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Information and Communication Technology for Development (ICT4D) and its Areas of Application

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ABSTRACT

This study explores the role of Information and Communication Technology (ICT) in socio-economic development and sustainability, focusing on the evolving landscape of ICT for Development (ICT4D) and the latest advancements represented by ICT 4.0 and ICT for Sustainability (ICT4S). It highlights the transformative potential of ICT in enhancing service delivery, governance, education, healthcare, agriculture, and environmental management. Integrating advanced technologies such as artificial intelligence, the Internet of Things, blockchain, and cloud computing has led to substantial improvements in various sectors, particularly in developing regions. This paper examines ICT's applications, challenges, and future directions towards achieving sustainable development goals, emphasising the importance of digital literacy, infrastructure development, and supportive policies. Through a review of current state-of-the-art technologies and their applications, this study aims to provide insights into how ICT can drive inclusive, innovative, and sustainable development.

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1.0 Introduction

Information and Communication Technology (ICT) includes technologies that facilitate communication and information processing by electronic means. The evolution of ICT began with early forms of computing in the 1940s, followed by the advent of the Internet in the late 20th century. This evolution led to notable changes in communication, social interaction, and information sharing. As ICT evolved, the expansion of its impact on society was witnessed, influencing sectors such as education, healthcare, and government (Schelenz& Pawelec, 2022a).

ICT for Development (ICT4D) refers to the application of ICT in socio-economic development, where it enhances the effectiveness of service delivery and governance, especially in developing countries (Walsham, 2017). ICT4D 1.0 focused on providing basic ICT infrastructure and services. It transitioned into ICT4D 2.0, which emphasised mobile technologies and their application in development contexts, recognising the role of users as innovators. The phase, ICT4D 3.0, aligned with sustainable development goals, focusing on transformative, inclusive, and sustainablenable approaches (Heeks, 2020). This phase incorporated a broader understanding of digital roles, products, and business models that contribute to development, addressing economic and political development aspects.

The latest advancement, often referred to as ICT 4.0, coincides with the fourth industrial revolution, highlighting the integration of digital, biological, and physical technologies (Mon & Del Giorgio, 2021a). ICT 4.0 incorporates artificial intelligence, big data analytics, cloud computing, and the Internet of Things (IoT), which are expected to drive significant changes in how we live, work, and interact. For developing countries, such changes could mean enhanced access to information, improved health outcomes through telemedicine, digital education platforms, and greater civic participation through e-governance models.

This study provides a summary of the ICT field and its related areas, including ICT4D, ICT 4.0, and ICT for sustainability, as well as the application areas of ICT4D, the challenges faced, and future directions. This study will serve as a guide to improve understanding and advancement in the application of ICT for achieving the global sustainable development goals.

The rest of the paper is organised as follows: in the next section, the field of ICT and related fields are presented, followed by a state of the art of ICT technologies, ICT4D, ICT 4.0 and ICT for sustainability. This is followed by the application areas of ICT4D, and thereafter, the challenges and future directions are given before a conclusion is drawn.

2.0 The Field of ICT and Related Fields

Information and Communication Technologies are defined as a broad sector of technologies that involve the handling, processing, and transmission of information through telecommunications. This includes a range of technologies that can include everything from network hardware to software applications, used to support the creation, storage, manipulation, and relay of information in various forms (Schelenz& Pawelec, 2022b).

ICT includes a range of critical components that enable modern digital interactions. They include hardware such as computers and networking devices, software like operating systems and applications tailored for specific tasks, and telecommunications, which cover both the internet and telephony systems. In addition, ICT involves data management and storage solutions, including databases and cloud services, essential for data accessibility and security. Each element plays an important role in facilitating efficient digital communication and data management in various sectors (Chen *et al.,* 2015).

Computer science, information systems, and telecommunications are interconnected fields pivotal to the technological landscape. Computer science focuses on the theoretical underpinnings of computation and information, encompassing software development, artificial intelligence, and network security. Information Systems bridges technology and business, focusing on the design and implementation of systems to enhance organisational effectiveness. Telecommunications facilitates the transmission of information across

distances via electronic means, forming the backbone of global communication networks.

The progression from traditional ICT models to the current ICT 4.0 paradigm marks a significant evolution in technology usage and application. Traditional models were primarily concerned with the basic transmission of data, evolving through stages marked by the introduction of the internet (ICT 2.0) and the proliferation of mobile and cloud technologies (ICT 3.0). Today's ICT 4.0 paradigm integrates digital advancements with physical operations through technologies like the Internet of Things (IoT), big data, and AI, creating smart, interconnected systems that enhance decision-making and operational efficiency in real-timeime environments (Mon & Del Giorgio, 2021b).

3.0 State-of-the-Art Information and Communication Technologies

The integration of advanced information and communication technologies such as the Internet of Things (IoT), artificial intelligence (AI), blockchain, cloud computing, edge computing, and 5G technology into various sectors has led to significant advancements and transformative potential across industries.

3.1 Internet of Things (IoT)

IoT technology revolutionises traditional life by connecting everyday objects to the internet, enabling efficient communication between people and things, as well as among things themselves. This connectivity enhances the functionalities of everyday objects. For instance, in sectors like healthcare and urban management, IoT facilitates the development of "smart cities" and advanced healthcare monitoring systems that help reduce energy consumption, improve traffic management in urban areas, and enable remote health monitoring and personalised patient care in healthcare (Mouha, 2021).

3.2 Artificial Intelligence (AI)

AI, particularly through its subfields like machine learning and deep learning, has drastically improved the capabilities of data analysis and decision-making systems. AI applications range from simple data handling to complex autonomous operations. In business, AI algorithms optimise operations, enhance customer service through chatbots, and support decision-making processes by providing insights from large datasets. In education, AI contributes to personalised learning experiences, adapting educational content to meet individual student needs and learning paces (Dwivedi *et al.,* 2024).

3.3 Blockchain

Blockchain technology offers a secure way to record transactions and manage data across a distributed network. Its applications extend from financial services to secure supply chain management, enhancing transparency and security in transactions across different sectors (Guo & Yu, 2022).

3.4 Cloud Computing and Edge Computing

Cloud computing provides the necessary infrastructure for storing vast amounts of data and running intensive computations required by IoT devices and AI algorithms. Edge computing complements this by processing data at the edge of the network, closer to where it is generated, which reduces latency and bandwidth use, and improves the speed of data processing. This is particularly crucial for real-time applications such as autonomous driving and real-time data analytics (Wang *et al.,* 2020).

3.5 5G Technology

5G technology is pivotal for enhancing the capabilities of IoT and AI. With its high speed and low latency, 5G significantly improves the efficiency of communication between connected devices. It supports the massive scale of IoT deployments required in smart cities and industrial automation, enabling faster data transfer, reduced latency, and higher reliability in communications (Dangi *et al.,* 2022).

4.0 ICT4D, ICT 4.0 and ICT for Sustainability

4.1 ICT4D

Information and Communication Technology for Development (ICT4D) is focused on using

technology to foster socio-economic development, particularly in underdeveloped and developing regions (Andersson & Hatakka, 2023). The primary goal of ICT4D is to make use of digital tools, platforms, and services to address critical issues such as poverty, inequality, education access, and healthcare inadequacies. ICT4D initiatives are context-specific, requiring thorough needs assessments and engagement with local stakeholders to tailor solutions to the socio-economic, cultural, and technological contexts of the target communities (Loh, 2015).

Key components of ICT4D include improving ICT infrastructure, enhancing digital literacy through capacity building, and developing sustainable business models that ensure the longevity of projects. ICT4D emphasises the empowerment of local technologists and entrepreneurs to drive initiatives, fostering local innovation and ownership (Masiero, 2024). Participatory approaches that involve the community in all stages of the project, from design to evaluation, are crucial for the success of ICT4D initiatives. Moreover, ICT4D projects require comprehensive monitoring and evaluation mechanisms to measure impact and facilitate continuous improvement (Abubakre & Mkansi, 2022).

4.2 ICT 4.0

ICT4.0 refers to the integration of advanced technologies such as artificial intelligence (AI), robotics, the Internet of Things (IoT), blockchain, and big data analytics into industrial processes (Mon & Del Giorgio, 2021a). This revolution is characterised by the fusion of digital, biological, and physical systems, creating smart factories and cyber-physical systems that enhance efficiency, productivity, and automation in industries. ICT4.0 is driven by advancements in connectivity, data processing power, and machine learning algorithms, enabling unprecedented levels of automation and intelligence in manufacturing and other sectors.

4.3 ICT4S

Information and Communication Technology for Sustainability (ICT4S) refers to the application of ICT to promote sustainable development and address environmental challenges. ICT4S initiatives aim to enhance environmental management, reduce carbon footprints, improve energy efficiency, and support the transition to sustainable practices across variousrious sectors (Hilty & Aebischer, 2015). The primary goal of ICT4S is to use technology to achieve sustainability goals, which include environmental preservation, social equity, and economic viability. Key components of ICT4S include environmental monitoring and management, energy efficiency, sustainable urban development, resource management, and facilitating a circular economy. ICT solutions can significantly enhance energy efficiency in industries, buildings, and transportation through smart grids, smart meters, and energy management systems. Moreover, ICT can play a crucial role in managing natural resources more sustainably and mitigating the effects of climate change through data analytics, modelling, and early warning systems for natural disasters (Visvizi *et al*., 2020).

4.4 A comparison of ICT4D, ICT 4.0 and ICT4S

Unlike ICT4D, which focuses on socio-economic development in marginalised regions, ICT4.0 primarily targets industrial and economic transformation in both developed and developing economies. The emphasis is on enhancing competitiveness, innovation, and productivity through the adoption of cutting-edge technologies. ICT4.0 initiatives often require significant investment in infrastructure and technology, as well as a skilled workforce capable of managing and utilising advanced systems.

While both ICT4D and ICT4S use technology to improve societal outcomes, they focus on different aspects of development. ICT4D primarily targets socio-economic development in marginalised regions, addressing issues like poverty, education, and healthcare. In contrast, ICT4S focuses on environmental sustainability and aims to promote sustainable practices across various sectors to preserve the environment, enhance social equity, and ensure economic viability.

ICT4D, ICT 4.0 and ICT4S represent distinct yet complementary approaches to leveraging technology for societal, industrial and environmental improvement. By integrating the

principles and technologies of ICT4D, ICT 4.0 and ICT4S, it is possible to create a more inclusive, innovative, and sustainable approach to global development. This integration can help achieve a balance between socio-economic development and environmental sustainability, ensuring a better future for both people and the planet.

Table 1
A Comparison of ICT4, ICT4.0 and ICT4S

Aspect	ICT4D (ICT for Development)	ICT 4.0 (Industry 4.0 Technologies)	ICT4S (ICT for Sustainability)
Primary Focus	Socio-economic development in underdeveloped/developing regions	Industrial transformation, smart manufacturing, and automation	Environmental sustainability and sustainable development
Key Technologies	Basic digital tools, mobile platforms, internet access	AI, IoT, robotics, blockchain, big data, cyber-physical systems	Smart grids, energy monitoring, IoT, data analytics, modeling
Target Areas	Poverty reduction, education, healthcare, digital inclusion	Manufacturing, logistics, production systems, industrial automation	Environmental monitoring, energy efficiency, sustainable urban planning
Development Approach	Participatory, context-specific, inclusive and empowering local stakeholders	Technology-driven, efficiency and productivity enhancement	Eco-centric, sustainability-driven across sectors
Infrastructure Requirement	Moderate; focuses on expanding access to ICTs	High; requires advanced infrastructure, connectivity, and skilled workforce	Variable; depends on scope (urban planning, energy systems, etc.)
Main Stakeholders	Local communities, governments, NGOs, development agencies	Industries, tech firms, governments	Environmental organizations, policy makers, industry, society
Goal	Social inclusion, empowerment, capacity building	Economic growth, competitiveness, industrial innovation	Sustainable development, reducing ecological footprint
Synergies	Can benefit from ICT4.0 innovations if adapted appropriately	Can support ICT4D by enabling smart agriculture, health, etc.	Can complement ICT4D/ICT4.0 by ensuring sustainability in development and industrial practices

5.0 ICT4D Application Areas

Information and Communication Technology for Development (ICT4D) encompasses a broad range of applications aimed at leveraging technology to address socio-economic challenges in developing regions. ICT4D initiatives play a crucial role in transforming various sectors, including agriculture, health, education, and climate change. By integrating digital tools and platforms, these initiatives strive to improve productivity, enhance access to essential services, and promote sustainable practices. Through the innovative use of technology, ICT4D aims to empower marginalised communities, bridge the digital divide, and foster inclusive development, ultimately contributing to the overall socio-economic advancement of disadvantaged populations.

5.1 ICT4D in Education

Information and Communication Technology (ICT) has become a crucial component in transforming education systems, particularly in developing regions. The integration of ICT in education facilitates an active, collaborative, creative, integrative, and evaluative learning environment, which significantly enhances the traditional methods of teaching and learning (Visvizi *et al.,* 2020).These technologies are utilized to support

and improve the learning process, making education more engaging and effective.

Some of the benefits of ICT in Education include the following:

- ICT-enhanced learning environments provide opportunities for interactive and participatory learning, encouraging students to engage actively in the educational process. Such environments promote self-paced, self-assessed, and self-directed learning, which is crucial for fostering independent learning skills.
- ICT allows for the creation of networks among educational institutions, facilitating the sharing of resources and information. It bridges the gap in quality of education between urban and rural areas by providing equal access to educational materials and resources.
- ICT supports the training of teachers in new skills and the introduction of innovative pedagogies into classrooms. This helps in updating teaching methodologies and incorporating modern techniques that are more effective in the current educational landscape.

Some example case studies and projects include the concept of "smart schools", which involves the integration of ICT in various aspects of education, promoting a more interactive and student-centred learning experience. These schools aim to foster an environment where students can learn at their own pace and assess their progress using ICT tools. The MOOCs (Massive Open Online Courses) which provide a platform for delivering quality education to a vast audience, often across geographical and socio-economic barriers. They offer flexibility in learning, allowing students to access course materials and lectures at their convenience, which is particularly beneficial for those in remote or underprivileged areas. In addition, projects like WoredaNet in Ethiopia highlight the role of ICT in improving educational access and quality in developing countries. This project uses ICT to connect educational institutions with government resources, enhancing the overall efficiency and effectiveness of the education system.

5.2 ICT4D in Health

Information and Communication Technology for Development (ICT4D) aims to use ICT to address challenges and promote development in various sectors, includingncluding healthcare (Kivunike *et al.,* 2015). In healthcare, ICT4D plays a pivotal role in enhancing access, improving quality, and ensuring efficient delivery of services, particularly in remote and underserved areas (Hoque & Ashraf, 2015). Some areas of application include the following:

Telemedicine exemplifies how ICT4D enhances healthcare by providing clinical services remotely. In regions with limited healthcare facilities, telemedicine allows patients to consult with specialists through video conferencing and other communication technologies. This reduces the need for travel, which is often costly and time-consuming. In Bangladesh, for example, telemedicine services have been integrated with community health programmes to provide remote consultations and treatment plans, significantly improving access to healthcare in isolated areas like the Chittagong Hill Tracts (Hoque, 2020).

Electronic Health Records (EHR) systems are another critical component of ICT4D in healthcare. They digitise patient records, making it easier to manage, share, and analyse health data. This transition from paper-based records to digital systems enhances the efficiency of healthcare services, reduces errors, and facilitates better patient follow-up. In Uganda, the implementation of the District Health Management Information Software System (DHIS2) has improved the timeliness and completeness of health data reporting, leading to better health outcomes and more informed informed decision-making (Kivunike *et al.,* 2015).

Mobile health (mHealth) applications are widely used in ICT4D to deliver health services and information via mobile devices. These applications are particularly valuable in areas with limited access to healthcare facilities. They can provide health education, reminders for medication, and remote consultations. For instance, the GrameenPhone Health Line in Bangladesh offers a 24-hour medical call centre, providing essential

health advice and emergency consultations via mobile phones, thus extending healthcare reach to rural and indigenous populations (Hoque, 2020).

Wearable health technology, such as fitness trackers and health monitors, is increasingly being used in ICT4D initiatives to promote preventive healthcare and chronic disease management. These devices collect real-time health data, which can be monitored by healthcare providers to detect early signs of health issues and intervene promptly. In remote areas, wearables can alert medical professionals to potential health problems, facilitating timely medical responses and improving overall health outcomes.

AI-powered diagnostic tools are revolutionising healthcare by providing accurate and rapid analysis of medical data. In the context of ICT4D, AI can be used to enhance diagnostic capabilities in underserved regions. AI algorithms can analyse medical images, predict disease outbreaks, and assist in clinical decision-making. For example, AI tools can help diagnose conditions such as tuberculosis and diabetic retinopathy in regions with limited access to specialists, ensuring that patients receive timely and accurate diagnoses.

Blockchain technology offers a secure and decentralised method of managing health records, which is crucial for ensuring data integrity and privacy in ICT4D projects. Blockchain enables the secure sharing of patient data across different healthcare providers and systems, facilitating coordinated care and improving patient outcomes. This is particularly beneficial in areas with fragmented healthcare systems, where consistent and reliable access to patient records is necessary for effective healthcare delivery.

Health Information Systems (HIS) integrate data from various sources to provide a comprehensive view of patient health and healthcare services. These systems streamline operations, reduce redundancies, and enhance decision-making. In rural and underserved areas, HIS can support telehealth services, improve resource allocation, and enable better health monitoring and reporting. For example, HIS implementations in rural clinics in Uganda have improved patient record management, facilitated better tracking of medical supplies, and enhanced overall healthcare delivery accuracy.

5.3 ICT4D in Agriculture

Information and Communication Technology for Development (ICT4D) has become a significant tool in enhancing agricultural productivity and sustainability, particularly in developing countries. The integration of ICT in agriculture helps to address various challenges, including limited access to information, inadequate market linkages, and inefficient farming practices. ICT4D initiatives in agriculture focus on leveraging technology to improve communication, increase efficiency, and promote sustainable farming practices (Chowhan & Ghosh, 2020).

Agricultural Information and Communication Centres (AICCs) play a pivotal role in disseminating agricultural information to farmers. These centres use various ICT tools, including mobile phones, radios, and the internet, to provide farmers with timely and relevant information on weather forecasts, pest control, crop management, and market prices. AICCs have been instrumental in bridging the information gap between agricultural experts and farmers, ensuring that the latter have access to essential knowledge and resources.

Mobile phones are widely used in rural areas to deliver agricultural information through SMS services. These services provide farmers with updates on weather conditions, pest outbreaks, and best farming practices. For example, the m-Agri platform in Bangladesh sends SMS alerts to farmers about critical agricultural information, helping them make informed decisions and improve crop yields.

E-agriculture platforms use the internet to offer a wide range of services, including e-commerce, online training, and access to agricultural databases. These platforms enable farmers to buy and sell agricultural products, access expert advice, and participate in online communities. In Bangladesh, platforms like Ek-shop provide an online marketplace for farmers to sell their products, reducing the dependency on intermediaries and increasing their profit margins (Chowhan & Ghosh, 2020).

Geographic Information Systems (GIS) and Remote Sensing (RS) technologies are used to collect and analyse spatial data related to agriculture. These technologies help in mapping soil types, monitoring crop health, and managing natural resources. By providing precise data on soil conditions and crop growth, GIS and RS enable farmers to adopt precision farming techniques, which optimise resource use and enhance productivity. In Bangladesh, GIS and RS are used to monitor flood-prone areas and manage irrigation systems, ensuring better water management and crop planning.

IoT devices, such as sensors and drones, are increasingly being used in smart farming to collect real-time data on soil moisture, temperature, and crop health. This data helps farmers make data-driven decisions, improving crop management and reducing wastage. IoT-based solutions are being explored to automate irrigation systems, monitor crop health, and manage livestock, leading to more efficient and sustainable farming practices.

5.4 ICT4D and Climate Change

Climate change presents one of the most significant challenges of our time, with far-reaching impacts on ecosystems, economies, and communities worldwide. The diverse manifestations of climate change, including increased frequency and intensity of extreme weather events, rising sea levels, and shifting agricultural zones, necessitate comprehensive strategies for adaptation and mitigation (Finlay et al., 2022). Information and Communication Technologies for Development (ICT4D) have emerged as powerful tools in addressing these challenges. By leveraging digital innovations, ICT4D enhances the capacity to monitor environmental changes, disseminate critical information, empower communities, and implement sustainable practices (Shabajee *et al.*, 2014).

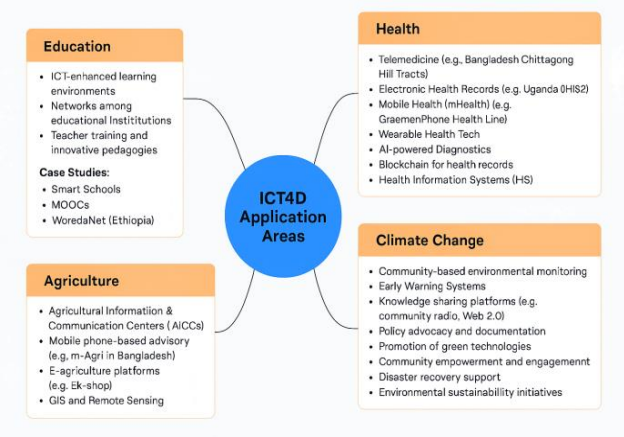
ICTs, such as mobile phones and sensor networks, are utilised for community monitoring frameworks. These technologies capture real-time data on environmental changes and support vulnerability assessments. In addition, ICTs are critical in developing early warning systems for extreme weather events. These systems use a range of ICT-based channels to provide alerts and warnings about flood risks and other climate-related hazards to communities, businesses, and individuals. ICT4D initiatives focus on sharing knowledge and best practices related to climate change adaptation. This includes using community radio and Web 2.0 tools to disseminate information, raise awareness, and build community resilience. ICT4D organisations engage in policy advocacy to address climate change. They work on documenting knowledge, conducting research to highlight policy gaps, and participating in networks that advocate for climate-related policies. ICTs support sustainable practices by promoting the use of green technologies, such as solar panels and fuel-efficient transport. These practices help reduce energy consumption and greenhouse gas emissions, contributing to climate change mitigation.

ICTs empower communities by enabling open engagement, crowd-sourcing, and supporting distributed communities. This helps in enhancing stakeholder engagement and ensuring that local communities are actively involved in climate change adaptation strategies.ICTs facilitate the coordination of disaster recovery information and support for people affected by acute climate change impacts. This includes providing training in flood management and coordinating disaster response efforts using ICT tools.ICT4D organizations run various environmental initiatives focusing on issues like forest preservation, water security, and sustainable agriculture. These initiatives use ICT to monitor and manage natural resources more effectively.

By leveraging ICTs, ICT4D initiatives significantly enhance the capacity to adapt to and mitigate the impacts of climate change. They provide essential tools and systems for monitoring, early warning, knowledge sharing, policy advocacy, sustainable practices, community empowerment, disaster recovery, and environmental sustainability initiatives.

Figure 1

A Mind Map of the Key Areas of Applications of ICT4D with Examples



6.0 Challenges and Future Prospects

Despite the transformative potential of ICT4D, ICT 4.0, and ICT4S, several challenges impede their full implementation and effectiveness:

- Developing countries often face significant infrastructure deficits, including limited internet connectivity, unreliable power supply, and inadequate ICT infrastructure. These constraints are compounded by limited financial resources, which hinder the deployment and maintenance of necessary ICT tools and services.
- The digital divide remains a substantial barrier, characterised by unequal access to technology and the internet. This divide is often more pronounced in rural and marginalised communities, exacerbating existing socio-economic inequalities and limiting the reach and impact of ICT initiatives.
- Many educators, healthcare providers, and farmers in developing regions lack the necessary ICT skills and training. The absence of continuous professional development and training programmes further impedes the effective integration of ICT into various sectors.
- Inconsistent and outdated policies and regulations can obstruct the implementation of ICT initiatives. There is often a lack of clear guidelines and supportive frameworks to promote ICT adoption and innovation in developing regions.
- Socio-cultural factors, including resistance to change and a lack of awareness about the benefits of ICT, can impede the acceptance and utilisation of ICT solutions. Addressing these barriers requires targeted awareness and education campaigns.
- The increased use of ICT raises significant security and privacy issues. Protecting sensitive data from cyber threats and ensuring the privacy of users is crucial, particularly in sectors such as healthcare and education.
- Looking ahead, several prospects and opportunities can enhance the effectiveness and impact of ICT4D, ICT 4.0, and ICT4S.
- Continuous advancements in technology, such as the proliferation of 5G networks, improved AI algorithms, and more affordable IoT devices, will enhance the capabilities and reach of ICT initiatives. These advancements can drive more efficient and effective solutions across various sectors.
- Strengthening collaborations between governments, private sector entities, non-governmental organisations, and international bodies can provide the necessary resources and expertise to scale ICT initiatives. Public-private partnerships can facilitate the development and deployment of innovative ICT solutions.
- Investing in capacity-building programmes to enhance digital literacy and ICT skills among educators, healthcare providers, farmers, and other stakeholders is critical. These programmes can empower local communities to use ICT effectively and sustainably.
- Developing and implementing supportive policies and regulatory frameworks can promote ICT adoption and innovation. These reforms should address issues such as data privacy, cybersecurity, and the equitable distribution of digital resources.
- Engaging local communities in the design, implementation, and evaluation of ICT initiatives ensures that solutions are contextually relevant and culturally

acceptable. Participatory approaches can foster local ownership and increase the sustainability of ICT projects.

- Ongoing research and innovation are essential to identify new opportunities and address emerging challenges in ICT4D, ICT 4.0, and ICT4S. Research can provide insights into best practices, inform policy decisions, and drive the development of cutting-edge solutions.
- Establishing monitoring and evaluation mechanisms can help assess the impact of ICT initiatives and identify areas for improvement. Continuous evaluation ensures that projects remain aligned with their objectives and adapt to changing needs and contexts.

7.0 Conclusion

The integration of ICT in various sectors has demonstrated immense potential in driving socio-economic development and sustainability, especially in developing regions. The evolution from ICT4D 1.0 to ICT4D 3.0 and the emergence of ICT 4.0 underscore the continuous advancement and application of digital technologies in addressing global challenges. Despite significant progress, several challenges such as infrastructure deficits, the digital divide, lack of training, and policy barriers hinder the full realisation of ICT's potential. Addressing these challenges requires collaborative efforts, investments in capacity building, supportive policy frameworks, and community engagement. Looking ahead, advancements in technology, public-private partnerships, and sustainable practices will play crucial roles in enhancing the effectiveness and impact of ICT initiatives. By leveraging the synergies between ICT4D, ICT 4.0, and ICT4S, we can foster a balanced approach to development that promotes economic growth, social equity, and environmental sustainability, ensuring a better future for all.

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9.0 Declaration of Conflicting Interests

The authors declare no conflict of interest.

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