cent of all temperature exchange equipment worldwide is managed in an environmentally unsound manner. Countries with no WEEE legislation (i.e. most low- and middle-income countries) release refrigerants directly into the atmosphere.

In addition, while hydrofluorocarbons do not directly deplete the ozone layer, they nevertheless contribute to climate change alongside chlorofluorocarbons and hydrochlorofluorocarbons. Hydrofluorocarbons are regulated by the Kyoto Protocol to the UNFCCC, which aims to reduce their net emissions to zero. Some hydrofluorocarbons are regulated by the Montreal Protocol which aims to phase them out. The unregulated export of WEEE from high-income to lower-income countries for recycling can also result in additional emissions from transport and handling, adding to the overall carbon footprint. It is crucial to implement proper WEEE management practices, including regulated recycling and responsible disposal processes, and to adopt the principles of the circular economy to minimize waste and the use of resources.

5.4 Identification, relevance and impact of e-waste on the global economy[54]

Less than one-quarter of the WEEE produced in 2022 around the world was documented as recycled. However, WEEE contains valuable and finite resources that can be reused if they are appropriately recycled. WEEE has therefore become an important income stream for individuals and some communities. People living in low- and middle-income countries, particularly children, face the most significant risks from WEEE due to the lack of appropriate regulations and enforcement, recycling infrastructure, and training. Despite international regulations on the transport of WEEE from one country to another, its transboundary movement to low- and middle-income countries continues, frequently illegally. WEEE is considered hazardous waste as it contains toxic materials and can produce toxic chemicals when recycled inappropriately. Many of these toxic materials are known or suspected to cause harm to human health, including dioxins, lead and mercury. Inappropriate recycling of WEEE is a threat to public health and safety.

EEE contains many different toxic substances, but users are unlikely to have contact with these substances as long as the equipment is in use. Once discarded, however, toxins can be released into the environment, unless disposal is managed in an environmentally sound manner. Many unsound practices have been observed at WEEE sites, including:

1) scavenging;
2) dumping on land or in water bodies;
3) landfilling along with regular waste;
4) open burning, or incineration for heating;
5) acid baths or acid leaching;
6) stripping and shredding of plastic coatings; and
7) disassembly of equipment by hand.

[54] World Health Organization (WHO). Electronic waste (e-waste), 2024.

These activities are considered hazardous to the environment and a danger to health, as they release toxic pollutants, contaminating the air, soil, dust and water at recycling sites and in neighbouring communities. Open burning and heating are considered the most hazardous activities due to the toxic fumes created. Once in the environment, these toxic pollutants can travel significant distances from the point of pollution, exposing people in distant areas to hazardous substances.

Children and pregnant women are especially vulnerable to the effects of hazardous pollutants from informal WEEE recycling activities. A particularly pernicious practice involves the exploitation of children as a source of cheap labour, picking through waste, scavenging, burning discarded WEEE and dismantling items into component parts by hand. These activities directly expose children to injury and toxic hazards. Working as a waste picker is considered by the International Labour Organization (ILO) to be one of the worst forms of child labour. In 2020, ILO estimated that as many as 16.5 million children globally were working in the industrial sector, of which waste processing is a subsector.[55] It is unknown how many child labourers participate in informal WEEE recycling.

WEEE exposure may be linked to the following health effects during pregnancy and in infants and children:

1) adverse neonatal outcomes, including increased rates of stillbirth and premature birth;
2) adverse neurodevelopment, learning and behaviour outcomes, which are especially associated with the lead released through informal e-waste recycling activities; and
3) reduced lung and respiratory function and increased incidence of asthma, which may be linked to the high levels of air pollution that characterize many WEEE recycling sites.

Children and pregnant women are uniquely vulnerable to the hazardous substances released through informal WEEE recycling activities. Toxic chemicals such as mercury can cross the placenta and may contaminate breast milk. Fetuses and young children are more vulnerable than adults to many of the pollutants released through WEEE recycling due to their rapidly developing bodies, especially their respiratory, immune and central nervous systems. WEEE contains several known neurotoxicants, including lead and mercury, that can disrupt the development of the central nervous system during pregnancy, infancy, childhood and adolescence. Some harmful toxicants from WEEE may also impact the structural development and function of the lungs. Changes to children's developing systems may cause irreparable harm and affect them for the rest of their lives.

Prevention and management

National and international actions are essential to protect communities from unsound WEEE recycling activities. Actions that can be taken include:

1) adopting and enforcing high-level international agreements;
2) developing and implementing national WEEE management legislation that protects public health;
3) incorporating health protection measures into national legislation;
4) monitoring WEEE sites and surrounding communities;

[55] International Labour Organization (ILO). Child labour: global estimates 2020, trends and the road forward. 2021.

5) implementing and monitoring interventions that improve informal WEEE recycling activities, protect public health and ensure vital sources of community revenue;
6) educating health workers across all levels on WEEE-related child health issues; and
7) eliminating child labour.

International agreements

The Basel Convention governs the transboundary movement of hazardous wastes and their disposal. It is a comprehensive environmental agreement that aims to tackle issues concerning the management of hazardous wastes, including WEEE. In 2019, the Ban Amendment to the Basel Convention entered into force, prohibiting the movement of hazardous wastes, including WEEE, from the countries of the Organisation for Economic Co-operation and Development (OECD), the European Commission countries and the Principality of Liechtenstein to other States that are party to the Convention. The Basel Convention runs programmes and workshops to develop and deliver guidance on the environmentally sound management of WEEE. It also provides states with guidelines on how to distinguish between waste and non-waste and on the transboundary movement of WEEE. Regional conventions also exist, including the Bamako Convention and the Waigani Convention. Both regional conventions arose in response to the Basel Convention and aim to further restrict the movement of hazardous wastes, including WEEE, in African and South Pacific countries.

Chapter 6 – Actions taken to address the challenges of e-waste processes and procedures

In response to the challenges set out above, ITU launched a comprehensive programme aimed at improving global e-waste management. The ITU initiative seeks to raise the global e-waste recycling rate to 30 per cent by 2023 and expand e-waste legislation to 50 countries.[56] This programme includes pilot projects in developing nations focused on the collection, dismantling, refurbishment and recycling of e-waste. Furthermore, mitigation efforts, such as awareness campaigns targeting key stakeholders and carbon credits for reducing emissions, are essential for promoting sustainable e-waste management.

Addressing e-waste requires collective action to raise awareness and implement effective strategies for recycling and reducing environmental harm. By integrating these measures, we can mitigate the impact of e-waste on both the environment and human health. Some case studies of efforts undertaken by ITU Member States and organizations in this regard are detailed below.

The management of e-waste in the Republic of Cameroon[57] has become a significant focus, with efforts to improve the processing and recycling of electronic waste. Despite having legal frameworks in place, challenges in enforcement and resource limitations have slowed progress.

Cameroon has regulations that specify user responsibility for e-waste disposal, but effective implementation has been lacking. A dedicated e-waste processing centre has not yet been established. However, recent initiatives have led to the development of an e-waste processing centre in Douala. Supported by the Global Environment Facility, this project aims to address challenges such as financial constraints and technological gaps. The centre will centralize e-waste processing, including dismantling, storage and recovery of valuable materials, contributing to the country's sustainability efforts.

Cameroon's e-waste management project represents a significant step in its environmental protection and sustainable development strategy, focusing on resource recovery and addressing critical e-waste challenges.

The World Bank Digital Development Global Practice[58] works in more than 100 countries to foster thriving digital economies. Its efforts include financing, advisory services and technical expertise, and it is supported by the International Finance Corporation and the Multilateral Investment Guarantee Agency.

The World Bank focuses on key areas such as expanding broadband connectivity, promoting digital industries, leveraging digital tools for climate resilience and enhancing cybersecurity. Its flagship initiatives, like the Digital Development Partnership and the Identification for Development Initiative, aim to accelerate inclusive digitalization and improve access to digital

[56] ITU-D SG2 Document 2/45 from Côte d'Ivoire.
[57] ITU-D SG2 Document 2/38 from Cameroon.
[58] ITU-D SG2 Document 2/74 from World Bank.

solutions in sectors like education, health care and governance. The World Bank also supports fragile regions by promoting ICT for sustainable development and disaster management, aligning efforts with global climate goals.

Collaboration between formal recyclers and informal workers is key for improving e-waste management.[59] By integrating the informal sector collection capabilities with the formal sector processing efficiency, both sectors can improve recycling rates and reduce environmental harm. Investments in infrastructure, such as specialized processing facilities, are crucial for handling e-waste responsibly. Formalizing the informal sector through regulations and training is essential for creating a circular economy, improving worker safety and promoting sustainable practices.

In the Republic of Indonesia[60] e-waste is managed according to hazardous waste regulations overseen by the Ministry of Environment and Forestry and the Ministry of Communication and Informatics. However, the country lacks dedicated e-waste regulation.

E-waste in Indonesia is classified as hazardous waste and therefore requires careful management to mitigate its harmful environmental and health effects. The Ministry of Communication and Informatics of Indonesia has launched several initiatives to improve e-waste management in the telecommunication sector, including the development of a national strategic plan, pilot projects, and policies for responsible disposal and recycling. In this way Indonesia is working towards better addressing e-waste and reducing its environmental and health risks.

Efforts to address e-waste and promote a circular economy are intensifying worldwide. GEM 2024[61] provided updated insights on global e-waste trends, with a focus on challenges and statistics. ITU, in partnership with UNITAR, supports regions such as eastern and southern Africa in harmonizing e-waste data, with countries like Burundi and Kenya benefiting from baseline studies.[62]

Governments are also enacting policies and regulations.[63] For instance, the Dominican Republic launched its national e-waste regulation in October 2023, following extensive consultations. ITU is supporting countries like the Republic of Rwanda, the Republic of Zambia and Paraguay in developing national e-waste regulations under the EPR framework.

In Burundi significant progress has been made in the management of WEEE. The Great Lakes Initiatives for Communities Empowerment, a key organization, collected and processed 32.6 Mt of e-waste in 2022, showcasing the country's efforts to address the growing e-waste problem.

The data from 2022[64] reveals monthly collection figures, with the highest amounts processed in April (5.09 Mt), February (4.05 Mt) and September (3.73 Mt). These efforts highlight ongoing challenges but also demonstrate Burundi's commitment to addressing e-waste. A key goal is to reduce WEEE volume by enforcing stricter product quality standards. Capacity-building initiatives across various sectors are also critical in supporting WEEE management efforts.

Despite ongoing challenges, Burundi's recognition of the need to raise awareness about improper waste management and the implementation of a "polluter pays" policy are crucial

59 ITU-D SG2 Document 2/111 from India.
60 ITU-D SG2 Document 2/184 from Indonesia.
61 UNITAR, ITU and Fondation Carmignac. The Global E-waste Monitor 2024.
62 ITU-D SG2 Document 2/195 from ITU BDT.
63 ITU-D SG2 Document SG2RGQ/78 from ITU BDT.
64 ITU-D SG2 Document SG2RGQ/126 from Burundi.

steps towards increasing participation in waste collection and enhancing overall e-waste management.

In 2020 the Dominican Republic, through the Dominican Institute of Telecommunications, sought technical assistance from ITU to develop regulations for managing WEEE. This initiative led to significant improvements in the country's e-waste management.

In December 2021,[65] an inter-agency cooperation agreement was signed between the Dominican Institute of Telecommunications and the Ministry of the Environment and Natural Resources of the Dominican Republic to focus on sustainable development. This collaboration emphasized the recovery, storage, transport and recycling of WEEE to reduce waste generation. As a result, regulations establishing a national framework for integrated WEEE management were approved under Presidential Decree No. 253-23. The regulation enforces EPR and ensures the environmentally sound management of WEEE, aiming to recover valuable raw materials.

The implementation of these regulations represents a significant milestone in improving post-consumption management of WEEE in the Dominican Republic. It demonstrates the country's commitment to environmentally responsible e-waste management and resource recovery.

Zambia has made significant strides in promoting sustainability and addressing climate change through actions aligned with global environmental sustainability objectives. These efforts are closely tied to advancing the UN SDGs and reflect the country's commitment to improving e-waste management and recycling.

The initiatives in Zambia[66] include replacing traditional scratch cards with electronic airtime recharge systems in collaboration with the Global System for Mobile Association of Zambia and mobile network operators to reduce waste by 2024. Thanks to the partnership between the regulatory authority of Zambia and the E-Tech Recycling Company, eco-friendly waste management is being fostered through two key programmes: the E-waste Drive and the My Environment School Campaign. Zambia is also working with ITU to establish EPR regulations, which will hold e-waste producers accountable for responsible management, supported by agencies like the Zambia Environmental Management Agency and the Zambia Information and Communications Technology Authority.

These ongoing initiatives demonstrate the dedication of Zambia to sustainability and e-waste management, setting a foundation for long-term environmental health and contributing to global sustainability goals.

Rwanda has made notable progress in managing e-waste since 2018,[67] with the Rwanda Utilities Regulatory Agency establishing regulations to address WEEE. A key policy initiative in this effort is the implementation of the EPR system, which aims to ensure the sustainable management of e-waste through a circular economy approach.

Rwanda generates approximately 7 000 Mt of e-waste annually. The introduction of the EPR system extends the responsibility of producers beyond the sale of the product to include the management of waste once the product reaches the end of its lifecycle. The system is part of the broader efforts of the country to achieve a circular economy, as outlined in the National Circular Economy Action Plan. ITU, in collaboration with partners like UNEP and GIZ, has provided

[65] ITU-D SG2 Document SG2RGQ/142 from the Dominican Republic.
[66] ITU-D SG2 Document SG2RGQ/146 from Zambia.
[67] ITU-D SG2 Document SG2RGQ/217 from Rwanda.

technical and financial support to this initiative. The second phase of assistance, running from 2023 to 2025, is supported by the Communications, Space and Technology Commission of the Kingdom of Saudi Arabia.

The efforts of Rwanda to manage e-waste through EPR align with the sustainability goals of the country and are supported by international partners. This initiative aims to foster a circular economy and addresses both the environmental and health risks associated with e-waste.

In conclusion, tackling the e-waste issue requires a multifaceted approach involving innovation, regulatory frameworks and public-private partnerships. Key measures include regulations like the EU WEEE Directive, the adoption of EPR, advancements in recycling technologies, and consumer education. International collaboration, particularly in developing countries, is essential for providing the infrastructure and technologies necessary for safe e-waste management. By aligning policies, technology and education, the global community can reduce the environmental impact of e-waste, promoting a more sustainable and circular economy for the future.

6.1 Ways and means towards reduction and reuse of e-waste

As seen above, the digital transformation, despite its undeniable benefits for emerging economies, poses a challenge for society in the form of e-waste. The proliferation of devices, large-scale manufacturing, frequent upgrades, and a frequently careless, irregular approach to handling e-waste are behind major environmental and health hazards facing countries around the world. In most emerging economies the informal sector constitutes almost 90 per cent of the e-waste industry, with just a fraction of e-waste being handled by authorized operators.

The informal sector dominates not only the collection of e-waste, but also its dismantling into constituent parts, which is often carried out in such a crude, unscientific manner that it harms not only the environment, by polluting groundwater and creating toxic fumes that worsen air pollution, but also the workers themselves, who risk severe skin and lung diseases.

Innovation in this field will redirect this stream of e-waste collection and recycling towards the formal sector, creating new employment opportunities for waste collectors and enhancing their quality of life.

In India, government policies and persistent efforts[68] aim to foster the scientific management of e-waste. Consumer-friendly policies are being developed by the Government with public and industry participation, capabilities for the scientific disposal of e-waste are being integrated into smart cities projects, and, through the innovative transfer of technologies, skills are being improved in the informal sector.

Thanks to the Government encouraging the deployment of Make in India green technologies, stakeholders have transferred technologies to enable the safe disposal and management of e-waste through innovation. This not only helps recycle and reclaim rare natural resources, but also greatly decreases carbon emissions and ensures employment generation, skill improvement and self-reliance, while achieving the vision of a circular economy for the country in a sustainable manner.

EPR policies hold producers accountable for the entire lifecycle of their products, with a particular focus on e-waste management. This approach encourages manufacturers to design

[68] ITU-D SG2 Document 2/81 from India.

products with a focus on their end-of-life disposal, thus promoting environmentally responsible recycling and disposal practices. Manufacturers should be mandated[69] to set up e-waste exchange facilities to make collection and recycling easier, and bulk buyers of electronic items should be explicitly charged with the safe and scientific disposal of their products. It should be the manufacturer responsibility to collect and ensure the recycling or disposal of e-waste generated during manufacturing. Only new EEE that complies with government regulations may be imported or placed on the market, and governments should incentivize innovation in the field. More innovative steps and standards are needed to reduce e-waste generation, for example by enabling users to use a single charger for various devices thereby reducing the need for multiple chargers and cables which would otherwise end up as e-waste. The EU compulsory adoption of USB-C as a universal charging standard helps minimize e-waste. This simple step alone aimed to cut e-waste by 11 000 Mt annually and save consumers up to EUR 250 million by reducing the need for multiple chargers.[70]

ITU[71] has played a crucial role in advancing EPR principles, especially in managing e-waste. ITU has developed guidelines for sustainable e-waste management based on EPR, which are outlined in ITU standard L.1021. These guidelines help countries create effective e-waste policies and regulations, supporting a circular economy for EEE.

According to GEM 2024,[72] of the 81 countries with national e-waste policies, 67 have adopted EPR principles, demonstrating a global shift towards producer responsibility in e-waste management. Through these initiatives, ITU emphasizes the importance of EPR in managing e-waste, promoting sustainable practices and fostering collaboration among stakeholders to tackle global e-waste challenges.

6.2 Consumer action to reduce the generation of e-waste[73, 74]

Lack of consumer awareness and involvement is a major obstacle for the effective recycling of electronic waste. Many people remain unaware of the environmental impact of e-waste or do not know how to correctly dispose of their electronic equipment. Companies can play a key role by informing their customers and employees about the importance of recycling e-waste and how to get involved.

Consumers, private persons and organizations alike have responsibilities and a crucial role in reducing e-waste. Conscious choices can help us move towards a circular approach to the lifecycle of our electronics for a new, more sustainable future.

Consumers need to take concrete steps to help reduce e-waste. These steps include the following:

69 https://www.itu.int/en/ITU-D/Environment/Pages/Publications/The-Global-E-waste-Monitor-2024.aspx.
70 https://www.europarl.europa.eu/news/en/press-room/20220603IPR32196/deal-on-common-charger-reducing-hassle-for-consumers-and-curbing-e-waste
71 https://www.itu.int/en/mediacentre/backgrounders/Pages/e-waste.aspx
72 https://www.itu.int/en/ITU-D/Environment/Pages/Publications/The-Global-E-waste-Monitor-2024.aspx
73 https://safetyculture.com/topics/circular-economy/e-waste-recycling/
74 https://resources.ironmountain.com/en-gb/blogs-and-articles/t/the-circular-economy-and-e-waste-achieving-a-more-sustainable-future

Extend equipment lifetime

This step involves changing consumer behaviour to be more responsible:

- Think before buying: do you really need the new gadget? Could you obtain the same item by purchasing a used/refurbished one? How durable is the item? Will you be able to have it repaired if necessary? In sourcing the item, consider vendors who have a take-back programme or who recycle old equipment.
- Repair, don't replace: before purchasing a new item of equipment, consider having yours repaired. It may be the least costly option, resolving several problems at once.
- Care and maintenance: stay up to date with maintenance (cleaning, upgrades/updates) and exercise due care in use. This can greatly extend the lifetime of your equipment.

Choose long-life products

A conscientious consumer buys items that will last a long time. There are things you can do before purchasing a piece of EEE:

- Choose products that are designed to last, that are made of good-quality material and are robustly designed.
- A cheap, mass-produced product may not be as wise a choice as a higher-quality one.
- Check the guarantee period and what the conditions would be if you had to have the product repaired.
- Choose products where the packaging is kept to a minimum and can be recycled.

Do your part to recycle WEEE

The consumer can contribute to WEEE recycling before, during and after the recycling stage. Some recommendations:

- Bring used EEE to a recycling centre, instead of abandoning it or disposing of it in household waste. Some companies have recognized the value of recycling electronic waste and are offering to purchase such equipment.
- Pre-sort the equipment before bringing it to the recycling point (batteries, cables, etc.).
- Think of environmentally friendly alternatives: equipment that is still functional could be reused by a family member or donated to a charity. In the same line, governments should be encouraged to create partnerships with companies that extract value from WEEE.

The short-term initiatives that Cameroon has taken to manage WEEE include specific rules for businesses and organizations to manage their WEEE, making them responsible for the removal and disposal of waste, unless otherwise agreed with the vendor.

Most WEEE is produced by household and commercial consumers. They have a responsibility to keep WEEE separate from other waste and to return hardware at the end of its life to the vendor. Consumers also bear the cost of WEEE management, whether indirectly in the form of a recycling tax at the point of sale or directly when used hardware is collected. Nonetheless, it is also pointed out that consumers need to be made more aware of their responsibilities and of the impact of WEEE on the environment and on human health.

In another example, in India, the Delhi neighbourhood of Seelampur is dealing with the environmental and health problems caused by the proliferation of WEEE through campaigns in the informal sector, which plays a crucial role in the management of the city WEEE. Workers are sometimes exposed to health hazards due to the lack of safety rules and systems. Efforts are therefore being made to put the sector on a formal footing and build collaboration between official and informal recyclers so as to obtain better outcomes in terms of health, safety and the environment while creating new jobs. Government representatives should commit to a transition from the unsustainable linear economic model to a formal sector, offering informal workers training programmes and suitable equipment along with formal government support to finance social security programmes. Such support can improve the economic and social welfare of workers in the informal sector and promote sustainable practices in the management of e-waste.

In summary, to reduce the production of e-waste, it is essential to aim for sustainability, repairs and recycling. Each act counts and helps to preserve our environment.

6.3 Incorporating e-waste into national circular economy action plans

Incorporating WEEE in national action plans for a circular economy has become an absolute necessity given the health and environmental risks caused by improper waste management and the economic potential that the valuable materials contained in defective/waste hardware represent.

Environmental awareness is growing by leaps and bounds, particularly within governments, under the influence of international pressure stemming from the international treaties and accords to which the countries are party, in particular the Basel Convention and regional rules on WEEE. Because of these agreements, countries are motivated to put national regulation in place.

It is undeniable that improper WEEE management can lead to public health problems, especially among informal sector workers, and it is our responsibility to leave a healthy and protected environment for future generations.

Studies have shown that WEEE contains numerous dangerous substances such as lead, mercury and cadmium. Improperly managed, these can lead to contamination of the soil, water and air, endangering ecosystems and human health.

Against this backdrop, India, with its programme for the management of e-waste through an approach based on the circular economy and innovation, has observed that, while the digital/ICT revolution has transformed lives and energized the emerging economies, it has also created risks for the environment and human health, due to improper WEEE management.

To take control of WEEE management and capitalize on its potential, the authorities have adopted policies and made efforts to encourage the scientific management of e-waste, with a consumer-friendly approach, and integrated the elimination of e-waste in their plans for smart cities. Green Make in India schemes and technology transfers for the safe disposal of e-waste are being supported by the Government with the aim of recycling resources, reducing the carbon footprint, creating jobs, improving competences and achieving a sustainable circular economy.

The rapid evolution of environmental policies has made the question of managing e-waste central to many considerations in the international arena, and its economic potential is widely recognized. Accordingly, countries are working on strengthening their national regulatory frameworks, moving beyond policies that aim merely at managing WEEE and working towards a circular economy, for a more comprehensive approach to WEEE management.

In this context, in 2011, Australia adopted a law for the responsible management of products, under which the National Television and Computer Recycling Scheme was established. This law also provides a map for the evolution and impact of responsible product management in Australia.

This document represents a step forward for regulation, from the adoption of a national waste policy in 2009, intended to improve the management of the environmental, health and safety impact of products, to the adoption of a law on the circular economy. Australia is an example of how a regulatory framework can be upgraded, as the country has had a law on the circular economy since 2012, allowing it to reduce the wastes that end up in landfills, particularly dangerous e-waste, and to increase the recovery of reusable substances.

For countries seeking to develop national policies for a circular economy, the ITU Telecommunication Development Bureau (BDT) provides technical and financial support. In this context, the GEM 2024 programme,[75] launched on 20 March 2024, is a key reference for decision-makers in politics and industry. It shows that a record 62 billion kg of e-waste were generated around the world in 2022, only 22.3 per cent of which was officially recycled. The report covers 81 countries, of which 67 have implemented EPR, 46 have national targets for collection of e-waste and 36 have recycling targets. The report is funded by ITU and partners such as the Sustainable Cycles programme of UNITAR and the Fondation Carmignac. A regional report for the western Balkans was also published, with six recommendations for the sustainable management of e-waste.

6.4 Incorporating ICTs into national circular economy action plans

Given the challenges of sustainable development, in particular those relating to the environment, it is more than ever important for States to initiate and adopt national circular economy plans that incorporate ICTs. Such plans provide a strategic framework for the transition to an economic model that is more sustainable and can reconcile economic growth with the preservation of natural resources, thanks to telecommunications/ICTs.

It is essential to incorporate ICTs in the national/State-level plans if they are to achieve their full potential.

Telecommunications/ICTs enable digital transformations that can promote the circular economy by making it easier to trace recycled products and supporting plans for the reuse of used parts.

Their importance was demonstrated with the development of a green battery ecosystem for certifying the residual life expectancy of electric vehicle batteries. This showed that the growing economic and environmental value of a circular economy for batteries is related to the management of electric vehicle batteries, including their reuse and recycling. The market for recycling electric vehicle batteries is now estimated to grow to USD 57.395 billion by 2040.

Incorporating ICTs into national action plans helps to optimize processes. The collected data can help identify bottlenecks and optimize production and distribution processes, reducing waste.

75 UNITAR, ITU and Fondation Carmignac. Global E-waste Monitor 2024.

Governments should also include ICTs in their national action plans to take full advantage of the economic benefits of the circular economy. One such potential benefit is the possibility of moving from an ownership-based model to a use-based one, creating opportunities for new business models relying on rental, subscription and sharing, among other possible solutions.

Finally, ICTs can provide a powerful boost at each of the key stages of the circular economy, especially repair, recovery and recycling, with the promise of new jobs.

Given its significant production of WEEE, the ICT sector has much to gain from the circular economy, along with other sectors such as manufacturing and agriculture. One can therefore justifiably state that the circular economy is a major issue for the ICT sector. Increasing equipment lifetimes and reusing and recycling equipment are thus crucial issues for reducing the environmental footprint of the sector.

These are some of the considerations that underly ITU commitment to the development of national plans and State-level regulatory instruments on the circular economy, putting its subject matter expertise at the disposal of countries and supporting them in finding funding for the requisite studies.

Chapter 7 – Way forward and conclusions

7.1 Climate change

The UNFCCC COP28 held in 2023 marked a significant turning point, with agreements focusing on the beginning of the end of fossil fuel reliance and supporting a just and equitable transition with deep emission cuts and increased climate finance.[76]

The European Reanalysis of the 5th Generation (ERA5) dataset[77] indicates that January 2025 was the warmest January on record worldwide, with a surface air temperature of 13.23°C, which was 0.79°C warmer than the average for the month from 1991 to 2020. In addition, it was 1.75°C warmer than the January normal before industrialization (1850-1900). The worldwide average surface air temperature surpassed 1.5°C above pre-industrial levels for the 18th month in a 19-month period. Twelve of these 18 months – from September 2023 to April 2024 and from October 2024 to January 2025 – saw temperatures considerably over 1.5°C, with ranges of 1.58°C to 1.78°C. Temperatures for July and August 2023, as well as May, June, August and September 2024, were around the 1.5°C threshold, ranging from 1.50°C to 1.54°C.

The integration of telecommunications/ICTs into climate action has become a central strategy. In 2022, UNEA identified digital transformation as crucial to reducing the environmental impact of the ICT sector, aiming to phase out 80 per cent of fossil fuel use and creating a near-zero-waste economy by 2050. Telecommunications/ICTs, including Earth observation, IoT and data centres, can help monitor the environment, track emissions and optimize energy usage. However, these technologies also contribute to increased demand for raw materials like lithium and cobalt, highlighting the need for a sustainable digital transformation that reduces energy consumption and emissions or mitigates environmental impacts.

The ICT sector contribution to global carbon emissions is estimated to be between 1.5 per cent and 4 per cent. User devices contribute nearly half of this carbon footprint, arising from both usage and product lifecycles. With the rise of IoT, the sector emissions are expected to grow significantly. To address this, the ICT industry is focusing on energy efficiency and e-waste management as key solutions.[78]

Cutting-edge technologies like Earth observation are crucial for tracking and controlling environmental changes, maximizing energy use and lowering carbon emissions in a variety of industries. The effects of climate change can be greatly lessened, and long-term environmental sustainability improved, by integrating these technologies with sustainable habits. Climate action focuses on reducing global greenhouse gas emissions by 50 per cent by 2030 and reaching net-zero by 2050. This involves transitioning to low-carbon energy sources, adopting enabling technologies, establishing stricter regulations and standards, and addressing the

76 COP28 Outcome Report
77 https://climate.copernicus.eu/surface-air-temperature-january-2025
78 K. Rajaraman. India. Developing green ICT policies for climate change mitigation: Indian perspective. ITU-D Workshop on green ICT and emerging technologies towards climate change mitigation, Geneva, 29 May 2023.

effects of CO_2 emissions. Mitigation, adaptation and resilience are the three pillars of climate action.

Governments and companies should encourage the purchase of green energy equipment through incentives and support R&D in the field of green energy. The increased use of cutting-edge carbon capture, utilization and storage technologies can reduce CO_2 emissions and transform CO_2 into products that are useful. It is crucial to reduce carbon emissions by implementing energy-saving measures including using fuel cells, HVAC systems, and low-emission lithium-ion batteries, solar power and building materials, and other strategies.

It is extremely important to explore the use of fuel cell systems based on hydrogen, small-scale solar wind hybrids, cylinder-based natural gas generators, generators using biodiesel, and aluminium-based fuel generators to reduce or eliminate the use of diesel in the ICT sector. Also, improving the power availability at telecommunication facilities and lowering reliance on diesel or other fossil fuel-based off-grid solutions can lower fuel usage and encourage the adoption of alternative energy sources.

Governments can also help telecommunication network operators and service providers overcome various challenges including: expensive capital and operating expenses; the replacement of conventional energy sources; the use of lithium-ion batteries, solar panels, and energy-efficient devices; the extra space needed for solar panel installation; and the high cost of producing green energy.

Space restrictions, such as the inability to install green energy equipment (solar panels, etc.) next to telecommunication towers, are a major constraint on the use of green energy sources for ICTs.

Geographical constraints such as terrain, climatic conditions, feasibility and overly complex municipal permits, can also make the process difficult. Other big constraints for the telecommunication sector include the significant challenges in obtaining space, feasibility, owner's agreements, buildings with adequate structural strength, and locations with appropriate orientation for roof-top sites. Energy-efficient appliances and the domestic production of lithium-ion batteries are the demands of the day.

Green energy technology is also incredibly expensive to operate and maintain. Financial barriers might stop or reduce the telecommunication industry interest to use it.

7.2 Electronic waste

In most of the emerging economies, the informal sector plays a crucial role in the management of e-waste, involving individuals such as e-waste pickers and scavengers who collect and sort discarded electronic devices. On the other hand, the formal sector, which consists of municipalities and e-waste management firms, is responsible for processing and recycling e-waste. There is a growing need to integrate the informal sector into the formal e-waste management system to improve efficiency and reduce the negative environmental impacts associated with improper e-waste handling.

The key to improving e-waste management lies in enhancing the collaboration between the informal and formal sectors. The informal sector collection efficiency can be significantly improved if e-waste pickers gain access to formal collection and processing facilities, along with proper training and equipment. By working together, informal waste pickers and formal recycling organizations can better separate recyclable materials from non-recyclable ones, ensuring that more e-waste is diverted from landfills.

The formal sector can invest in developing recycling infrastructure, such as establishing recycling facilities and creating waste disposal systems. This would enable the informal sector to have access to resources to improve the handling and processing of e-waste. Additionally, promoting e-waste separation techniques within the informal sector could incentivize workers to separate recyclables and increase the volume of materials that can be recycled or reused.

The shift from a linear economy to a circular economy is another critical step in improving e-waste management. The current linear economic model, which is unsustainable and vulnerable to disruptions, can be transformed through digital technologies that enhance efficiency, accountability and transparency in waste management systems. Digital transformation, including data management systems and recycling technologies, can ensure that e-waste materials and components are recycled and reused, thereby supporting the shift to a more sustainable circular economy.

Private sector involvement is essential to establish sustainable e-waste management practices. Through strategic partnerships with manufacturers and organizations practising EPR, informal e-waste collectors can gain access to significant volumes of e-waste, thus securing a stable income stream. Additionally, regulations should incentivize informal recyclers to adopt sustainable practices and align them with established safety and health standards.

Governments also play a vital role in supporting the formalization of the informal sector. Policy interventions, such as providing financial assistance, grants, loans and microfinancing, can help informal workers improve their practices and access the resources they need. Moreover, providing training and educational opportunities, such as entrepreneurship and vocational education, can enhance the efficiency and skills of informal sector workers. Access to social security, including health care, unemployment benefits and retirement plans, would further improve the livelihoods of informal sector workers.

Formalizing the informal e-waste sector in emerging economies is essential for sustainable e-waste management. By fostering collaboration between the informal and formal sectors, improving recycling infrastructure and implementing digital solutions, the efficiency of e-waste collection, separation and recycling can be significantly enhanced. Government support, through financial incentives, training and social protection programmes, will be key to integrating informal workers into the formal e-waste management system. With these steps, emerging economies can transition towards a circular economy and improve both environmental sustainability and the livelihoods of informal workers.

Reducing the environmental impact of e-waste and encouraging recycling should be the main goals of e-waste policies. EPR is a tool that governments can use to hold producers responsible for the recycling and disposal of their goods. The environment will not be contaminated by dangerous substances if there are stricter rules for managing e-waste safely. It is essential to increase public understanding of appropriate disposal and conscientious usage. To increase equipment longevity, policies should also encourage repair, reuse and refurbishing. Encouraging sustainable product design can help reduce future e-waste, while setting up specific locations for e-waste collection and working with recycling companies will guarantee correct handling.

The global efforts to improve e-waste management are slowly gaining traction. Among the 81 countries that have national e-waste policies, 67 have implemented EPR regulations, which hold producers accountable for the end-of-life management of their products. Additionally, 46 countries have set national e-waste collection targets and 36 have established recycling targets. These statistics reflect growing global awareness and action, but also highlight the need for more comprehensive systems to handle the sheer volume of e-waste being generated.

Annex – List of contributions and liaison statements received on Question 6/2

Contributions on Question 6/2

Web	Received	Source	Title
2/401	2025-04-22	United Kingdom	UK comments on draft Q6/2 final report
2/390	2025-04-21	Réseau International Femmes Expertes du Numérique	When machines paint: unpacking the environmental costs and ethical-intellectual property implications of AI-generated art
2/389	2025-04-21	Burundi	Management of waste electrical and electronic equipment in Burundi and the countries of the East African Community: strategies, policy, challenges and prospects
2/377	2025-04-16	BDT Focal Point for Question 6/2	ITU-D activities on ICTs and the environment
2/363 (Rev.1)	2025-05-09	Rapporteur for Question 6/2	Draft Output Report on Question 6/2
2/356	2025-03-13	Rwanda	Implementation of the Extended Producer Responsibility (EPR) principle for the management of electrical and electronic waste in Rwanda
2/334	2024-10-30	Côte d'Ivoire	Integrated National Strategy for the Promotion of the Circular Economy (SNIPEC) 2023-2027
2/324	2024-10-29	BDT Focal Point for Question 6/2	ITU-D activities on ICTs and the environment
2/302	2024-10-26	China	Signalling push technology: insights and perspectives
2/295 (Rev.1) +Ann.1	2024-10-22	China	AI for Good, bridge the AI divide
2/293 +Ann.1-2	2024-10-21	GSM Association	2024 Mobile Industry Impact Report: Sustainable Development Goals
2/285	2024-10-03	Republic of the Congo	Consumer protection against the risks of waste electrical and electronic equipment in the CEMAC zone
2/282	2024-10-31	Rapporteur for Question 6/2	Draft Output Report on ITU-D Question 6/2

(continued)

Web	Received	Source	Title
2/265	2024-09-25	Association for Progressive Communications	Building common agendas towards ICT for environmental justice
2/263	2024-09-24	Chad	Initiatives to promote going paperless in public authorities and management of waste electrical and electronic equipment
2/262	2024-09-24	Burundi	Collection of waste electrical and electronic equipment in Burundi: issues, challenges and perspectives
2/236	2024-09-04	India	Reducing disaster risk by using emerging technologies
2/232	2024-10-02	Rapporteur for Question 6/2	Annual progress report for Question 6/2 for November 2024 meeting
RGQ2/217	2024-04-26	Rwanda	Implementation of the extended producer responsibility principle for the management of electrical and electronic waste in Rwanda
RGQ2/196	2024-04-16	Republic of Korea	Innovative approaches for sustainable mobile phone collection and recycling
RGQ2/195	2024-04-16	Republic of Korea	Harnessing AI for climate action: balancing benefits and environmental impact
RGQ2/190 +Ann.1	2024-04-15	United Kingdom	Telecoms towards Net Zero?: An excerpt from Ofcom's Connected Nations report
RGQ2/185	2024-04-15	BDT Focal Point for Question 6/2	ITU-D activities on ICTs and the environment
RGQ2/171	2024-04-04	Russian Federation	The digital twin of the Ob-Irtysh River basin
RGQ2/146	2024-03-14	Zambia	Employing demand side e-waste management practices in the absence of a legal framework
RGQ2/142 +Ann.1	2024-03-12	Dominican Republic	Implementation of the regulation for integrated management of waste electrical and electronic equipment in the Dominican Republic and extended producer responsibility
RGQ2/135	2024-03-07	Cameroon	Responsibility of producers and consumers in a circular economy of electrical and electronic equipment
RGQ2/126	2024-02-29	Burundi	Initiatives for the management of waste electrical and electronic equipment in Burundi
RGQ2/119	2024-02-29	Haiti	Proposed text for the Final Report: Chapter 2, Section "Challenges faced by emerging economies due to the digital divide to combat harmful effects and assessment of climate change"

(continued)

Web	Received	Source	Title
RGQ2/118	2024-02-29	Haiti	Proposed text for the Final Report: Chapter 5, Section "Action to be undertaken by consumers to reduce the generation of e-waste"
RGQ2/109	2024-02-17	India	Proposed texts for the output report of Question 6/2
2/195	2023-10-17	BDT Focal Point for Question 6/2	ITU-D activities on ICTs and the environment
2/184	2023-10-16	Indonesia	Country experience: e-waste management challenges in Indonesia
2/183	2023-10-16	Australia	Regulatory approach to e-waste products in Australia
2/138	2023-09-22	Madagascar	Adoption of eSIM to protect the environment
2/128	2023-09-08	Burundi	Policy, challenges, opportunities and implications of WEEE management in Burundi
2/126 (Rev.1)	2023-09-14	Rapporteur for Question 6/2	Annual progress report for Question 6/2 for October-November 2023 meeting
2/111	2023-08-31	India	E-waste in emerging economies: towards formalizing the unorganized sector
2/107	2023-08-28	Kenya	Approaches that the Kenyan ICT sector regulator has adopted to manage e waste
RGQ2/78	2023-05-09	BDT Focal Point for Question 6/2	ITU-D activities on ICTs and the environment
RGQ2/27	2023-03-30	Haiti	Incentives in favour of dematerialization and online services
RGQ2/21 (Rev.1)	2023-03-23	India	Earth observation: role, prediction and relief in India
RGQ2/14	2023-03-16	Burundi	Issues associated with the collection and recycling of electrical and electronic waste in Burundi
2/TD/8 (Rev.1)	2022-12-07	Rapporteur for Question 6/2	Proposed work plan, table of contents and roles and responsibilities for Question 6/2
2/81	2022-11-25	India	E-waste management through circular economy and innovation in India
2/74	2022-11-18	World Bank	World Bank Study Group 2 Submission: Digital transformation
2/70	2022-11-23	BDT Focal Point for Question 6/2	ITU-D activities on ICTs and the environment

(continued)

Web	Received	Source	Title
2/46	2022-10-17	Inter-Sector Coordination Group	Mapping of ITU-D Questions to ITU-T Questions and ITU-R Working Parties
2/45	2022-10-14	Côte d'Ivoire	WEEE management in sub-Saharan Africa
2/38	2022-10-13	Cameroon	Near-term initiatives planned by Cameroon relating to the management of waste electrical and electronic equipment
2/32	2022-10-11	Haiti	Positive impact of dematerialization and online services on the environment
2/29	2022-09-08	Burundi	National policy for the management of waste electrical and electronic equipment in Burundi

Incoming liaison statements for Question 6/2

Web	Received	Source	Title
RGQ2/103	2023-12-20	ITU-T Study Group 5	Liaison statement from ITU-T Study Group 5 to ITU-D Study Group 2 Question 6/2 on information on new work items related to ITU databases on GHG emissions
2/106	2023-07-31	ITU-T Study Group 5	Liaison statement from ITU-T Study Group 5 to ITU-D Study Group 2 Question 6/2 on new Question 6/2 and collaboration
RGQ2/6	2023-02-17	ITU-T Study Group 20	Liaison statement from ITU-T Study Group 20 to ITU-D Study Group 2 Question 6/2 (reply to ITU-D Q6/2-2/91)
2/52	2022-11-08	ITU-T Study Group 5	Liaison statement from ITU-T Study Group 5 to ITU-D Study Group 2 Question 6/2 on ITU-T Study Group 5 activities
2/41	2022-10-18	ITU-R Study Group 6	Liaison statement from ITU-R Study Group 6 to ITU-D Study Groups 1 and 2 on Opinion ITU-R 104
2/19	2022-06-14	ITU-R Study Group 6	Liaison statement from ITU-R Study Group 6 to ITU-D Study Groups 1 and 2 on new Question ITU-R 147/6 (Energy Aware Broadcasting Systems)
2/14	2022-03-14	ITU-R Working Party 6C	Liaison statement from ITU-R Working Party 6C to ITU-D Study Groups 1 and 2, ITU-T Study Groups 5, 9 and 16, ISO and IEC on Energy Aware Broadcasting Systems
2/4	2021-10-27	ITU-R Working Party 6A	Reply liaison statement from ITU-R Working Party 6A to ITU-T Study Group 5 on work related to environment energy efficiency and the circular economy and new areas of study

Office of the Director
International Telecommunication Union (ITU)
Telecommunication Development Bureau (BDT)
Place des Nations
CH-1211 Geneva 20
Switzerland

Email: bdtdirector@itu.int
Tel.: +41 22 730 5035/5435
Fax: +41 22 730 5484

Office of Deputy Director and Regional Presence
Field Operations Coordination Department (DDR)
Place des Nations
CH-1211 Geneva 20
Switzerland

Email: bdtdeputydir@itu.int
Tel.: +41 22 730 5131
Fax: +41 22 730 5484

Digital Networks and Society (DNS)

Email: bdt-dns@itu.int
Tel.: +41 22 730 5421
Fax: +41 22 730 5484

Digital Knowledge Hub Department (DKH)
Email: bdt-dkh@itu.int
Tel.: +41 22 730 5900
Fax: +41 22 730 5484

Partnerships for Digital Development Department (PDD)
Email: bdt-pdd@itu.int
Tel.: +41 22 730 5447
Fax: +41 22 730 5484

Africa

Ethiopia
International Telecommunication Union (ITU) Regional Office
Gambia Road
Leghar Ethio Telecom Bldg. 3rd floor
P.O. Box 60 005
Addis Ababa
Ethiopia

Email: itu-ro-africa@itu.int
Tel.: +251 11 551 4977
Tel.: +251 11 551 4855
Tel.: +251 11 551 8328
Fax: +251 11 551 7299

Cameroon
Union internationale des télécommunications (UIT)
Bureau de zone
Immeuble CAMPOST, 3e étage
Boulevard du 20 mai
Boîte postale 11017
Yaoundé
Cameroon

Email: itu-yaounde@itu.int
Tel.: + 237 22 22 9292
Tel.: + 237 22 22 9291
Fax: + 237 22 22 9297

Senegal
Union internationale des télécommunications (UIT)
Bureau de zone
8, Route du Méridien Président
Immeuble Rokhaya, 3e étage
Boîte postale 29471
Dakar - Yoff
Senegal

Email: itu-dakar@itu.int
Tel.: +221 33 859 7010
Tel.: +221 33 859 7021
Fax: +221 33 868 6386

Zimbabwe
International Telecommunication Union (ITU) Area Office
USAF POTRAZ Building
877 Endeavour Crescent
Mount Pleasant Business Park
Harare
Zimbabwe

Email: itu-harare@itu.int
Tel.: +263 242 369015
Tel.: +263 242 369016

Americas

Brazil
União Internacional de Telecomunicações (UIT)
Escritório Regional
SAUS Quadra 6 Ed. Luis Eduardo Magalhães,
Bloco "E", 10º andar, Ala Sul
(Anatel)
CEP 70070-940 Brasilia - DF
Brazil

Email: itubrasilia@itu.int
Tel.: +55 61 2312 2730-1
Tel.: +55 61 2312 2733-5
Fax: +55 61 2312 2738

Barbados
International Telecommunication Union (ITU) Area Office
United Nations House
Marine Gardens
Hastings, Christ Church
P.O. Box 1047
Bridgetown
Barbados

Email: itubridgetown@itu.int
Tel.: +1 246 431 0343
Fax: +1 246 437 7403

Chile
Unión Internacional de Telecomunicaciones (UIT)
Oficina de Representación de Área
Merced 753, Piso 4
Santiago de Chile
Chile

Email: itusantiago@itu.int
Tel.: +56 2 632 6134/6147
Fax: +56 2 632 6154

Honduras
Unión Internacional de Telecomunicaciones (UIT)
Oficina de Representación de Área
Colonia Altos de Miramontes
Calle principal, Edificio No. 1583
Frente a Santos y Cía
Apartado Postal 976
Tegucigalpa
Honduras

Email: itutegucigalpa@itu.int
Tel.: +504 2235 5470
Fax: +504 2235 5471

Arab States

Egypt
International Telecommunication Union (ITU) Regional Office
Smart Village, Building B 147,
3rd floor
Km 28 Cairo
Alexandria Desert Road
Giza Governorate
Cairo
Egypt

Email: itu-ro-arabstates@itu.int
Tel.: +202 3537 1777
Fax: +202 3537 1888

Asia-Pacific

Thailand
International Telecommunication Union (ITU) Regional Office
4th floor NBTC Region 1 Building
101 Chaengwattana Road
Laksi,
Bangkok 10210,
Thailand

Email: itu-ro-asiapacific@itu.int
Tel.: +66 2 574 9326 – 8
+66 2 575 0055

Indonesia
International Telecommunication Union (ITU) Area Office
Gedung Sapta Pesona
13th floor
JI. Merdeka Barat No. 17
Jakarta 10110
Indonesia

Email: bdt-ao-jakarta@itu.int
Tel.: +62 21 380 2322

India
International Telecommunication Union (ITU) Area Office and Innovation Centre
C-DOT Campus
Mandi Road
Chhatarpur, Mehrauli
New Delhi 110030
India

Email:
Area Office: itu-ao-southasia@itu.int
Innovation Centre: itu-ic-southasia@itu.int
Website: ITU Innovation Centre in New Delhi, India

CIS

Russian Federation
International Telecommunication Union (ITU) Regional Office
4, Building 1
Sergiy Radonezhsky Str.
Moscow 105120
Russian Federation
Email: itu-ro-cis@itu.int
Tel.: +7 495 926 6070

Europe

Switzerland
International Telecommunication Union (ITU) Office for Europe
Place des Nations
CH-1211 Geneva 20
Switzerland

Email: eurregion@itu.int
Tel.: +41 22 730 5467
Fax: +41 22 730 5484

International Telecommunication Union
Telecommunication Development Bureau
Place des Nations
CH-1211 Geneva 20
Switzerland

ISBN 978-92-61-41141-1

9 789261 411411

Published in Switzerland
Geneva, 2025

Photo credits: Adobe Stock